The quantum mechanics description of a physical object stretched in space and stable in time from the relativistic space-time properties point of view, introduced in special theory of relativity, is considered and analysed. The mathematical model of physical objects is proposed. This model gives a possibility to unite a description of corpuscular and wave properties of real physical objects, i.e. fields and particles. There are substantiated an approach and a mathematical pattern which give a possibility to describe physical object not only in causal, but also in absolute remote fields of the Minkowski space. Applying the proposed approach to the microcosm description, one can get the equations that in passage to the limit transfer to such quantum mechanics equations as Schrödinger, Klein-Gordon-Fock and in particular case - the wave equation. The event nature of the received equations is discussed. It is shown that all mentioned equations reflect the space-time relativistic properties during the description of the invariant and non-invariant physics object characteristics.

INTRODUCTION

The predictions brilliantly proved in experiments won for the quantum theory the reputation of one of the most successful physical theories. However, up to present, the disputes about its meaning and limits of its implementation are not quiet yet. This is an unique phenomenon in the history of science [1,2]. The Nobel Prize laureate in physics M. Gell-Mann characterised the quantum physics as a discipline “full of mysteries and paradoxes, that we do not completely understand but are able to use. As we know, it perfectly operates in the physics reality description, but as sociologists would say, it is anti-intuitive discipline. The quantum physics is not a theory, but limits, in which, as we suppose, any correct theory needs to be included” [3].

The logistic analysis of a quantum mechanics as a science leads to the conclusion about its incompleteness and non-completability, in consequence of an inconsistency of the quantum objects, that is fixed in a corpuscular-wave dualism [4]. The theory incompleteness is an original “payment” for a tendency to create a non-contradictory description of contradictory objects. One of consequences of the quantum mechanics logistic analysis is a proof of an absence of a positive decision for a hidden parameter method, from point of view that “there are no any possibilities for more complete description in standard quantum mechanics theory limits. Its realization needs a quantum mechanics creation on a principal different basis”.

The facts of the particles and anti-particles annihilation with the photon and neutrino creation, the birth of particles from different classes during the high energy photons interactions are the circumstantial evidence of the unified origin of fields and particles. Do not discussing about “a forced formalism”, i.e. a science penetration into the fields with different from “everyday”, principal new forms and meanings, it would be desirable to decrease the formal apparatus as possible, by changing it to the system of views.

From this point of view, the development of physical object models, which give a possibility to unite the description of corpuscular and wave properties of real objects, i.e. fields and particles, has a conceptual meaning. Models need to correlate with the existing quantum mechanics approach, so as it has a brilliant experimental confirmation. Moreover, although some quantum mechanics postulates and concepts should be a corollary from the properties of the proposed model and properties of the space, where the object exists. If the relativistic properties are included in the space description, the corresponding expressions describing the object behaviour should have a relativistic nature and in passage to the limit should be transfer to well-known quantum mechanics equations. At any probability, if Minkowski space is examined, the absolute remote fields have to be included in the physical object description.

An effort has been undertaken to solve mentioned problems and “to pave a way” for the complement the existing quantum mechanics theory for the full, correct, non-contradictory theory, dreamed by Louis de Broglie, mentioned by Marry Gell-Mann, looked for by Ilya Prigogine.
I. PHYSICAL OBJECT

In special theory of relativity the object evolution is examined in a four-dimension space-time continuity with a pseudo-Euclidean metric. The supposition about the space-time continuity strikes against the conceptual problem, that we will call the scale problem. Let’s consider the four-dimensional space-time as some mathematical set. The Cantor’s power of a neighbourhood of any space point is equal to the power of whole space. The question is: what defines the observed size of a physics object, for example, elementary particles? The size of the observer could not be a reason. Moving this way we will come to the dilemma about the initial appearance of a hen or an egg. The speed of light as a fundamental constant connects space and time measurements but, apparently, is not good for a role of the scale coefficient. In all probability the problem can be solved by introducing in a description the discreteness. Considering a time as some parameter characterising the changing of processes in space and putting these processes in order during the analyses in a chronological sequence, realising the causality principle, the hypothesis about the space discreteness can be introduced. This way it is not difficult to demand the time continuity as some abstract parameter. However, of course, it is not necessary to refuse completely from the possibility of the time discreteness. Whether or not the discreteness is necessary. Let’s consider the possible variants of putting the events in order in inertial frames of reference. We will leave the question of the space discreteness open.

A conventional approach is the following [5]. Some frame is introduced in the four-dimensional continuity, which is represent a set of four continuous marks \((x,y,z,\tau)\) over the space and time coordinates. It is established, that the infinite set of the equivalent frames exists, and these frames are connected to each other with the help of four continued differentiable functions with the non-zero functional determinant. Usually, this demand is connected to the principle of the equivalence of inertial frames of references. It is considered that some property, unchangeable with these transformations, can correspond to each point. The property, expressed by the number, that “by order” don’t change during the transformations of the frames of references, is called invariant or scalar. It is said about an invariant or scalar field if this correspondence takes place not only for one concrete point but some number is compared with every point from some defined region, and all these numbers reflect the same invariant property. Thus, the scalar field is defined by the function against coordinates \(\phi(\vec{r},\tau)\), that can be interpreted as some continuous physical object.

For the stable in time physical object, due to the invariance of values in its every point, the operation integral can be composed for every point and by the principle of the minimum effect the trajectory of the object motion may be defined. This trajectory will represent the chain of the events putting in order in time. We will consider this approach as the classical one.

It often needs to have deal with non-invariant characteristics of physical objects. Let’s pose a set of one or more numbers \((g(\vec{r},\tau), h(\vec{r},\tau), \ldots)\) in some inertial frame of references, each of that is not a scalar. If there is a functional \(\int_{T_0}^{T} \omega(\vec{r},\tau) \, dt\) related to a fundamental frame of references \(\Omega\) in \(\mathbf{K}\), by the hyper-plane \(\vec{r} = \text{const}\). Note, that at any fixed moment of time the interval between any two events from \(V'\) will be space-like, because this hyper-plane will lay down in absolute remote fields of Minkowski space. For any point from \(V'\), by virtue of physical object stability, it will be such time interval \(\Delta{\vec{r}}\), what \(g(\vec{r},\tau') = g(\vec{r} + \Delta{\vec{r}},\tau')\). Thus, the function \(g(\vec{r},\tau')\) will describe the stationary process, defined in the space point \(\vec{r}\) (or in some discrete field of space). If the time average \(<|g'|>_T, <|g'|^2>_T\) exist with \(T \to \infty\), \(<g(T)>_T = \int_{-T}^{T} g(t)dt/(2T)\) and
\[ g'(\vec{r}, \tau') = g'_0(\vec{r}') + \sum_{k=1}^{\infty} g'_k(\vec{r}') \cos(\omega'_k \tau' + \alpha'_k) + g'_a(\vec{r}', \tau'). \]  

Considering \( g'(\vec{r}, \tau') \) as a part of the functional field (1), we will define this field as:

\[ \psi'(\vec{r}, \tau') = \sum_{k=0}^{\infty} q'_k(\vec{r}') \exp(i\omega'_k \tau') + q'_a(\vec{r}', \tau'). \]  

where \( \omega'_0 = 0 \), the limit of \( \langle \psi' \exp(i\omega \tau') \rangle_T \) with \( T \to \infty \) is equal to \( g'_k(\vec{r}') = g'_k(\vec{r'}) \exp(i\alpha'_k(\vec{r'})) \) with \( \omega = \omega'_k \), \( (k = 0, 1, 2, \ldots) \), and is equal to zero for all other values of \( \omega \). The analogous limit for the non-periodical component always is equal to zero for any \( \vec{r}' \) from \( V' \). Functions \( g'_k(\vec{r}') \) and \( \alpha'_k(\vec{r}') \) are real.

In frame \( K \) the considered function will be defined as \( \psi(\vec{r}, \tau) = \psi'(\vec{r}'(\vec{r}, \tau), \tau(\vec{r}, \tau)) \), that, with taking into account (2) and, designating \( \xi = \gamma(z - \beta \tau) \), \( \eta = \gamma(\tau - \beta z) - \tau \), may be represented as follows:

\[ \psi(\vec{r}, \tau) = \sum_{k=0}^{\infty} q_k(x, y, \xi) \exp[i\omega_k(\eta + \tau)] + q_a(\vec{r}, \tau). \]  

For every fixed harmonics (5) the scalar field (1) corresponding to the introduced normalised one will be equal to squared amplitude of the corresponding harmonics. As far as the scalar sum is also a scalar, the result scalar field corresponding to (5) is defined as:

\[ \phi(\vec{r}, \tau) = \sum_{k=0}^{\infty} |q_k(x, y, \xi)|^2 = \sum_{k=0}^{\infty} q_k^2(\vec{r}, \tau). \]  

The important distinguish of the normalised field (5) from the scalar one (6) is an oscillation, resonant nature of the first one. It is necessary to note that the established correspondence between (5) and (6) has not reciprocally a single meaning, because, for example, the information about the mutual phases of harmonics is loosing. However, in considering only one harmonic of the stable physical object function, this limitation is not important. But the information about frequency will be still loosing.

II. QUANTUM MECHANICS BASIC EQUATIONS

Omitting the corresponding indexes of \( \psi, q, \omega \) for the notation simplicity, we will represent the \( k \)-th harmonics of the spectrum expansion (5) as follows:

\[ \psi(\vec{r}, \tau) = \psi^k(\vec{r}, \tau) \exp(i\omega \tau), \quad \psi^k(\vec{r}, \tau) = q(x, y, \xi) \exp(i\omega \eta). \]  

Partial derivatives by \( \vec{r} \) and \( \tau \) for function \( \psi^k \) will be expressed in the following way:

\[ \frac{\partial \psi^k}{\partial \tau} = -\gamma \beta q \xi e^{i\omega \eta} + i\omega(\gamma - 1) q e^{i\omega \eta}, \quad \frac{\partial \psi^k}{\partial z} = \gamma q \xi e^{i\omega \eta} - i\gamma \omega \beta q e^{i\omega \eta}, \quad \frac{\partial \psi^k}{\partial x(y)} = q_x(y) e^{i\omega \eta}. \]  

It is designating here \( f_s = \partial f / \partial s \). For second derivatives the following expressions may be got:

\[ \frac{\partial^2 \psi^k}{\partial \tau^2} = \gamma^2 \beta^2 q \xi e^{i\omega \eta} - 2i\gamma(\gamma - 1) \omega \beta q \xi e^{i\omega \eta} - \omega^2(\gamma - 1)^2 q e^{i\omega \eta}, \quad \frac{\partial^2 \psi^k}{\partial z^2} = \gamma q e^{i\omega \eta}(q \xi / q - \omega^2 \beta^2) - 2i\gamma \omega \beta q \xi e^{i\omega \eta}. \]  

It is possible to cancel imaginary parts by combining the expressions for the first derivative in time (8) and the second one in space (9). This way for function \( \psi^k(\vec{r}, \tau) \) we will get the equation:

\[ -i\gamma \frac{1}{\psi^k} \frac{\partial \psi^k}{\partial \tau} + \frac{1}{2\omega \psi^k} \nabla^2 \psi^k = \frac{1}{2\omega} \frac{\nabla^2 q}{q} + \frac{\omega}{2} (\gamma - 1)^2. \]
Here \( \nabla^2 \equiv \partial^2 / \partial x^2 + \partial^2 / \partial y^2 + \partial^2 / \partial z^2 \) is a Laplace operator. The second term in the right part of the equation speeds to zero fast enough (\( \sim \beta^2 \)) with non-relativistic velocities. If it is possible to separate the variables in some frame of references or at least to separate the time variable in the function \( q \), so \( \nabla^2 q / q = u(x,y,z) \) and, supposing \( \omega = mc/h \), where \( m \) and \( h \) are some constants (usually \( m \) is understood as a rest mass, \( h \) is a Planck constant), we will get:

\[
- i \hbar c \frac{\partial \psi^b}{\partial \tau} + \frac{\hbar^2}{2m} \nabla^2 \psi^b = \left[ \frac{\hbar^2}{2m} u(x,y,z) + \frac{mc^2(\gamma - 1)^2}{2} \right] \psi^b.
\]

Designating \( \hbar^2 u(x,y,z)/2m = U(x,y,z) \), we will get in non-relativistic case in passage to the limit (\( \gamma \to 1 \)) the Schrödinger equation (conjugated to usually used) [7]. It is known that \( U(x,y,z) \) has a meaning of the potential energy of the particle in the force field, and \( \psi^b(\vec{r}, \tau) \) is agree with the de Broglie’s description of the particle wave properties.

The equation may be interpreted in the following way. The lengthy in space physical object is changing by an external field, moving or changing of the object internal structure will depend on this field. In distinguish of the Schrödinger equation, the equation (10) and, with some stipulations, (11) have to be true also in the relativistic case. It is necessary to pay attention to the particularity of the described passage to the limit to the potential function of the external forced field, because an interaction can be as complete as partial and also with new physical objects creation.

Combining the expressions analogous to (9) for function \( \psi(\vec{r}, \tau) \), it is possible to cancel imaginary terms in right part of the expressions. The following equation can be got:

\[
\frac{1}{\psi} \left( \frac{\partial^2 \psi}{\partial \tau^2} - \nabla^2 \psi \right) = - \left( \frac{\nabla^2 q - \beta^2 q_{zz}}{q} + \omega^2 \right). \tag{12}
\]

There are included the functions only from space coordinates on the right part of the equation in the fundamental frame of references (\( \nabla^2 q - \beta^2 q_{zz} \)) and, supposing \( \beta^2 q_{zz} \), but on the left part - in frame \( K \). Thus, with the stability condition of the considered physical object, it needs to be a scalar on the right part in brackets. Designating this scalar as \( (mc/h)^2 \), we will get the Klein-Gordon-Fock equation [8] for a free relativistic (pseudo-) scalar particle with rest mass \( m \), that corresponds to the conventional model, when the plane monochromatic wave is confronted to the particle (without spin). Thus, the introduced function (5) may be interpreted as a wave function of the physical object.

The particular case of the zero scalar corresponds to the wave equation. In this particular case, real and imaginary parts of the functional normalised field are the components of the electric and magnetic field intensities, and the scalar field, corresponding to this functional is a density distribution of the electromagnetic field. If the wave equation is considered as a special case of the common description of the physical objects, the introduced conceptions of the functional and corresponding scalar fields are getting very interesting physics analogies.

CONCLUSION

Thus, the proposed model of the physical objects allowing to unify the description of the corpuscular and wave properties of the real objects - particles and fields, has a conceptual nature. The model correlates with the existing quantum mechanics approach and, as follows, has an experimental confirmation in non-relativistic and in a number of particular cases. Such basic quantum mechanics equations as the Schrödinger and Klein-Gordon-Fock ones can be considered as a corollary from the proposed model properties and properties of a space, in which the physical object exists (it is considered the Minkowski space in this paper).

The proposed model includes the absolute remote fields of the Minkowski space in the description. On base of this possibility it is possible to go further- inside the physical object and to try to make clear its internal structure. So, this paper is supposed by the author as the first one in a number of papers, continuing this theme, in direction of further working up the theses following through the properties of the proposed model of the physical object and the space properties. For example, there are preparing papers about an internal structure of physical objects, their interconnections.

This work is an effort to remove the conceptual internal contradictions of the quantum mechanics theory. It is supposed, it will allow to find a way of creating in its frames the complete, correct, non-contradictory theory, dreamed by L. de Broglie, mentioned by M. Gell-Mann and "paved a way" by I. Prigogine.
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