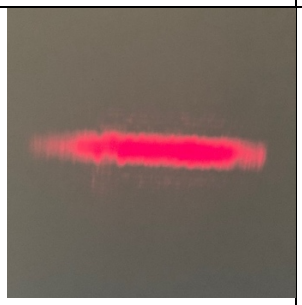
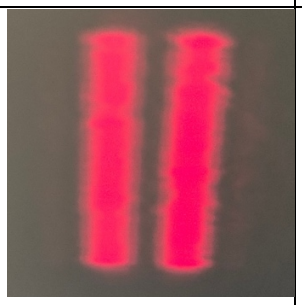
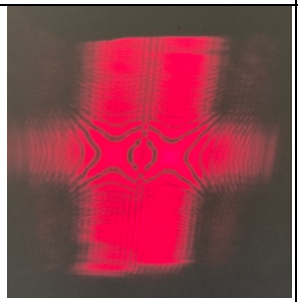
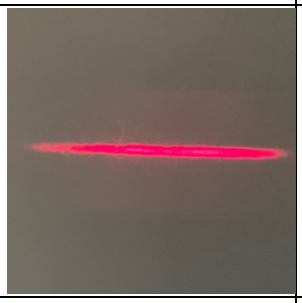
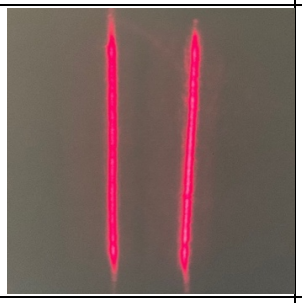
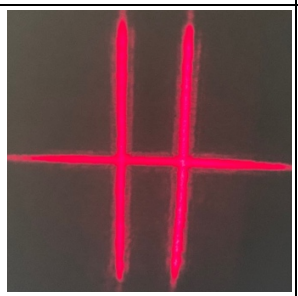
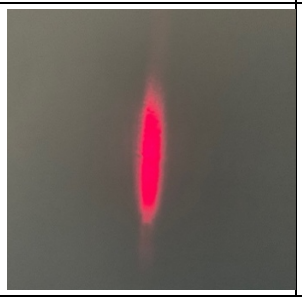
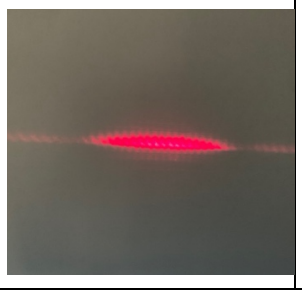
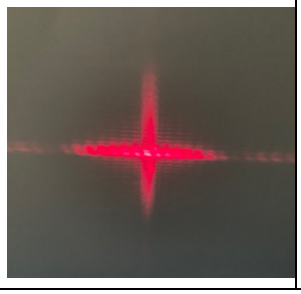
Superposition of Waves to Superposition of Patterns

--- Double slit Experiments to Cross Double Slit Experiments

Hui Peng, James Peng's Lab,
davidpeng1749@yahoo.com

Abstract

Young's double slit experiment produces a single interference pattern, which has been explained as the consequence of the Superposition of waves. The cross double slit consists of at least two components. A component is either a single slit or a double slit or a triple slit, etc. A cross double slit experiment produces a combination of at least two interference patterns. In this article, we propose the Superposition of patterns of cross double slit experiment: at certain distance from the diaphragm, the complete pattern is the Superposition of the patterns produced by each component, respectively.

L	P1	P2	P3	Superposition of pattern is valid: yes or no
10 mm				No. Since there is fine structure in P3, so $P1 + P2 \neq P3$ P1 and P2 are Particle patterns. P3 is Pre-Particle pattern
50 mm				Yes. Since there is no fine structure in P3, so $P1 + P2 = P3$ P1, P2 and P3 are Particle patterns.
1100 mm				Yes. $P1 + P2 = P3$ P1, P2 and P3 are interference patterns.

The Superposition of patterns is valid for the Particle patterns and the Interference patterns at certain distances from the diaphragm, while is not valid for the Pre-particle patterns and Transition patterns. The mystery is that when crossing two or more components at an angle, the fine structures emerge, which destroyed the Superposition of patterns. We show the Superposition of patterns in detail to provide phenomena for further theoretical study.

1. Introduction

The Young's double-slit experiment produces a single interference pattern that is explained as the consequence of the Superposition of two waves [1]. To study the Feynman's mystery of the double slits, the double slit experiments have been extended to the cross double slit experiments [2]. The cross double slit consists of at least two components crossing at the one point. A component is either a single slit (Figure 1g) or a double slit (Figure 1a) or a triple slit (Figure 1d), etc. A cross double slit experiment produces a combination of at least two interference patterns (Figure 1).

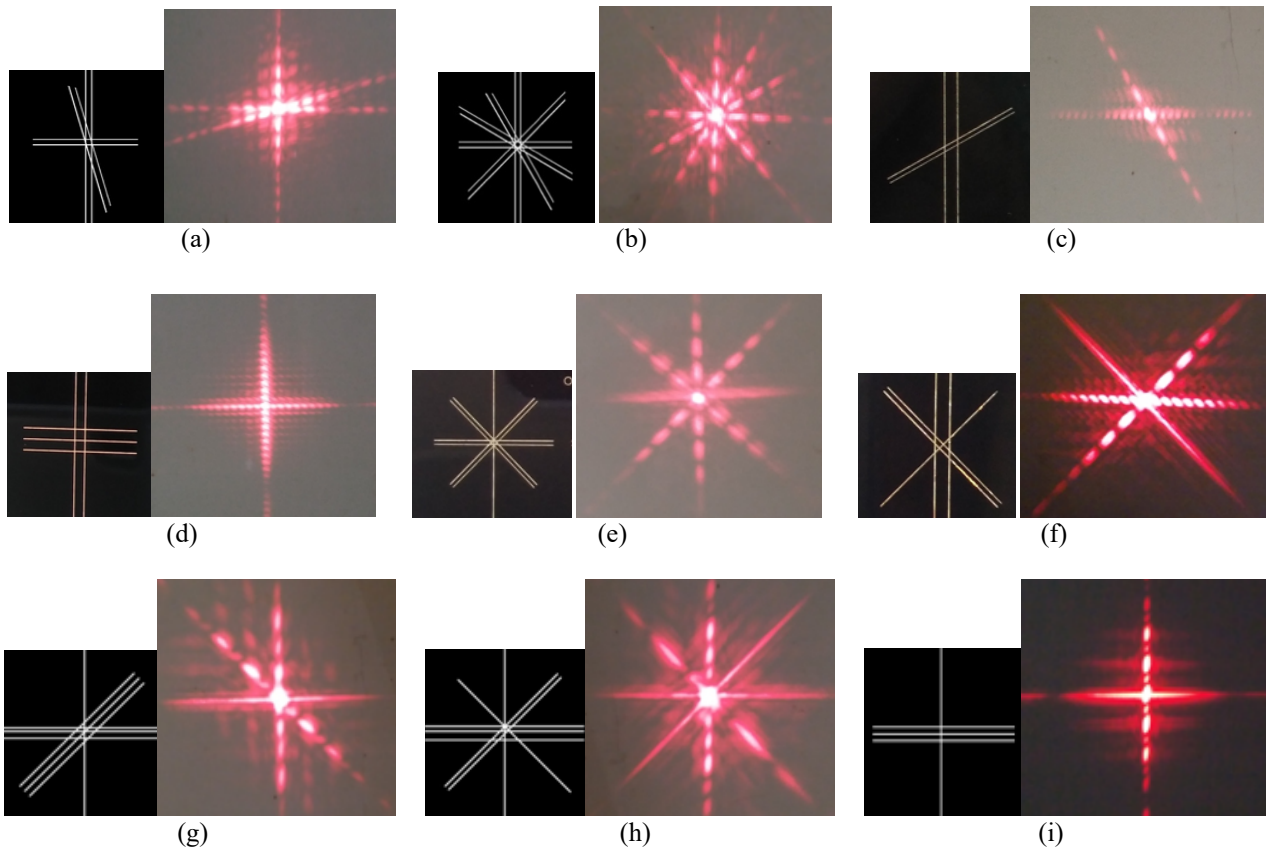


Figure 1. (a) three equal spacing double-slits crossing; (b) five equal spacing double-slits crossing; (c) a narrow spacing double-slit crossing a wider spacing double-slit; (d) a double-slit crossing a triple-slit; (e) a single slit and three equal spacing double-slits crossing; (f) single slit, narrow spacing double slit and wider spacing double slit crossing; (g) single slit, equal spacing triple slight and non-equal spacing triple slit crossing; (h) two single slits, double slit and non-equal spacing triple slit crossing; (i) single slit crossing equal spacing triple slit

Figure 1 shows several examples of the diaphragms and the complete patterns [3]. Hereafter, for simplicity, we refer them as "Cross-double-slit". Figure 1 shows that the pattern of each experiment consists at least two interference patterns crossing at the same point; each interference pattern is produced by corresponding component. Hereafter, for simplicity, we refer the diffraction patterns and interference patterns as "Interference pattern". However, we have shown that photons produce both non-interference patterns and interference patterns in the same classical wave experiment [4].

We raise a question whether the complete pattern of a cross double slit experiment is the superimpose of patterns produced by each component, respectively?

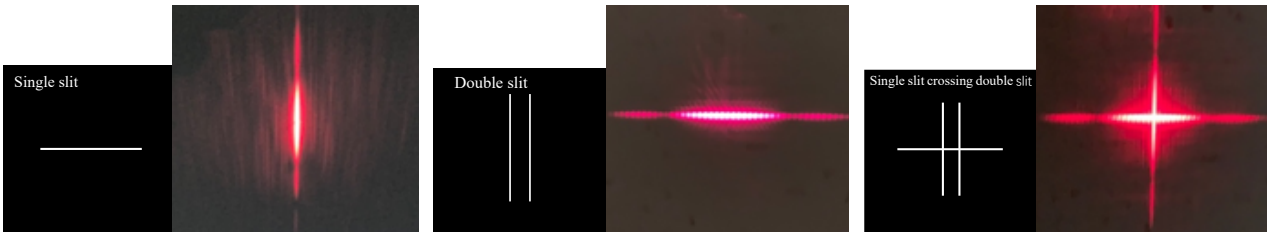
In this article, we propose the Superposition principle of patterns for the cross double slit experiments and then, study the Superimpose of patterns in detail to provide phenomena/evidence for further theoretical study.

2. Superposition of Patterns in Single Slit Crossing Double Slit Experiment.

Let us propose a new principle below:

Superposition principle of patterns: at certain distance from the diaphragm of a cross-double-slit wave experiment, the complete pattern consists at least two patterns crossing at the same point; each pattern is produced by corresponding component.

Let us consider the simplest wave experiments: a single slit experiment (Figure 2a), a double slit experiment (Figure 2b) and a single slit crossing a double slit experiment (Cross-double-slit) (Figure 2c). The experimental setup of the cross double slit (Figure 2c) is the superimpose of the single slit (Figure 2a) and the double slit (Figure 2b).



(a) (b) (c)

Figure 2. (a) single-slit and pattern; (b) double-slit and pattern; (c) cross-double-slit and pattern

It is obvious that the interference pattern (Figure 2c) is the Superposition of the interference pattern (Figure 2a) and the interference pattern (Figure 2b). Namely, the interference pattern (Figure 2c) is the Superposition of two interference patterns.

Next let us study whether the Superposition principle of patterns is valid for the non-interference patterns of the cross double slit experiments. We utilize the lens in the single slit (Figure 2a), the double slit (Figure 2b) and the cross double slit (Figure 2c) experiments respectively.

Experimental setup (Figure 3): placing the lens between the diaphragm (of either single slit, or double slit or cross double slit) and the screen at difference distance L from the diaphragm.

Observation (Figure 4): for comparison, we place the lens at the same distance for each step for each experiment (Figure 4).

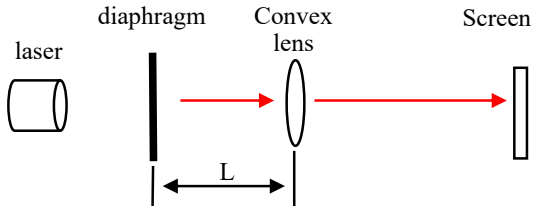
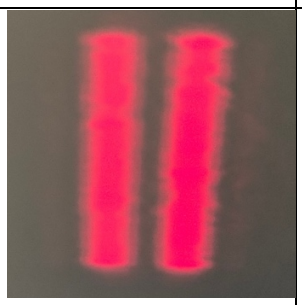
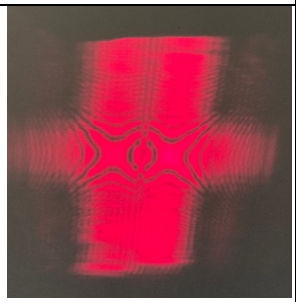
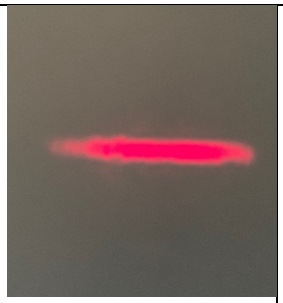
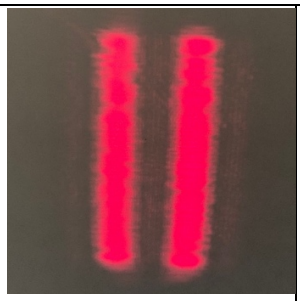
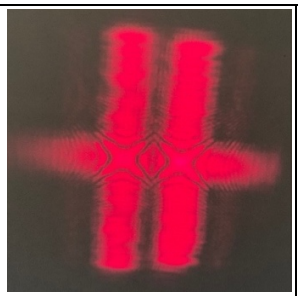
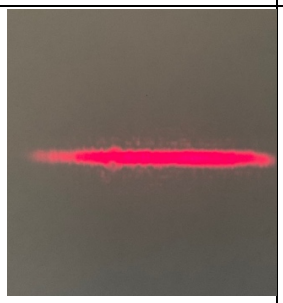
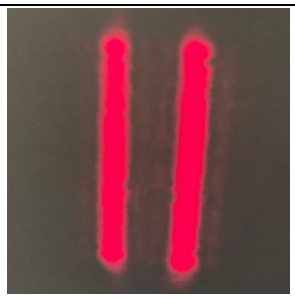
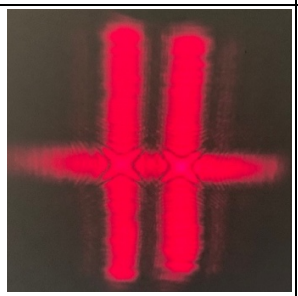
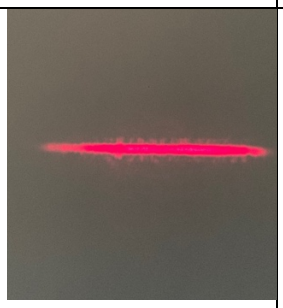
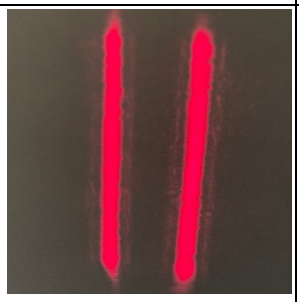
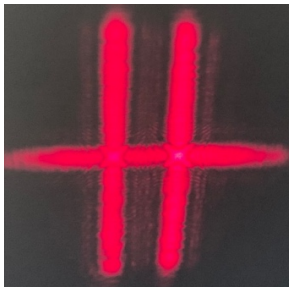
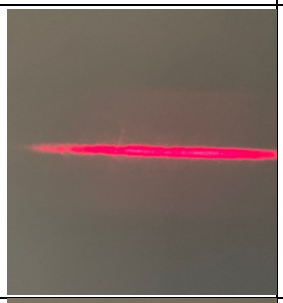
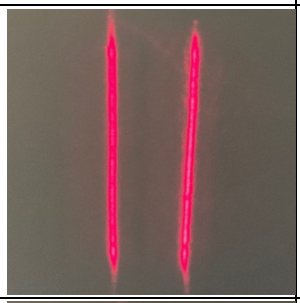
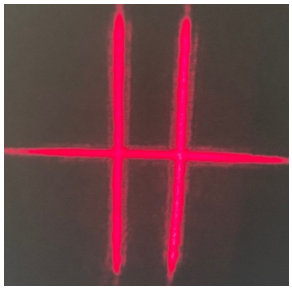
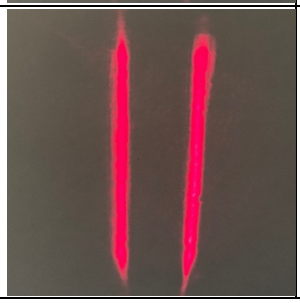
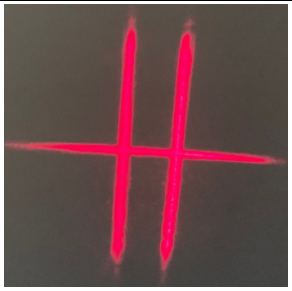


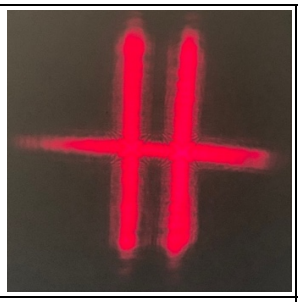
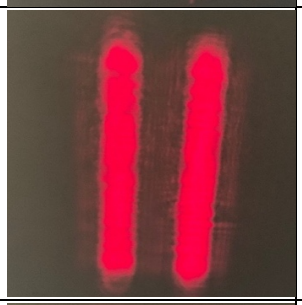
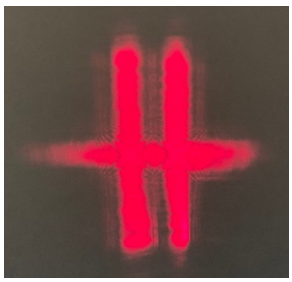
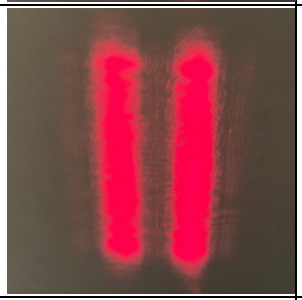
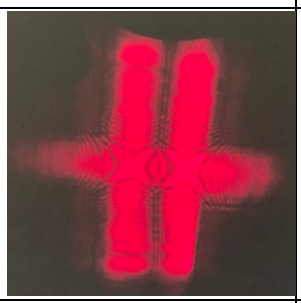
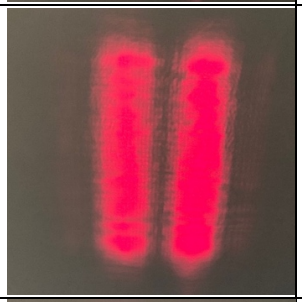
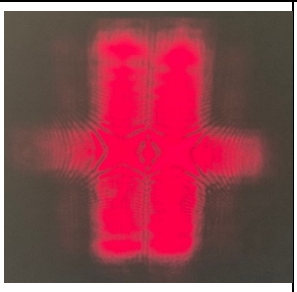
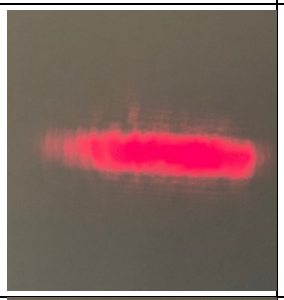
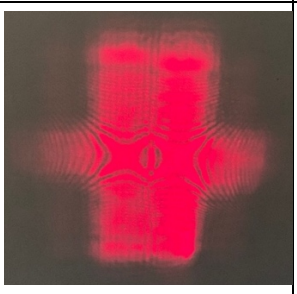
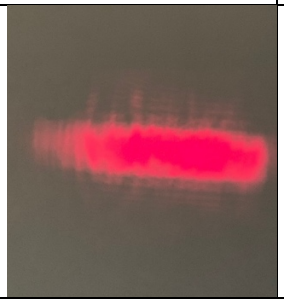
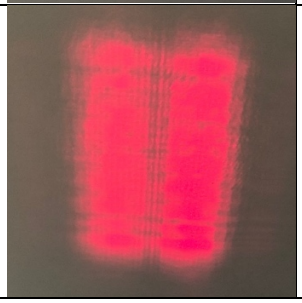
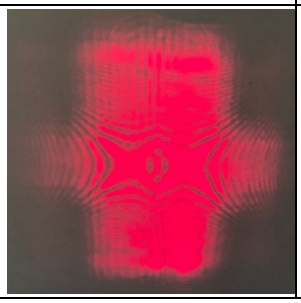
Figure 3. Experimental setup

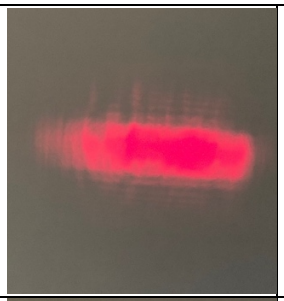
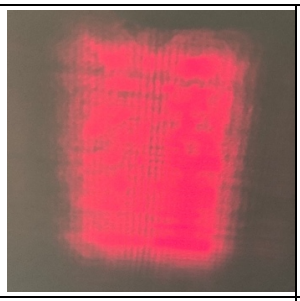
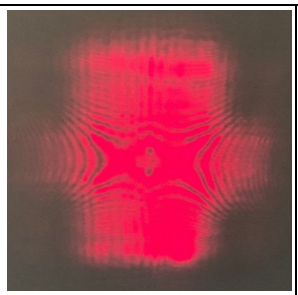
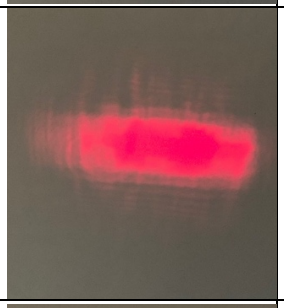
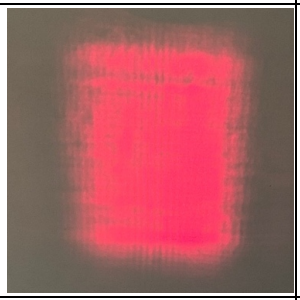
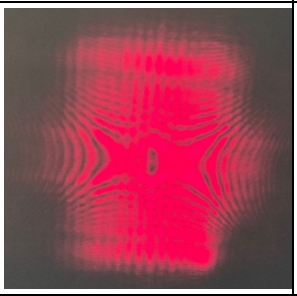
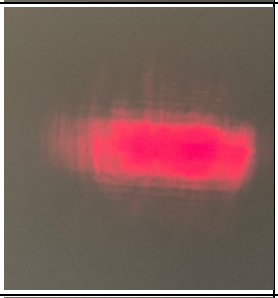
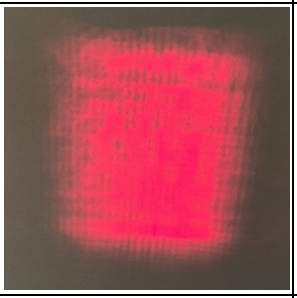
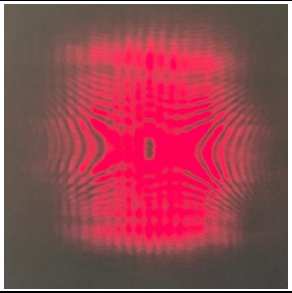
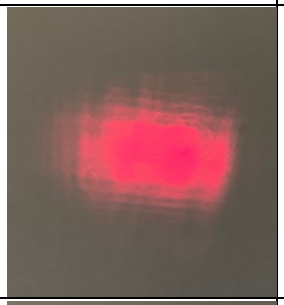
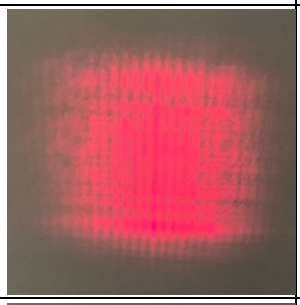
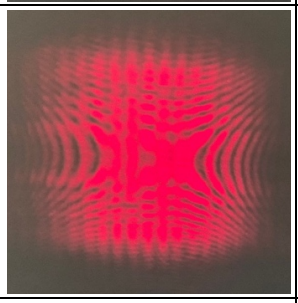
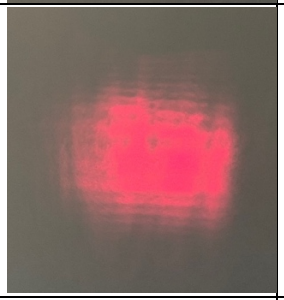
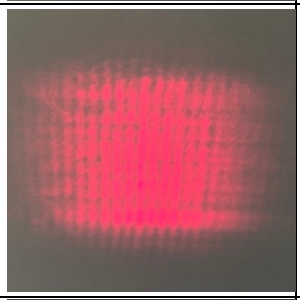
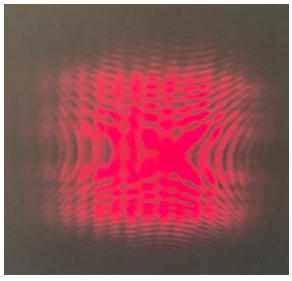
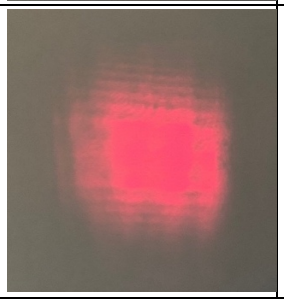
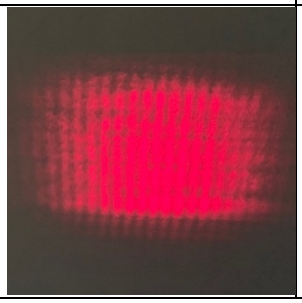
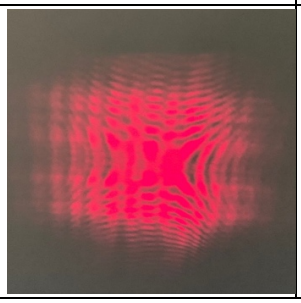
Observations and Comparison: shown in the following table.

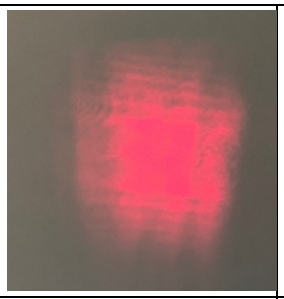
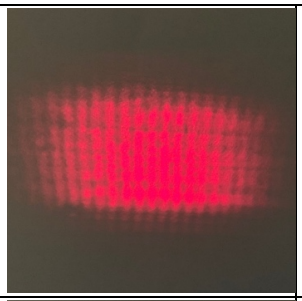
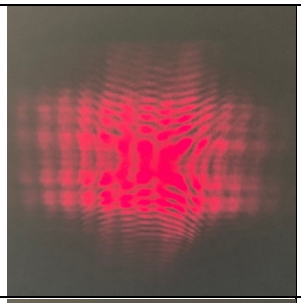
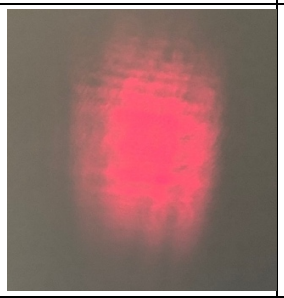
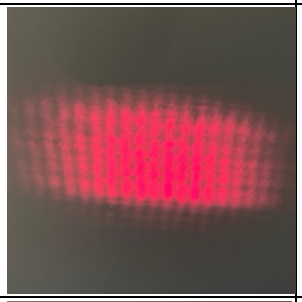
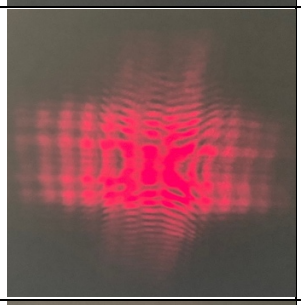
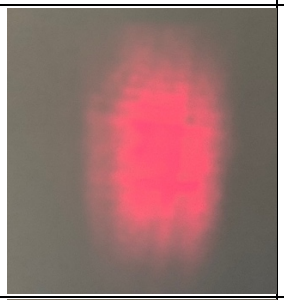
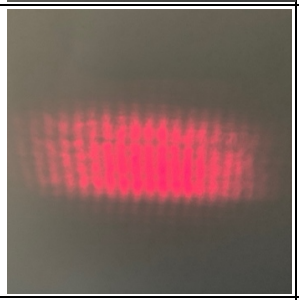
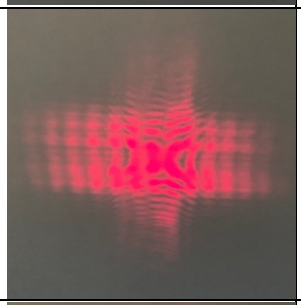
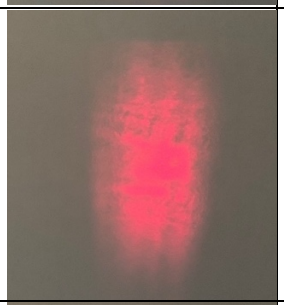
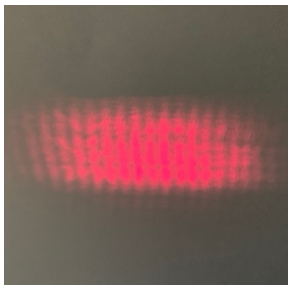
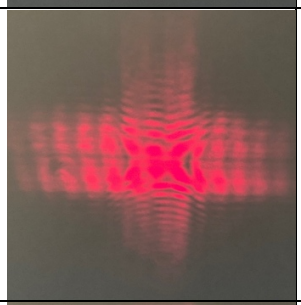
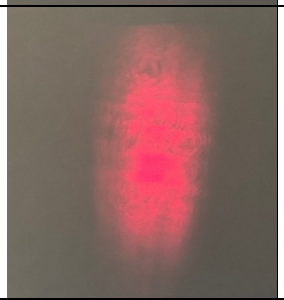
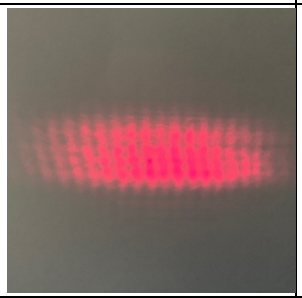
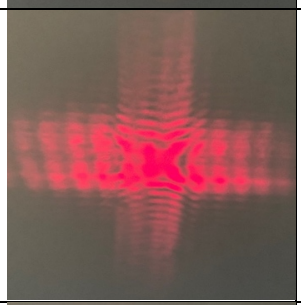
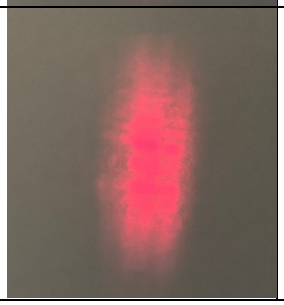
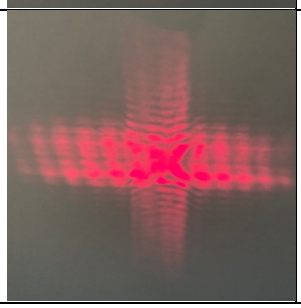
Table: Superposition patterns and Non-Superposition patterns

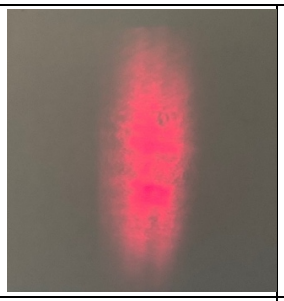
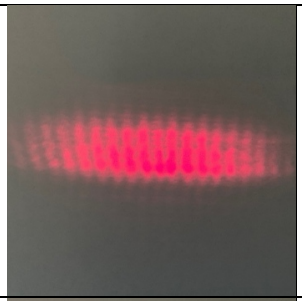
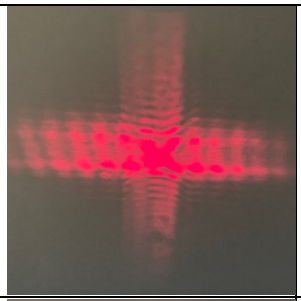
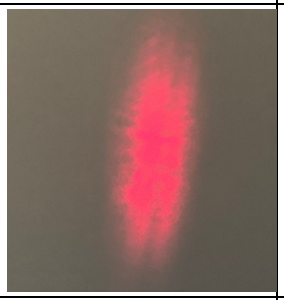
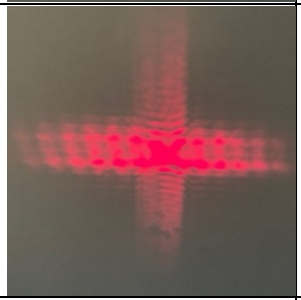
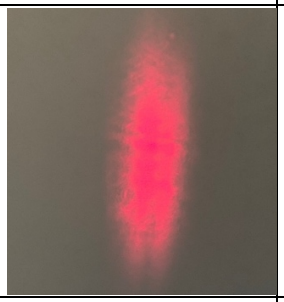
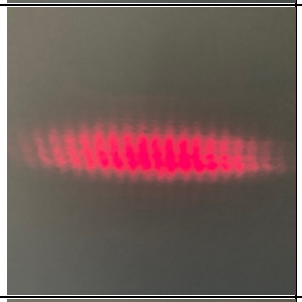
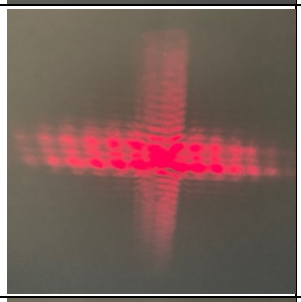
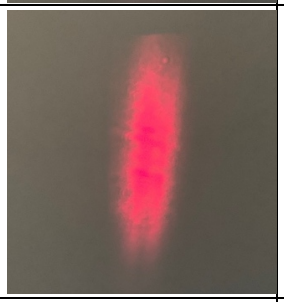
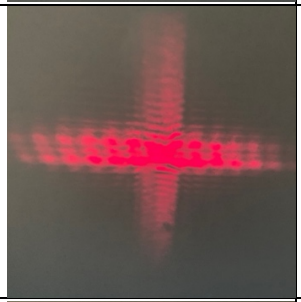
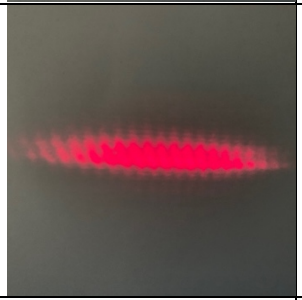
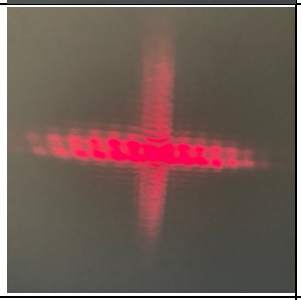
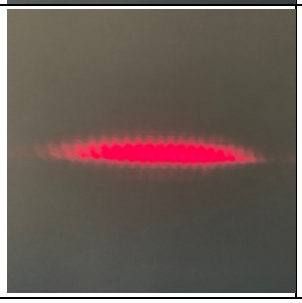
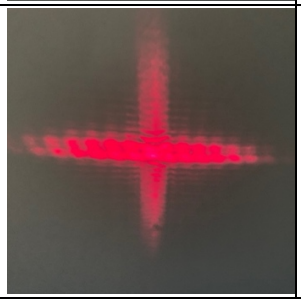
L (mm)	Single slit: Pattern as P1	Double slit: Pattern as P2	Cross double slit: Pattern as P3	Superposition is valid: yes or no
10				No there is fine structure in P3, so $P1 + P2 \neq P3$ P1 and P2 are Particle patterns. P3 is Pre-Particle pattern [4]

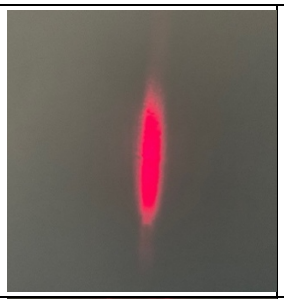
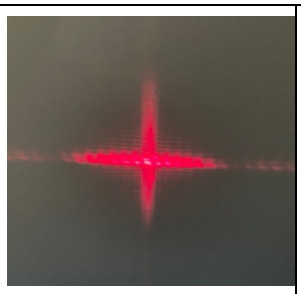
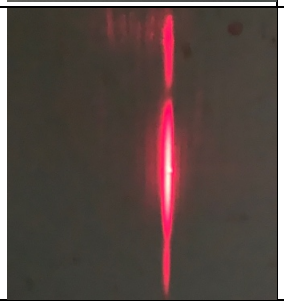
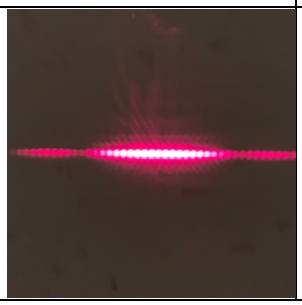
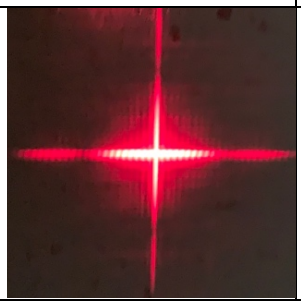
20				No there is fine structure in P3, so $P1 + P2 \neq P3$ P1 and P2 are Particle patterns. P3 is Pre-Particle pattern
30				No there is fine structure in P3, so $P1 + P2 \neq P3$ P1 and P2 are Particle patterns. P3 is Pre-Particle pattern
40				No: there is fine structure in P3, so $P1 + P2 \neq P3$ P1 and P2 are Particle patterns. P3 is Pre-Particle pattern
50				**Yes**: there is no fine structure in P3, so $P1 + P2 = P3$ P1, P2 and P3 are Particle patterns.
60				**Yes**: there is no fine structure in P3, so $P1 + P2 = P3$ P1, P2 and P3 are Particle patterns.

70				**Yes**: there is no fine structure in P3, so $P1 + P2 = P3$ P1, P2 and P3 are Particle patterns.
80				No: there is fine structure in P3, so $P1 + P2 \neq P3$
90				No: there is fine structure in P3, so $P1 + P2 \neq P3$
100				No: there is fine structure in P3, so $P1 + P2 \neq P3$
110				No: there is fine structure in P3, so $P1 + P2 \neq P3$
120				No: there is fine structure in P3, so $P1 + P2 \neq P3$

130				No: there is fine structure in P3, so $P1 + P2 \neq P3$
140				No: there is fine structure in P3, so $P1 + P2 \neq P3$
150				No: there is fine structure in P3, so $P1 + P2 \neq P3$
200				No
250				No
300				No

350				No
400				No
450				No
500				No
550				No
600				No

650				No
700				No
750				No
800				No
900				No
1000				No

1100				**Yes**: $P1 + P2 = P3$ P1 and P2 are interference patterns. P3 is the combination of P1 and P2
≥ 1100 No lens				**Yes**: $P1 + P2 = P3$ P1 and P2 are interference patterns. P3 is the combination of P1 and P2

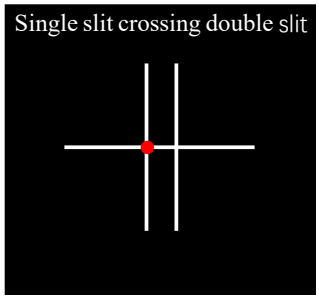
After $L \geq 1100$ mm, P1, P2 and P3 are all Interference patterns and $P1 + P2 = P3$ and thus, the Superposition principle of patterns is valid.

3. Summary

The Superposition principle of patterns for cross double slit experiments is valid for the Particle patterns and the Interference patterns at certain distance from the diaphragm, while is not valid for the Pre-particle patterns and Transition patterns. The mysteries are

(1) when components crossing at one point, the fine structures emerge, which destroyed the Superposition principle of patterns;

(2) when a photon is passing through the RED dot in the following figure, should the photon behave as it is in the single slit, or in the double slit, or random?



Reference

[1] D. A. Russell, "Acoustics and Vibration Animations" at http://www.acs.psu.edu/drussell/Demos/copyright.html. July 1996.

[2] Peng, H. "Cross-Double-Slit Experiment and Extended-Mach-Zehnder Interferometer. *Open Science Repository Physics*, http://doi.org/10.7392/OPENACCESS.45011872, May 2019.

[3] For a review article see Hui Peng, "Double Slit to Cross Double Slit to Comprehensive Double Slit Experiments", Research square, preprint, DOI: https://doi.org/10.21203/rs.3.rs-555223/v1 May 2021.

[4] Hui Peng, "Non-interference patterns evolving to interference patterns --- Universal phenomena of single slit, double slit, cross double slit, triple slit, disc ring, 1D grating and 2D grating experiments. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.21820155.v1 Jan. 2023.