About wave-particle duality

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Abstract

In contemporary physics a current Quantum Mechanics (QM) theory holds that all particles exhibit a wave nature and vice versa. However, the meaning or interpretation of this statement has not been satisfactorily resolved yet. According to the multispace conception [1] the force field and space are synonyms. Each particle has several force fields: electric, magnetic, gravity. Therefore the particle can be simultaneously in several spaces. So a photon in its own electric and magnetic spaces is a particle, but in the gravity space the photon is a wave. This phenomenon is intrinsic wave-particle duality. The scattering and collisions of fermions (electrons) can form a picture of distribution similar to wave interference. It is apparent wave-particle duality because fermions remain as lumps.

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01.55.+b General physics; 04. General relativity and gravitation; 03.50.-z Classical field theories; 12.10.-g Unified field theories and models

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Introduction

It is experimentally proved that the particle in some cases acts as a lump and in other cases it has wave behavior. The difficulties to explain wave-particle duality is best described by the words of Albert Einstein [2]:

“It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do.”

The slits through which photons or electrons pass are basic experiments for the investigation of wave-particle behavior. Another view on the experiments with particles is disclosed below.

One slit experiment

The beam of particles (usually photons or electrons) fall on the wall with a slit or a hole. The particles passing through the slit scatter and reach the screen in different amounts depending of the scattering angle (Fig. 1.).

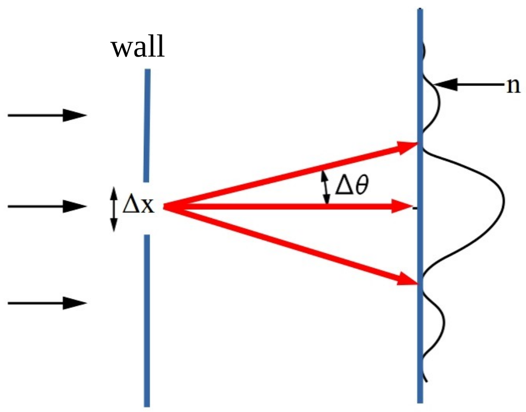

Fig. 1. One slit experiment [3].
Δx – width of slit or hole;
$\Delta\Theta$ – angle of scattering;
n – number of particles.

The angle of scattering depends on the width of a slit. For narrower slits the angle of scattering is wider. If the slit is wide, the angle of scattering is small. The problem is how to simultaneously measure the position and vertical momentum of the particle on the screen. The above-mentioned serves as the background to conclude that it is impossible to exactly measure the position and the momentum. Mathematically it is expressed in the Heisenberg uncertainty principle.

There are some assumptions which have not been taken into consideration. In other words, according to Einstein there are "hidden variables". The most important of them are facts that the slit is not perfect (Fig. 2), the wall has thickness, the surface of the slit has roughness, etc.

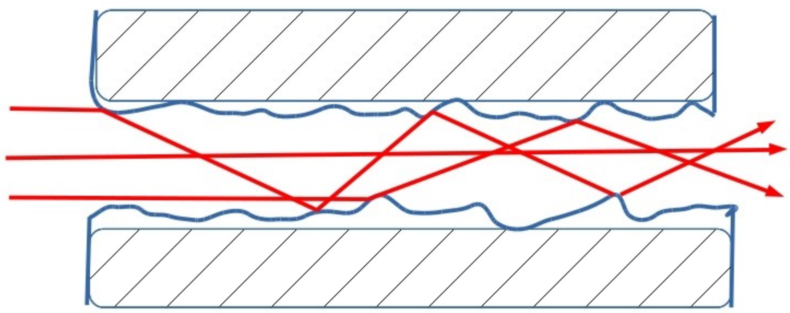

Fig. 2. Path of particles through slit.

The particles scatter from the walls of the slit. If the slit is wide, the majority of the particles go straight. If the slit is narrow, the majority of the particles scatter from the walls and spread widely on the screen.

Double slit experiment

There are two slits close to each other and a gun which shoots bullets (electrons). When one slit is closed (Fig. 3.), the bullets are distributed by probability P_1. When slit

2 is closed, the bullets are distributed by probability P_2. When both slits are open, they give the sum of probabilities P_{12}. When a beam of electrons is used, a more complicated picture of distribution is obtained (see Fig. 1). It is similar to interference of waves.

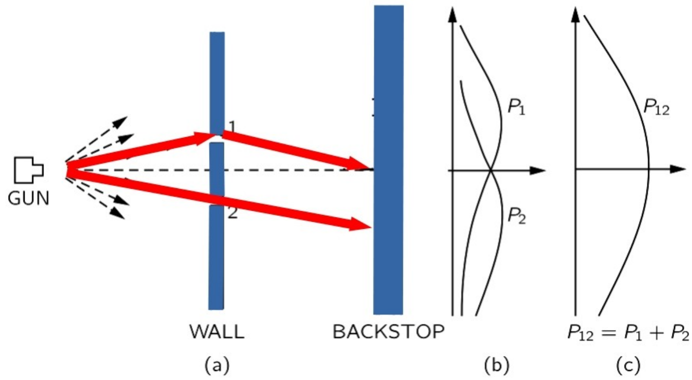

Fig. 3. Two slit experiment with bullets [4].
P_1 – probability of distribution through slit 1.
P_2 – probability of distribution through slit2.
P_{12} – sum of probabilities.

Usually the above phenomenon is explained by wave properties of electrons and other particles. This explanation is not consistent because electrons cannot be in the opposite phase like waves and they cannot compensate each other.

A similar phenomenon is observed in the desert, where the wind blows sand into a wavy structure. It is the result of sand-grain collisions. This does not mean that the grains of sand are waves. This suggests that electron collisions lead to the wavy structure of the probability pattern on the screen (backstop). The probability pattern similarly to sand dunes can be described in terms of the wave theory. They are apparent waves.

Conclusions

There are two different cases of particle behaviour, i.e., intrinsic and apparent wave-particle duality. The bosons (photons) are wave packets and in the gravity (ordinary) space they are waves but in its own (electromagnetic) space they are particles. This is intrinsic wave-particle duality. The fermions (electrons, protons etc.) are particles. The scattering and collisions of electrons in the double slit experiment show the distribution of electrons similar to wave interference. It can be described as waves. However, it does not mean that fermions are waves. This is apparent wave-particle duality.

References

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