Observer Effect and Hidden Variables

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Abstract

In modern physics, it is assumed that all particles have both corpuscular and wave properties. The double slit experiment shows that when the properties of a particle are measured, it inexplicably turns into a particle that has no wave properties, i.e. it loses its duality. The analysis of the experiment shows that any particle performs many different motions at the same time. Chaotic thermal fluctuations, part of which is in the transverse direction, zitterbewegung [1] and longitudinal movement (drift) in the direction of the slit. The measuring instrument cancels the transverse oscillations, so the interference pattern fades.

Keywords: physics, QM, double slit experiment, observer effect, zitterbewegung, interference, philosophy, chemistry

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01.55.+b General physics; 03.65.-w Quantum mechanics; 03.65.Ta Foundations of quantum mechanics; measurement theory; 03.75.-b Matter waves.

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Introduction

In modern physics, it is believed that the double-slit experiment proves that any particle is also a wave and can be in a state of superposition, i.e., can be in all possible states simultaneously. The evidence of this is an interference-like pattern that appears on the screen behind the double slit. Any attempt to measure the motion of the particles erases the interference pattern. This is the essence of the observer effect. Quantum mechanics (QM) cannot fully explain this. Below is an explanation of this phenomenon.

Facts of double-slit experiment

The principle of the double-slit experiment is shown in Figure 1.

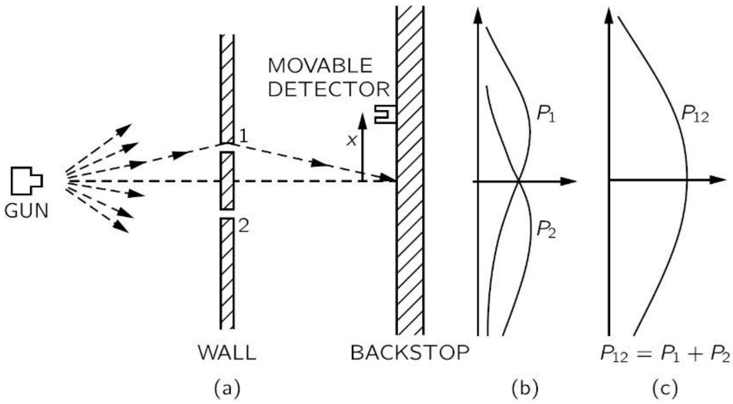

Figure from [4]

Fig.1. Double-slit experiment with bullets.
The setup of experiment (a), the pattern of hits through each slit (b)
and their sum (c).

The experiment revealed the following facts:

1. If only 1 electron is shot at the wall, then it passes through one of the slits and only 1 dot appears on the backstop. This is not unusual because an electron is indivisible and half an electron cannot pass through each of the slits.
2. If a beam of electrons is fired at the slits, then on the backstop the electrons form periodic groups that resemble an interference pattern of waves (Fig.2.). This phenomenon is considered by QM as evidence for the wave-like nature of particles.

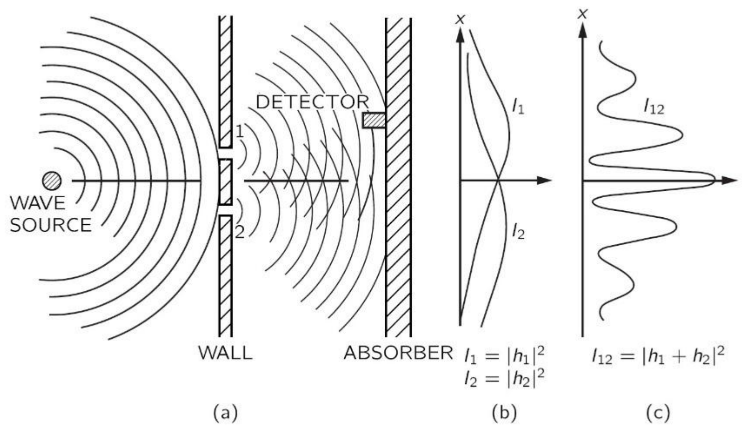

Figure from [4]

Fig.2. Double-slit experiment with waves.

The setup of experiment (a), the pattern of hits through each slit (b) and their sum (c).

3. If the electrons have to pass through the measuring instrument, the interference pattern disappears and a pattern similar to a normal distribution is seen on the absorber (Fig.1). This is an observer effect that is not observable in macroscopic measurements.
4. The same applies to photons.

Interpretation of the double-slit experiment in QM

There are many interpretations of the double slit experiment, but none of them fully explain it. Let's look at the main concepts.

1. Based on the de Broglie hypothesis, all particles are also waves, i.e., wave-particle duality [2].
2. These waves are described by the Schrödinger wave equation. This is the main equation of QM.
3. It follows from the Schrödinger equation that a particle can be in all possible states simultaneously. This is the principle of superposition. According to this principle, a single photon should also pass through both slits simultaneously, but this does not happen. The photon passes through only one slit and no interference pattern is observed.
4. The observer effect means that measurement leads to the collapse of the wave function.

So, when passing through two slits, these waves form an interference pattern. If two waves in antiphase meet, they cancel each other out. This explains the dark bands in the interference pattern. Electrons and other fermions cannot cancel each other out. QM does not explain this.

An alternative interpretation of the double-slit experiment.

Any measuring instrument has a greater or lesser effect on the object being measured. For example, when measuring voltage, part of the current flows through a voltmeter. If in classical physics the effect of the measuring instrument is negligible, then in QM it is significant. In this case, the peculiarities of the motion of electrons and other particles should be considered.

Elementary particles are in endless motion [5]. The main causes are heat (thermal movement), zitterbewegung as well as electric and magnetic fields (drift). It has been experimentally established [6] that an external electromagnetic field cancels out the oscillations of the zitterbewegung (Fig.3). This is the Observer Effect because an electron can only be measured with the help of an electric/magnetic or electromagnetic field.

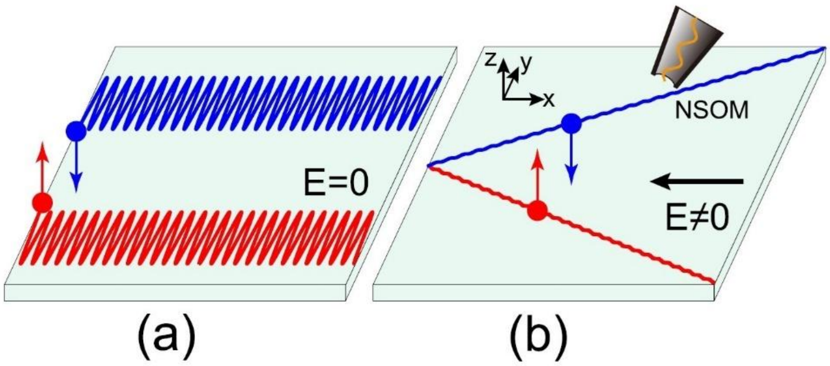

Figure from [6]

Fig.3. The Observer Effect.

Zitterbewegung oscillations for two electrons with opposite spins without (a) and with (b) an external electric field.

The oscillations of the Zitterbewegung are transverse to the direction of electron motion in the slits. Therefore, when the electrons exit the slits, they can collide and form groups that look like an interference pattern.

This applies to all elementary particles.

Conclusions

The formation of an interference-like pattern on a screen in a double-slit experiment does not prove the Wave-Particle hypothesis. To explain this, the zitterbewegung fluctuations are sufficient. QM does not take them into account.

Albert Einstein was right when he thought QM was incomplete.

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