Journal of Applied Mathematics and Physics, 2018, 6, 2461-2467
http://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

Particles Actually Represent the Names of Types of Waves

Marat Vladimirovich Guryev

Shipilovskaya Street, 62/1-172, 115682, Moscow, Russia
Email: mvguryev@mail.ru

How to cite this paper: Guryev, M.V. (2018) Particles Actually Represent the Names of Types of Waves. *Journal of Applied Mathematics and Physics*, **6**, 2461-2467.
https://doi.org/10.4236/jamp.2018.612207

Received: September 27, 2018
Accepted: December 4, 2018
Published: December 7, 2018

Abstract

It is accepted that quantum mechanics (QM) describes motion of waves and particles. Therefore, we must use wave-particle duality (WPD), which is usually considered as one of the foundations of QM; however, WPD is well known as a self-contradictory concept. These contradictions insensibly spoil our subconscious thinking about the micro-world (MW). This article shows that known trials to solve these contradictions are erroneous. Quantum jumps (QJs) are shown to be very lame arguments for the real existence of particles. I offer rejecting the concept of particles and using their names as labels for types of corresponding waves. Thus, we can discard contradictions created by WPD. This approach is validated in the article by careful analysis of real calculation methods of quantum electrodynamics (QED). For the first time, it is noticed that proper 4-coordinates of particles are not in use in real calculations in QED. This implies that particles do not take part in real calculations, which describe properties of atoms and molecules. It follows that particles do not exist as such. Therefore, we must acknowledge that we actually use the names of "particles" merely as names of types of given waves, but not as real, physical objects.

Keywords

Particles, Quantum Jumps, Quantization, 4-Coordinates of a Particle, Quantum Electrodynamics, Wave Function

1. Introduction

It is generally accepted that quantum mechanics (QM) describes motion of waves and particles within micro-world. Therefore, we must use in practice wave-particle duality (WPD). The concept of WPD is usually considered as one of the foundations of QM. We will consider the standard modern concept of

WPD, which requires that we describe quantum-scale objects using both theoretical methods—wave mechanics and the classical approach—jointly. WPD states that it is impossible to describe separately any quantum entities as particles or waves. WPD was created 100 years ago and QM has changed for this time. Therefore, it is useful to reconsider so old assertions. It is possible to say that WPD actually was created in order to introduce classical concept of particle into verbal interpretation QM.

The reader should keep in mind that we are only considering interpretation of QM because WPD is a part of the interpretation of QM but not of the exact calculation methods. Therefore, the result of our consideration of WPD will exclusively influence on our subconscious thinking, which depends mainly on interpretation.

It is necessary to consider two quite different known approaches to the interpretation of fundamental problems of QM. First, we cite the generally accepted approach from a well-known textbook [1]: "Here, 'to understand' does not mean just the mastery of the mathematical formalism, but rather an understanding within the framework of our conceptual ideas acquired on the basis of classical and nonrelativistic phenomena". We should acknowledge that, in this quotation, the term "understanding" describes pleasant intellectual feelings and words but not exact results. This approach is convenient for amateurs in QM, which are not qualified enough for real calculations within QM.

Second, there is the approach by which we describe Nature by exactly calculated physical quantities and compare them with the results of corresponding measurements. This approach is in use in quantum electrodynamics (QED) for calculations of properties of atoms and molecules (see, e.g. [2]). It is worth noting that QED is the most precise theory developed by humankind. This direct approach, which is not so elegant as classical words in usual interpretation of WPD, will be the foundation of our work in the article. Therefore, we will use in this article the approach that is accepted in QED.

It is possible to say that we will require our interpretation to conform exactly to the calculation methods of atomic QED. In other words, we should acknowledge that we can actually only describe Nature but not explain it using elegant words from classical mechanics (CM). The matter is that there exists Ehrenfest's theorem, from which it follows that CM is merely approximated consequence from QM. As a result, our use of CM in WPD for explanation of the results of QM represents a tautology.

Therefore, it is no wonder that WPD is a self-contradictory concept. This is obvious from the well-known examples in the simplest case of the double-slit paradox, which is the standard example of these contradictions. We knew long ago about the existence of contradictions in WPD and have even become accustomed to them. Unfortunately, habitual contradictions in theory are harmful, because they insensibly spoil our subconscious thinking about the micro-world (MW).

A serious attempt was made to solve these contradictions in [3]. Unfortunately, in that case, all considerations were based on an ancient theory of destructive measurement in QM and the well-known Born's hypothesis that the wave function (WF) represents the amplitude of the probability density of a particle at a given point of the phase space. This hypothesis was recently disproved in [4]. Furthermore, destructive measurement theory was recently disproved in [5]. Therefore, we should not consider this type of trial seriously.

I offer a simple method for breaking free from the contradictions in WPD. In this approach, we should reject the concepts of particles and WPD and use the names of particles as names of WFs. For example, "electron" will be name of kind of all corresponding WFs that we use to describe atoms and molecules in QM. This method of describing particles changes only interpretation but changes nothing in the calculation methods of QM.

It is worth noting that, recently, Hobson reached the conclusion that "There are no particles, there are only fields" [6]. Unfortunately, he merely expounded the well-known contradictions in WPD in detail and offered to refuse particles. He did not noticed that there are generally accepted well-known arguments for the existence of particles together with waves. Therefore, we have no right to brush the concept of particles aside. We must carefully explain and validate the bold changes in the interpretation of QM that are offered here.

Recently, this issue was solved for photons [7]. Thus, the goal of this article is to prove that this approach exempts us from all types of the mentioned contradictions.

The remainder of the paper is organized as follows: Section 2 proves that quantum jumps (QJs) are lame arguments for the proof of existence of particles; Section 3 is devoted to a refutation of the known hypothesized connection between waves and particles; and Section 4 is devoted to a strict consideration of the difference between particles and waves. The replacement of "particles" for names of types of waves is validated in Section 5. Finally, Section 6 provides a brief conclusion.

2. Quantum Jumps Are Very Lame Arguments for Proof of Existence of Particles

The main argument for the existence of particles is the obvious existence of QJs at the transitions between states of quantum objects. A simple example in the usual description is as follows: We can ionize atoms by the corresponding light, and thus, obtain electrons with QJs and detect these electrons in the form of the QJs current pulse of the detector. Thus, for a long time, QJs have been interpreted as the arrival or departure of particles from an object. We will try to disprove this opinion.

We will proceed from the assumption that all the tried equations of QM describe physical reality but not our pleasant feelings. We should draw attention to the fact that QJs take place in the transitions of quantum objects if and only if at least one discrete state takes part in the transitions. This implies that transitions between continuous states represent the other kind of events, in contrast to transitions in which discrete states take part.

The transitions between continuous states have been well investigated. Accelerators and their exact theory have been known more than 50 years ago (see, e.g. [8]), as well as quantum collision theory (see, e.g. [9]). In all these cases, transitions take place between continuum states without QJs. We can say that there is no one report on QJs from the transitions between continuum states of atoms, molecules, or nuclei. Nobody has emphasized this fact until now.

If we accept that particles exist in QJs, we should acknowledge that they exist only in the case of transitions with the contribution of discrete states. This limitation has no physical reasons if we assume that QJs are the result of the motion of real particles.

We should acknowledge that QJs take place because there exists another mechanism of transitions between discrete states than soft transitions for continuous states. The truth is that soft description is principally impossible for transitions in which discrete states take part. QJs are the only possibility for describe exactly transitions where discrete states are involved.

Sometimes, the operation of quantization is considered as argument for the real existence of particles. I draw the reader's attention to the notion that we cannot use quantization (Q) as a proof of existence of particles. The issue is that we can apply Q to any mathematical expression, regardless of its physical meaning. This implies that Q has no definite physical meaning and is merely imitation of the explanation of QJs. I repeat that we must only describe Nature but not try to explain it by pleasant words based on CM. Therefore, the existence of jumps is not a proof of the existence of particles because a jump is merely an inevitable event at the transition from discrete states of objects up or down. This implies that the existence of QJs is very lame argument for the existence of particles.

3. Even though Particles Exist, They Are Not Connected with Waves

Now, we consider a direct argument against the existence of particles as physical objects. We know that the concept of particles contradicts that of waves. Otherwise, we must describe WPD as a unified theory, combined from the theory of wave motion and theory of motion of classical particles. Therefore, descriptions of "classical" and quantum motions as different parts in unified theory must be physically connected in the general description in the QM calculation methods.

We can say that the concept of WPD was conceived when physicists began to try to coordinate the concepts of waves and particles. Such attempts were made by Born, among others, who introduced following postulate into QM 90 years ago: WF represents the amplitude of the probability density of a particle to be at a given point of phase space. In such a way, well-known Born's postulate (BP) connects the concepts of waves and particles and gives reasons for acknowledging the reality of WPD. BP is now widely used as the general interpretation of WF in QM.

It was recently shown however, that WF is not the probability density of any particle [4]. This implies that real waves and their real particles (if they exist) are not connected at all. Therefore, we have to say now that there is no definite connection between the real properties of WF and particles. Such connections may exist if and only if WPD actually exists. Thus, we should acknowledge that WPD does not exist in reality. However, we use both terms in our physical texts associated with real calculations—particle and wave! Therefore, we need to take the step described in the next section.

4. About Differences between Waves and Particles in Reality

The overwhelming majority of physicists are sure that they know everything about the difference between waves and particles. However, real definitions of these concepts are not simple. Here, we carefully investigate the physical meaning of the terms "wave" and "particle", which we use in practice. To accomplish this, we must carefully refine the concepts of particle and wave in interpretation in modern QM. In the simplest case of point particle, it is an object, which we can fully describe by the value of its coordinate 4-vector and momentum 4-vector. A real particle has only its proper 4-coordinates and depends on them directly without the participation of any intermediate functions.

In contrast to particles, we must describe any waves by the value of definite WF, which depends on value of 4-vector in given point of phase space. WF is just some function that represents a solution of some wave equation. The solutions of Dirac's equations are in routine use as null approximations to atomic WFs within atomic QED. Arguments of WF represent values of 4-coordinates in a given point of phase space and at some values of 4-momenta. This implies that WF within QM is always some function of4-vector.It is clear that the term "wave" denotes a more complicated object than the term "particle" does. Thereto we must note that, accordingly, working with waves requires higher qualifications than working with particles does.

Real calculations in atomic QED are generally complicated. Therefore, we should choose for our consideration the most definite part of the calculation methods in QED. The issue is that complicated calculation methods can be different in subjective details. The final part of any calculation approach is usually (but not always) the matrix element (ME) of the amplitude of probability of any transition in the MW object. We must remember that value of such ME strictly determines the calculated real value of the transition probability (TP), which must coincide with the measured value of TP. Any such ME does not depend on the details of the intermediate stage of calculations, as only this ME is strictly determined by the initial and final states of the object of study and corresponding operators. Investigating such an ME gives us the opportunity to unambiguously examine the roles of particles and waves in its creation.

I draw the reader's attention to what we often say or write, as follows: This WF describes a given particle, and we can say that electrons or any other particles interact, and so on. It is the last step to replace "particles" with names of types of waves in the general case.

5. Proof That "Particles" Are Merely Names of Types of Waves

In this section, we will first use the habitual terminology, but gradually, we will understand that our term "electron" is merely the name of a type of wave. Let us look at the expression for some final matrix element in a serious textbook on QED [10]. We will consider the simple case from this book: The scattering of an electron by an electron, in which these two electrons collide with 4-momenta p_1 and p_2 and emerge with 4-momenta p_1 and p_2. We will use relativistic units.

We can say that our quantum object (pair of electrons) transits from the initial state to the final one. The matrix element for this elastic scattering, which describes transition of our object from initial into the final state, is

$$M_{fi} = 4\pi e^2 \left\{ \frac{1}{t} \left(\overline{\psi}^*_2 \gamma^\mu \psi_2 \right) \left(\overline{\psi}^*_1 \gamma_\mu \psi_1 \right) - \frac{1}{u} \left(\overline{\psi}^*_1 \gamma^\mu \psi_2 \right) \left(\overline{\psi}^*_2 \gamma_\mu \psi_1 \right) \right\}. \quad (1)$$

Here, $t = \left(p_1 - p_1^* \right)^2$, $u = \left(p_1 - p_2^* \right)^2$, $\psi_1 \equiv \psi_1 \left(\mathbf{r}, \mathbf{k}, t \right)$, and $\psi_2 \equiv \psi_2 \left(\mathbf{r}, \mathbf{k}, t \right)$ are WF of interacting electrons, and all γ are Dirac's matrixes, which describe the interaction between electrons. These WFs are solutions of appropriate Dirac's equation. They are functions of 4-vectors of coordinates and depend on 4-vectors of momenta.

We do not see in expression (1) any direct dependence of M_{fi} on 4-coordinates without the intermediate participation of WF. This implies that we do not see participation of any particles in Equation (1), which is a simple expression for typical ME. Reading any textbook or paper on atomic or molecular QED, the reader can ascertain that this result is actually general for any ME in this field.

We should acknowledge that we truly describe all the particles by 4-coordinates inside intermediate WF but not by proper 4-coordinates of these particles. We would see proper coordinates in Equation (1) if and only if there are electrons existing as real particles but not words. What types of things are these electrons that do not have their proper coordinates? Such electrons can only be words but not real physical objects as particles. Nevertheless, we use these words (just words) in real calculations in QED. This use is convenient and habitual.

Now, we can make the final step and acknowledge that our usual "particles" represent merely the names of types of waves. If we understand this simple fact on a subconscious level, we will free ourselves of our thinking about the role of WPD contradictions. It is obvious that the new interpretation of particles relates to all definite physical objects of MW.

Let us note, incidentally, that in using this classification, we should acknowledge that all waves relevant to one type are undistinguishable in principle because there are no reasons for the differences between them. Waves of one type are solutions of the same wave equation. Thus, we no longer need the well-known special postulates about the identity of objects with the same type of wave.

6. Conclusions

We have proved that particles in QM are merely habitual words. We offer to acknowledge that we use these habitual words as names of types of different waves, which are in consideration within QM. This implies that we must delete only the physical concepts of particles. At this point, we can work with terms of particles, keeping in mind that these terms are the names of types of waves, not physical objects.

Replacement of particles for names of waves exempts us not only from the old double-slit paradox in QM; it also frees us of our erroneous subconscious thinking about WPD as a whole. It is clear and extremely important that this achievement also relates to relativistic QM in the general case, apparently without restrictions. Incidentally, we have proved a known postulate of QM that waves with the same name for their type are moreover indistinguishable.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Schwabl, F. (2007) Quantum Mechanics. 4th Edition, Springer, Berlin, Heidelberg, New York, 369.

[2] Grant, I.P. (2007) Relativistic Quantum Theory of Atoms and Molecules. Springer Science+Business Media, New York. https://doi.org/10.1007/978-0-387-35069-1

[3] Cohen-Tannoudji, C., Diu, B. and Laloe, F. (1977) Quantum Mechanics, v.1. John Wiley and Sons, Inc., Paris.

[4] Guryev, M.V. (2017) Wave Function Is Not Amplitude of Probability Density. *American Journal of Modern Physics*, **6**, 49-50. https://doi.org/10.11648/j.ajmp.20170604.11

[5] Guryev, M. (2017) The "Non-Locality" of Entangled States Is Seeming Phenomenon. *Journal of Applied Mathematics and Physics*, **5**, 1791-1976.

[6] Hobson, A. (2013) There Are No Particles, There Are Only Fields. *American Journal of Physics*, **81**, 211-223. https://doi.org/10.1119/1.4789885

[7] Guryev, M.V. (2018) Photon Is Shortened Name for Electromagnetic Field but Not a Particle. *Journal of Applied Mathematics and Physics*, **6**, 1883-1885.

[8] Edwards, D.A. and Syphers, M.J. (1983) An Introduction to the Physics of High Energy Accelerators. Wiley Series in Beam Physics, John Wiley and Sons, Hoboken.

[9] Joachain, C.J. (1983) Quantum Collision Theory. 3rd Edition, North-Holland Physics Publishing, Amsterdam.

[10] Berestetskii, V.B., Lifshitz, E.M. and Pitaevskii, L.P. (1982) Quantum Electrodynamics, Elsevier Ltd., Amsterdam.