Many-worlds interpretation of quantum mechanics and wave-particle dualism.

Bezverkhniy Volodymyr Dmytrovych.

Ukraine, e-mail: bezvold@ukr.net

Abstract: Based on the wave-particle duality and the principle of quantum superposition, it is shown that an elementary particle is an oscillator in which a periodic process of energy conversion takes place. Then, the transition from particle to wave, that is, the transition from one quantum state to another, is a simple change in the oscillator when the frame of reference is changed. Consequently, the many-worlds interpretation of quantum mechanics does not make sense, since there is one real Universe with elementary particles exhibiting wave and corpuscular properties.

Keywords: Wave-particle duality, principle of quantum superposition, de Broglie oscillations, de Broglie interval wave, Einstein's field equations, many-worlds interpretation of quantum mechanics.

INTRODUCTION.

All interpretations of quantum mechanics are based on the explanation of the wave-particle dualism of microparticles. Indeed, when a microparticle, for example, an electron, passes through two slits, in order to calculate the place of its hitting the screen, it is necessary to assume that it is not a point particle that passes through the slits, but a certain wave of matter. On the other hand, the photoeffect and the Compton effect can be explained only on the basis of the assumption that light, that is, an electromagnetic wave, is a stream of corpuscles.

Thus, it follows from the corresponding experiments that any microparticle of matter, or a physical field, depending on the conditions of the experiment, can behave like a point particle or a wave. Explaining this transition from corpuscular to wave behavior is the essence of any interpretation of quantum mechanics. Further, we will also explain this transition, taking into account the principle of quantum superposition. But, to begin with, let's recall how de Broglie came to the wave description of microparticles, since this is of fundamental importance for understanding.

Louis de Broglie suggested that for the electron, as for any elementary particle, there is a certain periodic process that occurs with a certain frequency [1]:

"…In quantum theory, I assumed that there is a periodic process associated with the electron as a whole (the material point). This process for an observer stationary relative to an electron would occur over the whole space with the same phase...".

De Broglie asked the question: if a periodic process is associated with an electron, what will an external observer see?

Reflecting on this question, he realized: an outside observer will see a wave! This is how de Broglie waves were discovered.

Consequently, the de Broglie wave is the internal vibrations of elementary particles that are seen by an external observer. And the wave and corpuscular properties are the experimental registration of these vibrations under certain conditions. That is, an elementary particle is not a corpuscle, and not a wave, but a more complex system, which, in fact, is an oscillator, and in which kinetic and potential energies pass into each other with a certain frequency. It is for this reason that a corpuscle and a wave cannot exist simultaneously, which expresses the principle of complementarity.

"…According to this principle, for a complete description of quantum-mechanical phenomena, it is necessary to use two mutually exclusive ("additional") sets of classical concepts, which provide comprehensive information about the phenomena as integral.

For example, additional in quantum mechanics are space-time and energy-impulse patterns.

Descriptions of any physical object as particles and as waves complement each other, one without the other is meaningless, the corpuscular and wave aspects of the description must necessarily be included in the description of physical reality...

In principle, the states of a physical system are impossible, in which mutually complementary quantities had at the same time precisely defined values..." [2].

RESULTS AND DISCUSSION.

Next, we will give two quotes: the first provides an analysis of the wave-particle duality of microparticles from the point of view of the principle of quantum superposition, and the second shows the relationship between the momentum of a microparticle and an interval. These quotations are sufficient for a physical interpretation of quantum mechanics.

"...From the experiment with double slits it follows unequivocally that an electron (or a photon, or any other elementary particle) can manifest itself both as a particle and as a wave, and this is an experimental fact. But it should be understood that the same electron (or photon) cannot simultaneously be a particle and a wave, it follows logically from the principle of quantum superposition and the very essence of quantum mechanics [1, 2]...

Consider an electron that can sometimes manifest itself as a particle (1 quantum state), and sometimes it can manifest itself as a wave (2 quantum state) and apply the quantum superposition principle.

To understand the principle of quantum superposition, we quote citation [3]:

“For example, consider two quantum states (actually existing) are described by wave functions $\psi1$ and $\psi2$. From the principle of superposition [1, p. 21] it should be clearly, that their linear combination ($\psi3 = C1\psi1 + C2\psi2$) will be the third quantum state (as actually existing), which will be described by a wave function $\psi3$.

What does it mean? The fact that the measurement of a certain physical value d in the state $|\psi1>$ will result d1, and for measure a value for of d in the state $|\psi2>$ will result d2. When the third quantum state $|\psi3>$ is realized, then when measuring a physical quantity, the quantum system will take the values d1 and d2 with probabilities, respectively, |C1|^2 and |C2|^2. That is, in a quantum state $|\psi3>$ when we will have many dimensions sometimes d1 value and sometimes d2 (with certain known frequency)”.

So let's give an analysis. Consider an electron (or photon) that manifests itself as a particle ($|\psi1>$ this quantum state 1, which describes an electron as a particle), then consider an electron as a wave ($|\psi2>$ this quantum state 2, which describes an electron as a wave).

Their linear combination ($\psi3 = C1\psi1 + C2\psi2$) will be, as usual, the third quantum state $|\psi3>$, which will be described by the wave function $\psi3$ and will describe the real elementary particle (electron, photon)...

That is, a real elementary particle (an electron or a photon) can manifest itself both as a particle (the first quantum state $|\psi1>$) and as a wave (the second quantum state $|\psi2>$).

...You may ask: “What in this analysis means the value of d (more precisely, d1 and d2)?”

The answer is obvious:

1) if we consider a particle ($|\psi1>$ this quantum state 1, which describes an electron as a particle), then d1 is the kinetic energy;

2) if we regard an electron as a wave ($|\psi2>$ this is a quantum state 2, which describes an electron as a wave), then d2 is the potential energy.

That is, the elementary particle is actually an oscillator in which the kinetic energy and potential energy transfer into each other, and when we fix the kinetic energy we register the particle (device 1), when we fix the potential energy we register the wave (device 2). From this consideration of the elementary particle, the Bohr complementarity principle (since the potential and kinetic energy completely change into one another) and the Heisenberg uncertainty principle logically follow...” [3].

“...The fact that it is impossible to accurately measure both the coordinate and the momentum for an elementary particle can be demonstrated if we take into account, as was shown earlier [3], that the de Broglie wave is an interval wave.

$$S = h / p$$

Where S — is interval,

$$S = ƛc. * (1 – v^2 / c^2)^0.5 * c/v$$

ƛc. – is the Compton wavelength of the corresponding microparticle.

The formula of Louis de Broglie:

$$S = h / p$$

which connects space-time (the interval) and the momentum of the microparticle (and hence its total energy), is an analogue of A. Einstein's well-known field equations (GR) [4], but only for the microworld.

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

This means that an elementary particle in the space-time continuum occupies a certain area, which is determined by the interval. That is, a microparticle has a certain extent in time and space (Δt, Δx). Therefore, the simultaneous determination of the coordinate and momentum is impossible by definition..." [4].

CONCLUSION.

Thus, it is obvious that the wave-particle dualism is simply the vibrations of elementary particles according to de Broglie, which are fixed by certain types of devices in different frames of reference. Corpuscle is an elementary particle in the "internal" frame of reference, and a wave is a fixation of an elementary particle in the "external" frame of reference. If we consider a corpuscle, then it can be argued that a corpuscle is energy (kinetic) concentrated at a point, since elementary particles, by definition, are point objects. When considering a wave, energy (potential) spreads throughout the space determined by the interval, since the wave is an extended object.

Therefore, taking into account the wave-particle dualism, that is, the oscillations of elementary particles, one can quite reasonably assert that an elementary particle is a kind of oscillator in which a periodic process of transformation of kinetic energy into potential energy takes place, and vice versa (depending on the coordinate system).

Then, the collapse of the wave function is a transition from one quantum state to another (for example, from a wave to a particle), which is equivalent to a change in the oscillator, or a transition from one frame of reference to another ("internal" and "external" frames of reference). And therefore, the collapse occurs instantly.

This means that there is one real Universe with elementary particles exhibiting wave and corpuscular properties, and therefore, the many-worlds interpretation of quantum mechanics does not make sense. Since there are no "parallel Universes", in each of which the same laws of nature operate, but which are in different quantum states. Moreover, with this approach, quantum mechanics and the theory of relativity can be easily combined, since they turn out to be very similar. Consider this.

The sequence of events in time, according to the theory of relativity, completely depends on the frame of reference; for accounting, the space-time continuum is used, which is created by matter (if we consider outer space, one might say, by mass).

If we take into account de Broglie's interval waves [5], then in quantum mechanics everything is exactly the same: the space-time continuum is created by de Broglie's interval waves, that is, elementary particles, that is, mass. And what is important, the sequence of events in such a quantum world will also depend only on the frame of reference, or, in other words, on the observer.

“Thus, ...the interval wave connects space-time (interval) and the total energy of a microparticle (impulse of a microparticle), just like A. Einstein's field equations connect the curvature of space-time with the energy-momentum of matter. In fact, the de Broglie interval wave is an analogue of Einstein's equations for the microworld, since both the equations and the interval wave connect the characteristics of space-time with the energy-momentum of matter...” [4, p. 5].

REFERENCES.

1. Louis de Broglie. Selected Works. Volume 1. The formation of quantum physics: the work of 1921-1934. Moscow, Logos, 2010. P. 203 (About frequency of the electron); Louis de Broglie. Sur la frequence propre de Pelectron. Compt. Rend. 1925. 180. P. 498.
2. Complementarity (physics). Wikipedia. https://en.wikipedia.org/wiki/Complementarity_(physics)
3. Bezverkhniy V. D., Bezverkhniy V. V. Quantum-Mechanical Analysis of the Wave–Particle Duality from the Position of PQS. SSRN Electronic Journal (January 2019). P. 1, 3-4. https://dx.doi.org/10.2139/ssrn.3308190
4. Bezverkhniy V. D. Heisenberg's Uncertainty Principle and Wave-Particle Dualism. SSRN Electronic Journal (June 2021). P. 2. https://dx.doi.org/10.2139/ssrn.3865301
5. Bezverkhniy V. D., Bezverkhniy V. V. De Broglie Interval Wave and Heisenberg's Uncertainty Principle. SSRN Electronic Journal (August 2019). https://dx.doi.org/10.2139/ssrn.3435852