Photon chamber ——Showing Particle Nature of Light in 2D-Grating Wave Experiments

Hui Peng[1]

[1]Affiliation not available

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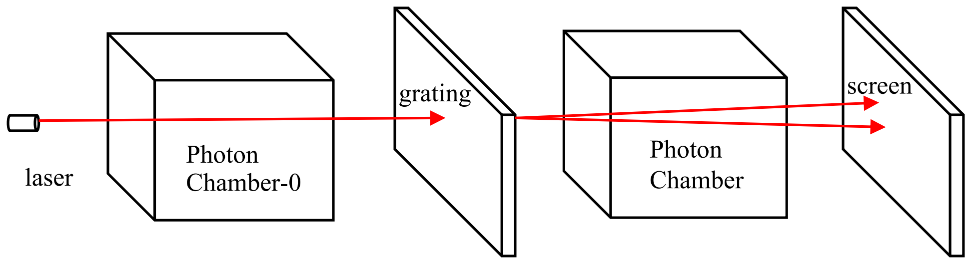
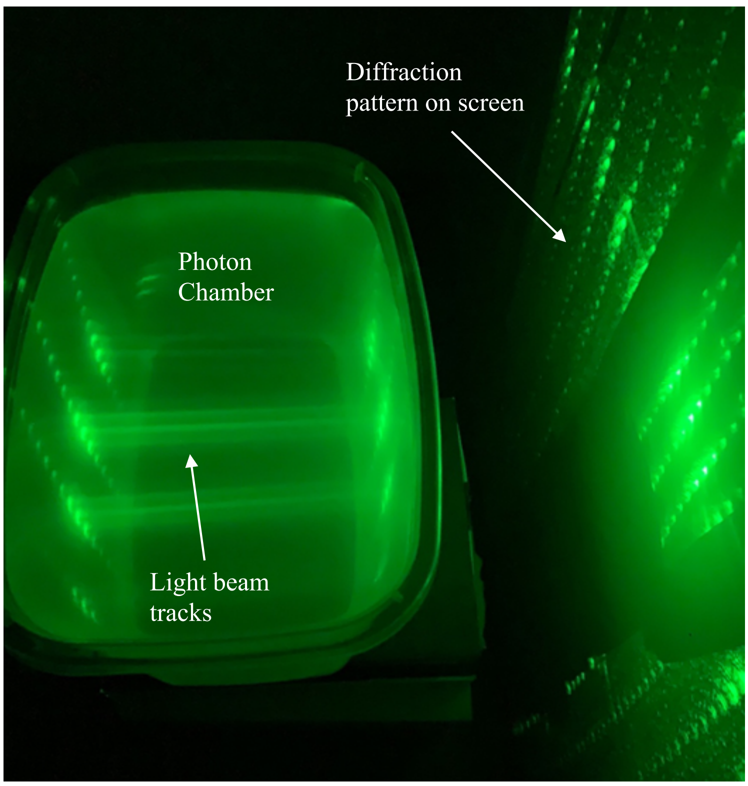
--- Showing Particle Nature of Light in 2D-Grating Wave Experiments

Hui Peng

*Corresponding author: davidpeng1749@yahoo.com

Abstract Young's double slit experiments, which represent the mystery of quantum mechanics, have been described by wave theories such as the electromagnetic wave, quantum probability waves and pilot waves. Recently, the photon chamber has been proposed to detect the traces of the light beams in the 1D-grating diffraction experiments, namely to visualize the passage of the light beams.





In this article we apply the photon chamber to the 2D grating. The experiments show that the light beams behave as rays moving through the photon chamber. The existence of the light tracks indicates the particle nature of the light beams in the wave experiments. The challenge is to explain the fact that

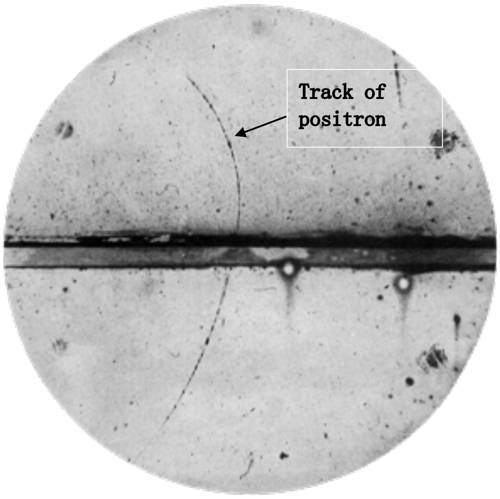
the light pass through the photon chamber, which may be placed anywhere between the grating and the detecting screen, as photons, while still distribute as waves on the detecting screen.

Keywords: grating, 2D-grating, photon chamber

1. Introduction

The evolution of the concept of the nature of light/photons has a long history. The Young's double slit experiment shows that the light behaves the same as waves before and after passing through the slide of the double slit. Einstein (1905) proved that light is quanta [1], which combining with Young's double slit experiment led to wave-particle duality. Bohr (1927) proposed the complementarity principle. Feynman (1956) called "[the double slit experiment] contains the only mystery [of quantum mechanics]" [2]. One of the reasons why the mystery is long-standing is the lack of variety of experimental data.

In the particle physics, the cloud chamber [3] and bubble chamber [4], etc., have been invented to detect a particle that interacts with the contents. By looking for the track, one can identifies the existence of a particle. An example is the observation of the track of the positron in a cloud chamber by Anderson [5].



Recently, by taking into account the concept of the cloud chamber, we introduced the photon chamber to study the 1D-grating experiments [6]. The grating experiment is referred as the wave phenomena.

In this article we apply the photon chamber to study the 2D-grating experiments. The experiments show that the light beams behave as particles (photons) and distribute as waves in the same wave experiments, which phenomenon is visually observable without ambiguity.

2. Photon chamber

For studying the nature of the light in the grating experiments, the photon chamber is proposed, which functions as a photon-detector for visualizing the photons passing through the chamber. A photon chamber consists of a transparent container filled with the mixture of water and fine powder (Figure 1). Then we apply the photon chamber in the 2D-grating experiments, in which the partial of light beam is reflected by the particles of the powder, while the partial of the light passes through the photon chamber and forms the diffraction pattern on the screen/detector. The tracks of these reflected photons are visible, which indicating that, before landing on the screen/detector, the light behaves as particles, photons.

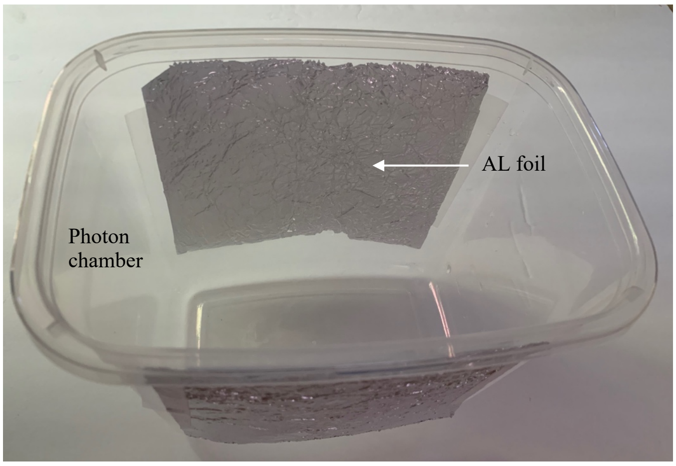


Figure 1. Photon chamber

3. Experiment Setup

The experiment setup is shown in Figure 2a. Two photon chambers, the photon chamber-0 and the photon chamber, are placed between the laser and the grating and between the grating and the detector/screen respectively.

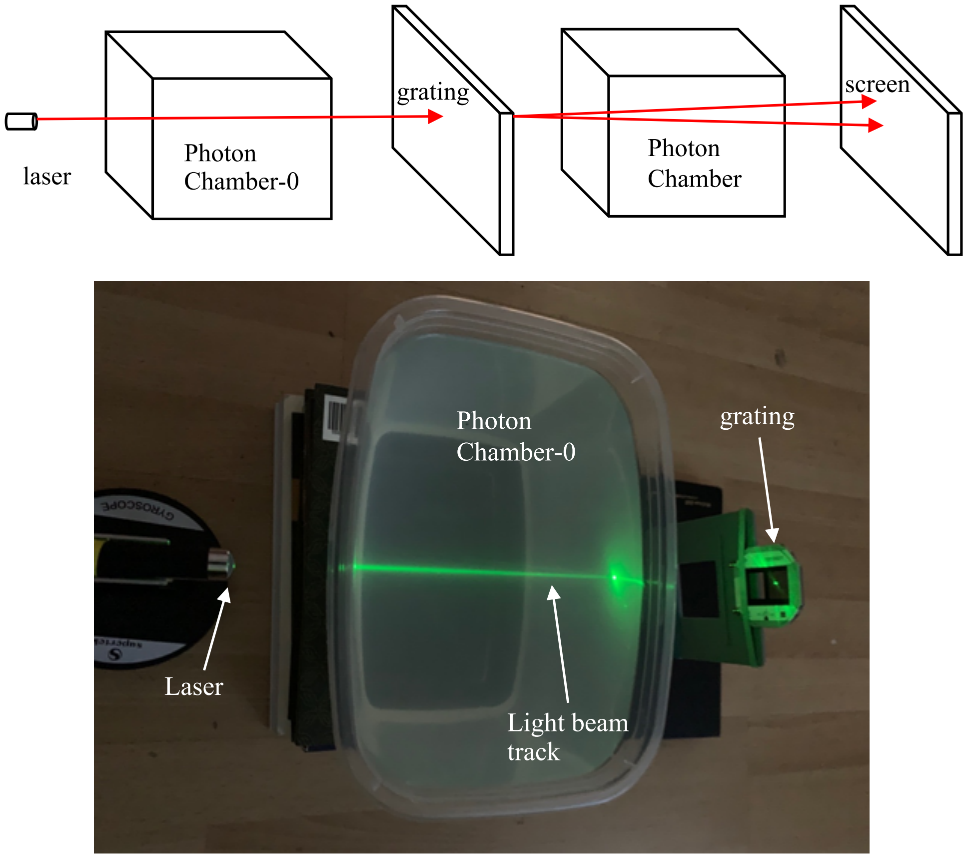


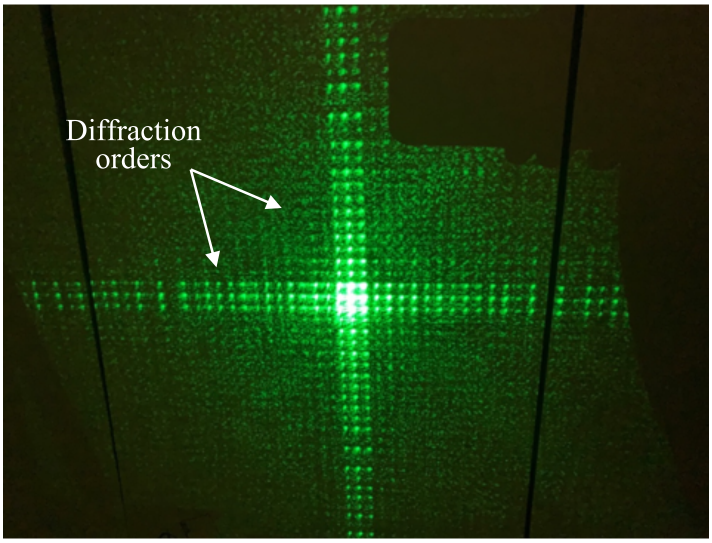
Figure 2. Experiment setup

The track of the laser light beam in Figure 2 indicates that the light beam behaves as particle, photons. Namely before passing through the grating, the light behaves as particle.

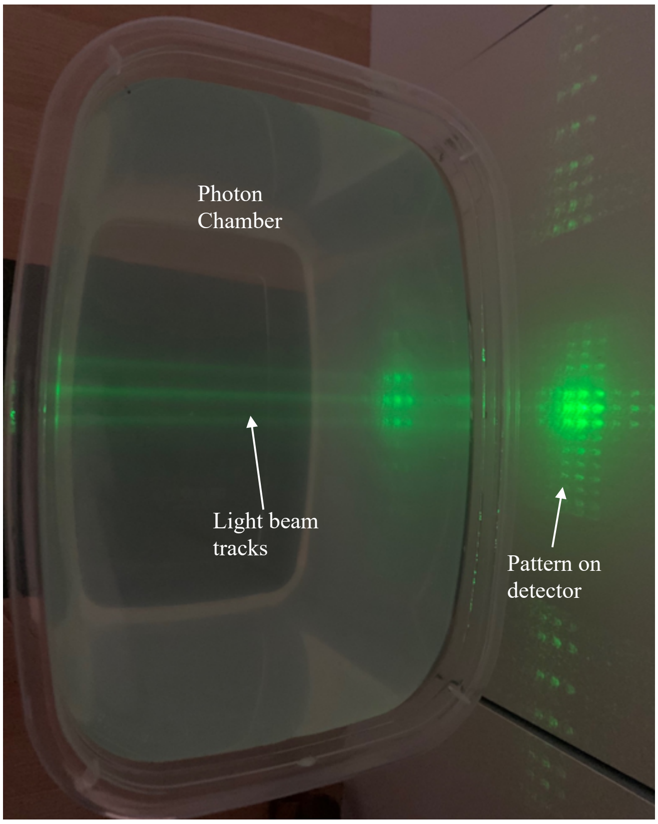
4. Applications: 2D-Grating Experiments

4.1. Grating Producing 2D-Diffraction Pattern: Light Behaves as Particles

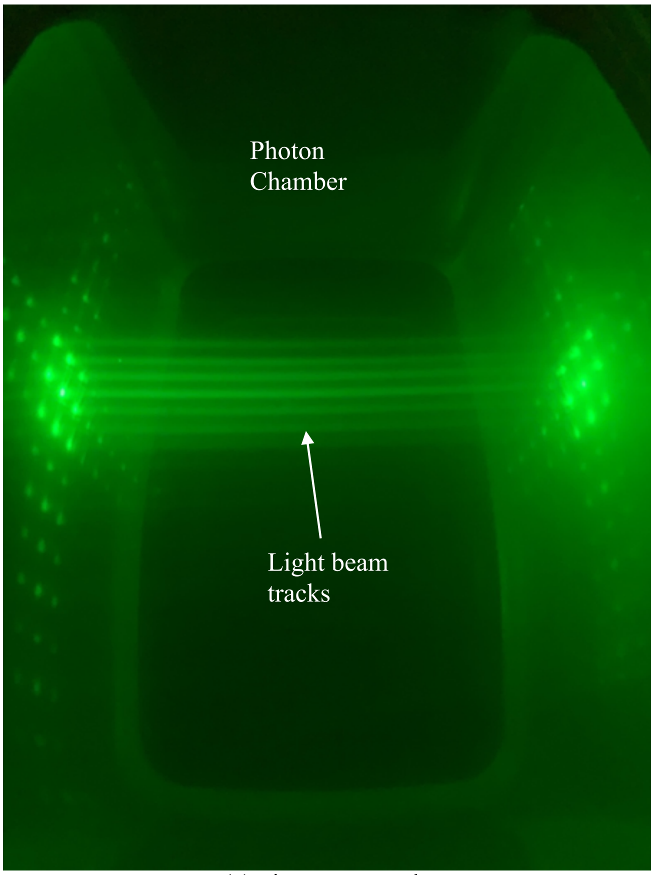
Experiment-1 (Figure 3,4): Figure 3a shows the diffraction pattern without the photon chamber.



(a)



(b) top view



(c) view at an angle

Figure 3. Diffraction pattern of 2D grating

Observation (Figure 3):

Figure 3a shows the 2D-diffraction pattern produced by the 2D-grating without the photon chamber. The pattern contains a large number of diffraction orders. It is a typical wave experiment.

The light beams pass through the left-side of the photon chamber, the chamber, and finally land on the screen and form the diffraction pattern.

Figure 3b is the top view, which shows the tracks of the laser beams inside the photon chamber. Figure 3c is the closer look at an angle. Each diffraction order on the left-side wall of the photon chamber corresponds a diffraction order on the right-side wall, and a light-track connects both orders.

We suggest that this experiment shows the challenge that the light beams pass through the photon chamber from the left-side to the right side behaving as particles, while the light beams distribute as waves on the lift-wall and the right-wall of the photon chamber, and finally form the diffraction pattern on the detecting screen.

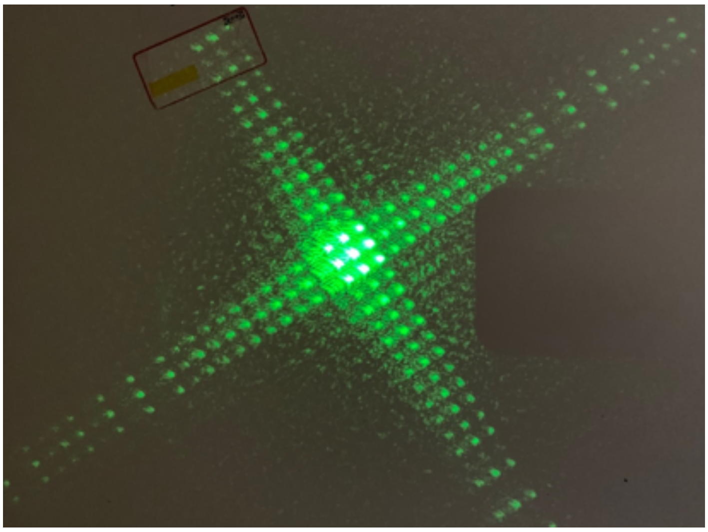
4.2. Tilt Grating Producing 2D-Diffraction Pattern: Light Behaves as Particles

Experiment-2 (Figure 4):

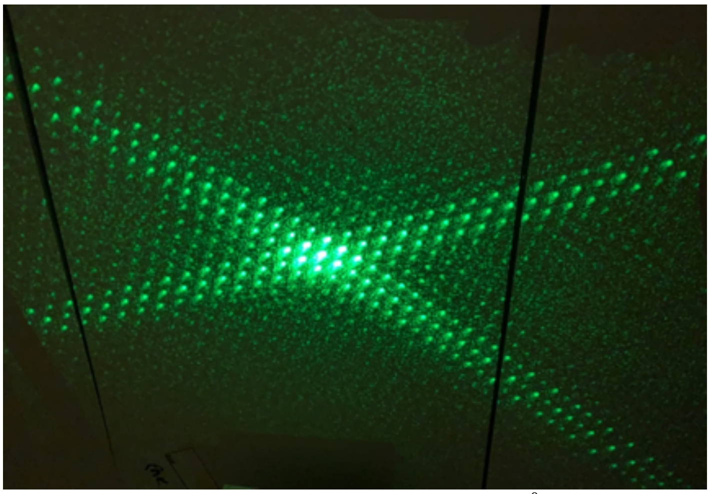
Observations: Figure 4a shows the diffraction pattern of the tilt grating without the photon chamber.

Figure 4b shows the diffraction pattern of the tilt grating CW rotating 30^0 without a photon chamber. The diffraction pattern is curved [7].

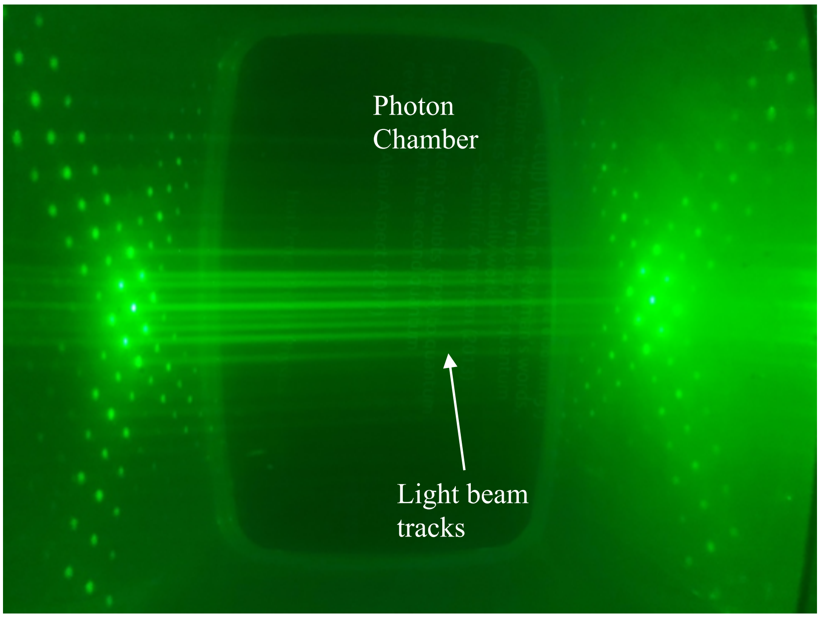
Figure 4c and 4d show the diffraction patterns of the tilt grating CW rotating 30^0 within the photon chamber. The pictures are taken from different angle.



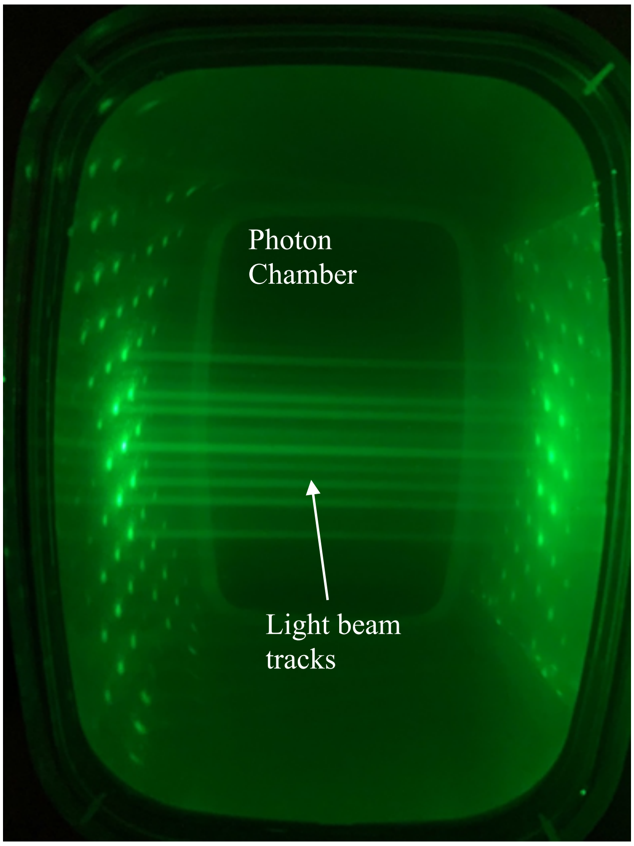
(a) Pattern of tilt grating



(b) Pattern of tilt grating CW rotating 30^0



(c) Tracks of light beam in photon chamber

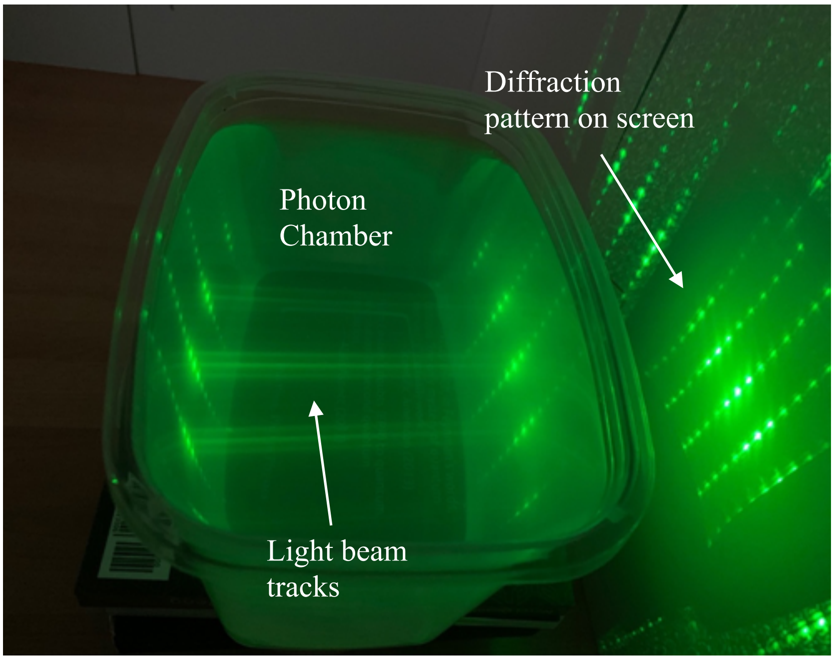


(d) Tracks of light beam in photon chamber

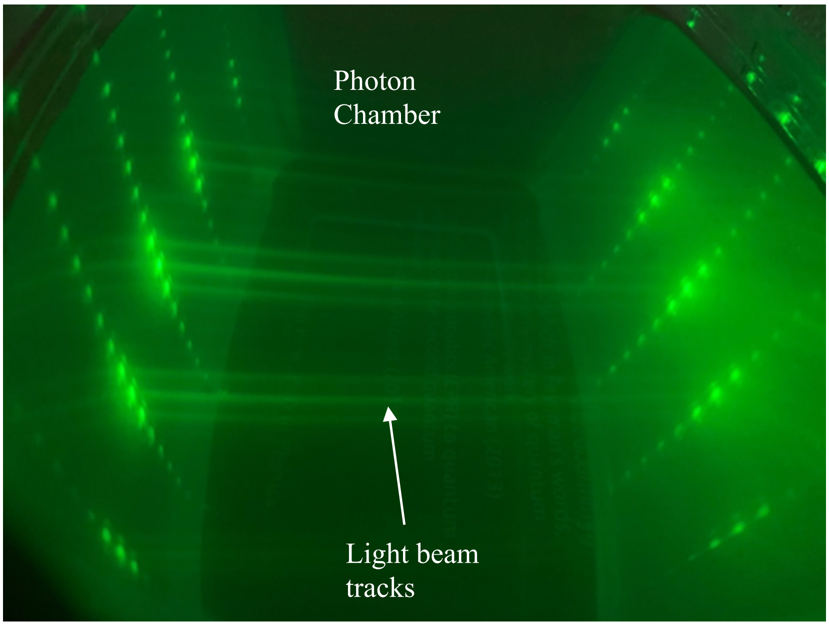
Figure 4. Tracks of light beams in 2D-grating experiments

4.3. Samples of 2D-Grating Producing Diffraction Pattern: Light Behaves as Particles

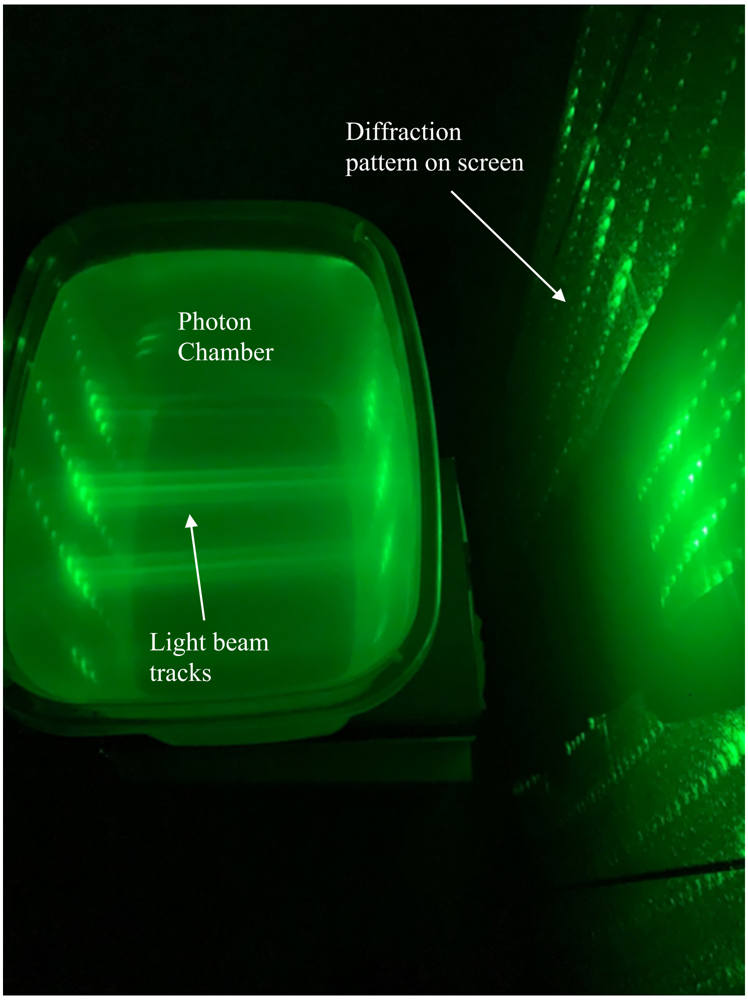
Next are some examples of the tracks shown in the photon chamber during the 2D-grating experiments.



(a) Tracks of light beam in photon chamber



(b) Tracks of light beam in photon chamber



(c) Tracks of light beam in photon chamber

Figure 5. Tracks of Multi light beams passing through photon chamber

Observation (Figure 5): Tracks of multi light beams passing through the photon chamber is observed.

5. Summary

In this article we utilize the photon chamber to detect the traces of the light beam in the 2D-grating experiments, namely to visualize the passage of light beam.

The wave-particle duality states that the light may be described either as a particle (as photons in photoelectric effect) or as waves (as an electromagnetic wave in all wave experiments).

Bohr's complementarity principle (the One of the milestones of quantum mechanics) states that a single quantum can exhibit a particle-like or a wave-like behavior, but never both at the same time. These are mutually exclusive and complementary aspects of the quantum system.

In this article we show that: the 2D-grating diffraction experiments are well described mathematically by wave theories, but the light behaves as particles (shown by the photon chamber) simultaneously in the same experiment. Thus, the grating experiment violates both the wave-particle duality and the Bohr's complementarity principle.

The Photon chamber experiments suggest:

(1) the light may be described as a particle (for example, in the Photon chamber, and the photon chamber may be placed anywhere between the grating and the screen and between the laser source and the grating) and as waves (as distribute on the detecting screen) in the same grating experiment.

(2) a single quantum can exhibit both a particle-like and a wave-like behavior, at the same time.

(3) The challenge is to explain physically the fact that the light beams behave as photons, while still distribute as waves on the screen.

The photon chamber is very inexpensive and easy to be home-made and thus, can be utilized to study the nature/behavior of the light.

Reference

[1] Einstein, A. "On a Heuristic Viewpoint Concerning the Production and Transformation of Light". Ann. der Physik 2006 **322** (6): 132–148, 1905.

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

[3] N. Das Gupta and S. K. Ghosh, "A Report on the Wilson Cloud Chamber and its Applications in Physics". Reviews of Modern Physics. **18** (2): 225-365, DOI:10.1103/RevModPhys.18.225, *1946.*

[4] Donald A. Glaser, "Some Effects of Ionizing Radiation on the Formation of Bubbles in Liquids". Physical Review. 87 (4): 665. DOI:10.1103/PhysRev.87.665, 1952.

[5] Carl D. Anderson, "The Positive Electron". *Physical Review* 43 (6): 491–494. DOI:10.1103/PhysRev.43.491, 1933.

[6] Hui Peng, peng, hui (2022): Photon Chamber --- Showing Particle Nature of Light in 1D-Grating Experiments. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.20045858.v1

[7] Hui Peng, "Non-Uniform Diffraction Pattern of 2D-Cross-Grating ---Rotating Grating Around Three Axes. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.19172846.v1, Feb. 2022.