Advances in Computer, Signals and Systems (2021) 5: 10-13
Clausius Scientific Press, Canada
DOI: 10.23977/acss.2021.050203
ISSN 2371-8838

Early Studies of Quantum Mechanics

Yuxin Zhang

Jiangsu Tian Yi High School, Wuxi, Jiangsu, China

Keywords: Quantum mechanics, Wave-particle duality of light, Photoelectric effect, Two-slit experiment, The de broglie relations, Quantum superposition

Abstract: The origin of light research is very early, but the understanding of the nature of light has gone through a long process. Is light a wave or a particle? From the beginning of the seventeenth century to the end of the wave-particle duality of light in the early twentieth century, a total of more than three hundred years. It was this debate that propelled the development of science and led to the birth of quantum mechanics, the great achievement of physics in the 20th century. Thus during this part, it will mainly cover the development of the wave-partivle duailty of light and some specific experiments which directly relates to it.

1. Introduction

It has been long discussed whether the light is made of the particles or waves. It was not until 1905 that scientist first mentioned that indeed, light has both the traits of the wave but also the particle. In this part, I will discuss some specific experiments to prove this idea such as the photoelectric effect, which confirms that light has something ro to with the particles. And also in the two-silt experiment, it is shown that light has the trait of the waves. So it appears that there may be some relationship that closely connected the particle and the waves, and this will be specific discussed in the de Brogile relation part.

2. Photoelectric Effect

The photoelectric effect means that under the irradiation of electromagnetic wave of a certain frequency, the electrons inside absorb energy from the light and then escape from the mental to form an electric current, that is, the light generates electricity. When the wavelength of light is less than a certain value, electrons can be emitted, that is, the limit wavelength, and the corresponding optical frequency is called the limit frequency. The critical value depends on the metal material, and the energy of the emitted electrons depends on the wavelength of the light and is independent of the intensity of the light, which cannot be explained by the fluctuations of the light. Another paradox here is the transient nature of the photoelectric effect: according to the wave theory, electrons in a metal accumulate enough energy to fly off the surface of a metal if the incident light is weak and lasts longer. [1]

3. The Formula Needs to Solve the Photoelectric Effect

E=hv

In quantum theory, E= HV is an axiom that can be verified but cannot be proved. The mystery of Planck's quantum could be revealed if a more fundamental hypothesis were proposed, and the axiom proved or deduced physically.

E=hv-W

hv is the energy of the light that irradiate metal, and the inner h is the frequency of the light, simply the higher the frequency of the light, the greater the energy carried. And W0 is the work function of the electron. That is, in the metal, the free electron is bound by the attraction of the nucleus, and you have to give it a certain amount of energy in order for it to break free of the nucleus and a beam of light hits a piece of metal, light; Frequency is v, we know that hv is the energy of a photon, namely the minimum of the light energy, metal electrons must get rid of the bondage of the nucleus fly out of the metal surface will need to absorb energy, and the absorption of a photon, but if the photon energy is not enough to make electronic fly out of the metal surface, electronic fly not to come out, then we can't see a photoelectron. If the energy is greater than the required energy , the photoelectric effect occurs and the excess energy is converted into the kinetic energy of the photoelectron.

Ek=eUc

According to Einstein's photoelectric effect experiment, the photoelectrons come out and enter the circuit. When the voltage of the external circuit is adjusted to a certain value, the electrons cannot enter the circuit. So the work done by the electron to go to the negative. That's exactly the same thing as the kinetic energy coming out of the electron. Ek is the kinetic energy coming out of the photoelectron. E is the amount of charge on the electron, and Uc is the cutoff voltage.

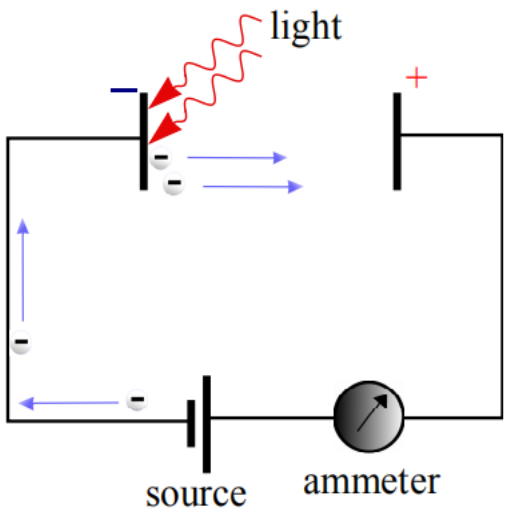

Fig.1 Specific Experiment about the Photoelectric Effect

Here is the photoelectric effect device. A power supply connects the two components

The metal. They are charged (electrons are moved), but no net current flows through them Circuit. This changes when light strikes a negatively charged sheet of metal. At least: If the frequency of the light is high enough, it can detach electrons from the metal/ Go through the gap and get to the other side. This will cause the current to flow as detected. Current meter. On the other hand, if the frequency is too low, nothing will happen.

4. Two-Slit Experiment

Double-slit interference refers to the phenomenon that parallel monochromatic light is projected onto a baffle with two slits, the slits are close together, the light waves of parallel light are transmitted to the slits at the same time, and become two wave sources (called coherent wave sources) whose vibration condition is always the same, and their light is superposition with each other in the space behind the baffle.

5. The Related Formula to the Two-Slit Experiment

$\Delta x = \lambda D/d$

X is the distance between two adjacent light (or dark) stripes, L is the distance between the two slits to the screen, D is the distance between the slits, λ is the wavelength of light

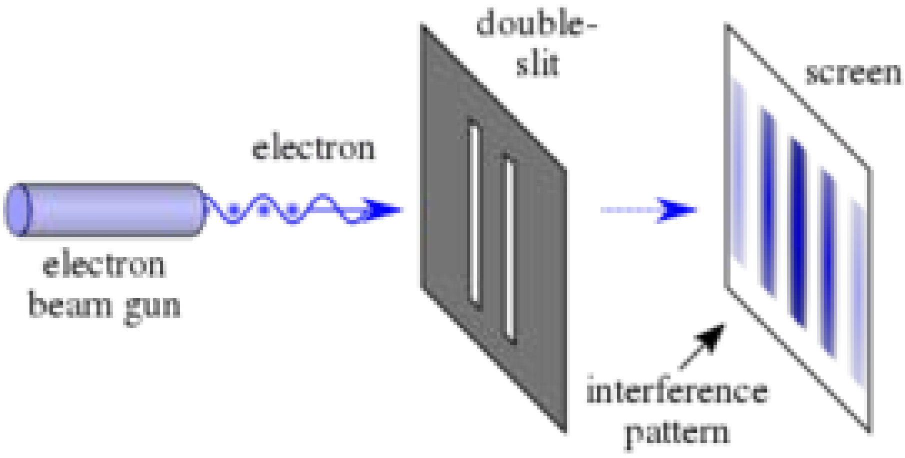

Fig.2 Specific Two-Silt Experiment

6. Wave-Particle Duality of Light

During this experiment, initially, Innocently, you think of two very narrow, bright stripes, very close to each other. Strangely, that's not what you see. Instead, you'll see a series of bright and dark stripes alternating. These bands are exactly what you see when waves produce interference patterns. [2]

7. The de Broglie Relations

DE Broglie proposed in 1924 that microscopic particles also have volatility, and based on the relationship between light waves and photons, he linked the particle properties of microscopic particles (energy E and momentum P) and wave properties (frequency and wavelength) with the so-called DE Broglie relationship.

8. The Importance of the de Broglie Relations

DE Broglie's theory scientists can accept the theory that all matter has waves. All matter is as volatile as the photon and electrons discovered by scientists. It's a big step in the human mind.

9. Wave-Particle Duality of Light

It means that light has both wave and particle properties. Scientists have found that light can both travel forward like a wave and sometimes behave like a particle. Hence we call light "wave-particle duality". The essay above shows how those two experiments respectively show that the light has both qualities of the particle and also the wave, and we can also use the de Broglie relations to connect the two traits.

10. Quantum superposition

The superposition principle of states is the most basic principle in quantum mechanics. Its correctness cannot be derived from any mathematical theorem or formula, but can only be verified by practice.

Suppose the system has a set of self-contained set functions {φi}, i =1, 2...T, then the system of state | φ >, can by this group of a linear combination of the state function, and below is a specific experiment which can better help understand this idea.

11. Conclusion

Based on the photoelectric effect, two-slit experiment, The de Broglie relations, scientists gradually find.

The truth behind the mystery. Wave-particle duality is an important concept in quantum mechanics. In classical mechanics, the objects of study are always clearly divided into two classes: waves and particles. A typical example of the former is light, while the latter constitutes what we call "matter". In 1905, Einstein proposed a quantum interpretation of the photoelectric effect, and people began to realize that light waves had both the properties of waves and particles. In 1924, DE Broglie proposed the "wave of matter" hypothesis, believing that, like light, all matter has wave-particle duality. According to this hypothesis, electrons can also have fluctuations such as interference and diffraction, which was later confirmed by electron diffraction experiments. Because the microscopic particles have wave-particle duality, the motion law of the microscopic particles is different from the motion law of the macroscopic objects, and the quantum mechanics describing the motion law of the microscopic particles is also different from the classical mechanics describing the motion law of the macroscopic objects.

References

[1] John A Wheeler.At Home in the Universe, pp.112, 1994.

[2] Florian Kaiser, Thomas Coudreau, Pérola Milman, Daniel B. Ostrowsky, Sébastien Tanzilli(2012),Entanglement-Enabled Delayed-Choice Experiment,[online] Available:http://science.sciencemag.org/content/338/6107/637