Logical reloading in statistical description of particle dynamics

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Abstract

Logical reloading is a replacement of one system of basic concepts inside a physical conception by another equivalent system of basic concepts. The logical reloading does not change the conception. However, a generalization of the conception at different equivalent systems of basic concepts (axioms) leads, in general, to different results. In particular, at transition from a nonrelativistic conception to corresponding relativistic conception it is very important to use adequate basic concepts. In the paper one considers problems connected with a use of inadequate basic concepts in statistical description of stochastic particle motion.

1 Introduction

Contemporary theoretical physics meets problems in some new regions of investigation. These problems are connected with a use of inadequate concepts. The fact is that, a concept, which is adequate in some region of physics, may be inadequate in other region. For instance, consideration of the space-time geometry as a logical construction is adequate in our world [1]. However, it is inadequate in microcosm and in megacosm, where the space-time geometry becomes to be nonaxiomatizable and ceases to be a logical construction.

Another example. Statistical description of particle dynamics in terms of probability, which is adequate in nonrelativistic physics, appears to be inadequate in relativistic physics. Statistical description of particle motion becomes to be necessary, when particles move random. In this case one considers statistical ensemble of many independent random moving particles.

The statistical ensemble of stochastically moving particles forms a dynamic system, which is described by some dynamic equations, although a single particle does not form a dynamic system, and there are no dynamic equations, describing motion of a single indeterministic particle. Investigating the dynamic system (statistical ensemble), one can describe a mean motion of the indeterministic particle. The mean motion of a particle does not depend on the number of the particles in the statistical ensemble. It is important only, that the number of particle would be large enough (infinite). Neither dynamic equations for the statistical ensemble, nor mean values of dynamical variables depend on the number of the particle in the statistical ensemble. Formally one can accept, that the statistical ensemble consists of one particle. Then the statistical ensemble may be considered as a statistical average particle. As far as such a statistical ensemble is normalized to unity, the density of particles can be interpreted as a probability density of the particle location. As a result one obtains description of an indeterministic particle in terms of the probability density. It is the probabilistic conception of the statistical description (PCSD).

The statistical average particle has properties, which are rather close to properties of individual particle, and they are mixed sometimes. There are two characteristic differences. The individual particle has finite number of the freedom degrees, and its dynamic equations are ordinary differential equations, whereas the statistical average particle has infinite number of the freedom degrees , and its dynamic equations are partial differential equations, in general. Besides, the individual particle has no alternative properties, for instance, it can pass only through one of two slits at the same time, whereas the statistical average particle may have alternative properties, for instance, it can pass through both slits at the same time.

The quantum particle, described by the Schrödinger equation, has properties of the statistical average particle. It is described by partial differential equations, and it can pass through two slits at the same time. In other words, the quantum particle has properties, which are characteristic for a statistical ensemble.

After explanation of heat phenomena by means of the kinetic gas theory it was reasonable to think, that quantum effects may be explained as some stochastic motion of microparticles. Some researchers [3, 2] tried to obtain quantum mechanics as a statistical description of stochastically moving microparticles. They failed to explain the quantum mechanics as a statistical description of stochastically moving particles. Moyal [3] tried to reduce quantum dynamic equations to the form, which is characteristic for dynamic equations of stochastic processes. Fenyes [2] tried to obtain statistical description, using similarity between the Schrödinger equation and the Fokker equation for diffusion processes. Both authors used the concept of the wave function without understanding, what it means. Explanation of quantum phenomena is hardly possible without understanding, what is the wave function. However, then nobody knew, what is the wave function.

Note, that in a similar situation Boltzmann did not use the concept of thermogen for explanation of thermal phenomena. He explained thermogen as a chaotic motion of molecules. Interpretation of the wave function was given only in the end of twentieth century [4]. It appeared, that the wave function is simply a way of description of motion of an ideal continuum media.

The fact, that the Schrödinger equation may be reduced to irrotational flow of some quantum fluid was shown by Madelung [5]. However, representation of the hydrodynamic equations for ideal fluid in terms of the wave function needs a complete integration of hydrodynamic equations.

For transition from the Schrödinger equation to the system of four hydrodynamic equations the complex Schrödinger equation is represented in the form of two real equations for amplitude $\sqrt{\rho}$ and for the phase φ. To obtain hydrodynamic equations, it is sufficient to take gradient from the equation for the phase φ. As a result one obtains four dynamic equations, which turn into hydrodynamic equations after introducing proper designations. In other words, for transition from dynamic equations in terms of the wave function to the hydrodynamic form of these equations, one needs to differentiate dynamic equations. On the contrary, to pass from hydrodynamic form of dynamic equations to their representation in terms of the wave function, one needs to integrate dynamic equations. In the case of the irrotational flow this integration is carried out rather simply, whereas in the case of vortical flow the way of integration became to be known only in the end of twentieth century [4].

Bohm [6] used the hydrodynamic representation of the Schrödinger equation for interpretation of quantum mechanics. He started from the wave function and quantum principles and interpreted them in hydrodynamic terms. However, he could not found quantum mechanics on the basis of hydrodynamics, because for such a foundation he would start from hydrodynamic concepts and equations, in order to obtain the wave function in hydrodynamic terms. He could not make this, because in this case he would be forced to integrate hydrodynamic equations in general case, but not only for irrotational flows. Integration of the hydrodynamic equations was not known almost during the whole twentieth century.

Information on other attempts of a statistical foundation of quantum mechanics can be found in the book by Holland [7]. All authors tried to found the nonrelativistic quantum phenomena on the basis of nonrelativistic statistical description. This circumstance was the main reason of failures. The nonrelativistic quantum mechanics describes a mean motion of particles, and the mean motion is nonrelativistic. However, the nonrelativistic character of the mean motion does not mean, that the exact particle motion is also nonrelativistic. Stochastic component of the particle motion may be relativistic, and this component disappear at the averaging. To obtain a correct description one should use a relativistic statistical description.

Nonrelativistic statistical description is produced usually in terms of the probability density. It uses nonrelativistic concept of particle state as a point in the phase space of coordinates and momenta. At proper normalization the nonnegative density ρ of particles in the phase space is used as a probability density.

In the relativistic physics the state of a particle is determined by its world line (not as point in the phase space). As a result the particle density at some spatial point x is determined by the vector $j^k(x)$ of the 4-current. This vector cannot be described in terms of the probability density. As a result the statistical description of relativistic stochastic particle differs from the nonrelativistic statistical description. The relativistic statistical description of stochastically moving particles is a consideration of many stochastic particles (statistical ensemble), and it is the original definition of the statistical description. Consideration of the statistical ensemble of stochastic particles is a consideration of some continuous medium, consisting of infinite number of stochastic particles. Thus, a statistical ensemble of stochastic particles is a dynamic system, which is described by some dynamic equations, whereas a single stochastic particle is not a dynamic system, and there are no dynamic equations, describing a single stochastic particle.

Consideration of the statistical ensemble admits one to obtain a dynamic system, whose evolution can be investigated. Of course, the relativistic statistical description in terms of statistical ensemble and that in terms of a fluid are connected. However, one prefers to use nonrelativistic statistical description in terms of the probability density. The Brownian particles are described by means of the nonrelativistic statistical description. Such an approach is true, because stochastic component of the Brownian particle motion is nonrelativistic, and the state of the Brownian particle may be described as a point in the phase space.

However, application of nonrelativistic statistical description to quantum particle is incorrect, because *the nonrelativistic quantum mechanics is in reality a relativistic conception.* This statement looks rather unexpected. But note, that if one knows nothing about the stochastic component of a particle motion, one should consider the general (relativistic) case. If one considers the nonrelativistic quantum mechanics as a relativistic conception, but the quantum mechanics appears to be a nonrelativistic conception, such a consideration of quantum mechanics as relativistic conception will be true, because a nonrelativistic conception is a special case of a relativistic conception. However, if one considers the quantum mechanics as a nonrelativistic conception, but it appears to be a relativistic conception, the nonrelativistic consideration will be incorrect, in general.

Thus, if one tries to obtain a statistical foundation of quantum mechanics as a statistical description of stochastically moving particles, one should use adequate relativistic concepts. Formalism of nonrelativistic quantum mechanics is nonrelativistic. To produce a statistical foundation of quantum mechanics, one should carry out a logical reloading, i.e. a transition from inadequate (nonrelativistic) concepts to adequate (relativistic) concepts. It means that the probability density $\rho(x)$ should be replaced by the "probability vector" $j^k(x)$ (world lines density). Introduction of 4-vector $j^k(x)$ means a consideration of some "quantum fluid". The wave function ψ is a way of the fluid description [4], and it appears as a result of description of the "quantum fluid", which describes the state of the statistical ensemble. As a result the main concept of the quantum mechanics (the wave function) appears to be a secondary derivative concept. The wave function may be introduced and interpreted in terms of concepts of the statistical ensemble. This fact admits one to found the quantum mechanics as a statistical description of stochastically moving particles.

Relativistic character of the nonrelativistic quantum mechanics makes to be useless the construction of relativistic quantum theory as a result of uniting of quantum and relativistic principles. Such an uniting is inconsistent, because nonrelativistic quantum mechanics is already a nonrelativistic approximation of a relativistic conception. Such an uniting reminds an uniting of axiomatic conception of thermodynamics with the model conception of the kinetic gas theory. Relativistic quantum theory should be obtained as a refuse from the nonrelativistic approximation of the relativistic statistical foundation of the quantum mechanics. It means that the conventional conception of the relativistic quantum theory is doomed to fitting instead of logical development of the existing relativistic statistical description.

It is worth to note, that the logical reloading to relativistic conception of statistical description does not need any new hypothesis. The probability density is not used simply, because it is an attribute of nonrelativistic description. In general, we use the Newtonian investigation strategy "Hypotheses no fingo", which means: "Find a mistake and correct it!" In the crises period of the theoretical physics development, when there are mistakes in the application of fundamental concepts, such an investigation strategy is more effective, than the strategy of invention of new hypotheses, compensating these mistakes.

The foundation of the quantum mechanics as a statistical description of stochastically moving particles puts a question on the reason of this stochasticity. This stochasticity cannot be suppressed by a reduction of temperature, which is used for suppression of the thermal motion of molecules. It appears, that the stochastic motion of microparticles may be explained as result of the multivariant space-time geometry in the microcosm [9]. Such a possibility has arisen due to a progress of our knowledge of geometry [10]. The new capacities of the space-time geometry generate the program of the physics geometrization [11], where all physical quantities, including the particle mass, are geometrized.

2 Statistical description as a corollary of the quantum mechanics formalism

The quantum mechanics was considered as a statistical conception all the time. But there was disagreement about interpretation of the wave function, which is the main object of quantum mechanics. Some investigators [12, 13, 14, 15, 16] consider, that the wave function describes a statistical ensemble of quantum particles. Other investigators use the so-called Copenhagen interpretation [17], where it is supposed, that the wave function describes a single quantum particle. All investigators assume, that the interpretation of the quantum mechanics and, in particular, of the wave function does not depend on the quantum mechanics formalism.

Discussion between disciples of statistical interpretation and those of the Copenhagen one lasts since the moment of the quantum mechanics creation. Now the Copenhagen interpretation is dominating. On the basis of this interpretation another interpretation appears, for instance, so-called multi-world interpretation.

In reality, a true interpretation of the wave function may be obtained *on the basis of the quantum mechanics formalism.* If in the action for the Schrödinger particle, described by the Schrödinger equation, one goes to the limit $\hbar \to 0$, one obtains a classical description. If the obtained action describes a single free classical particle, having finite number of the freedom degrees, then the world function describes a single quantum particle. If in the limit $\hbar \to 0$ the obtained action describes a statistical ensemble of classical particles, which has infinite number of the freedom degrees, then the wave function describes a statistical ensemble of quantum particles. Thus, the problem of the wave function interpretation is to be solved on the basis of the mathematical formalism.

For the free Schrödinger particle we have the following expression for the action

$$\mathcal{S}_{\mathrm{q}}: \qquad \mathcal{A}_{\mathcal{S}_{\mathrm{q}}}[\psi, \psi^*] = \int \left\{ \frac{i\hbar}{2} \left(\psi^* \partial_0 \psi - \partial_0 \psi^* \cdot \psi \right) - \frac{\hbar^2}{2m} \boldsymbol{\nabla} \psi^* \boldsymbol{\nabla} \psi \right\} dt d\mathbf{x} \tag{2.1}$$

where $\psi = \psi(t, \mathbf{x})$ is a complex one-component wave function, $\psi^* = \psi^*(t, \mathbf{x})$ is the complex conjugate to ψ, and m is the particle mass. After the change of variables

$$\psi = a \exp(iS/\hbar) \tag{2.2}$$

the action (2.1) turns into the action

$$\mathcal{S}_{\mathrm{q}}: \qquad \mathcal{A}_{\mathcal{S}_{\mathrm{q}}}[a, S] = \int \left\{ -a^2 \partial_0 S - \frac{a^2}{2m} (\boldsymbol{\nabla} S)^2 - \frac{\hbar^2}{2m} (\boldsymbol{\nabla} a)^2 \right\} dt d\mathbf{x} \tag{2.3}$$

At $\hbar \to 0$ the quantum dynamic system $\mathcal{S}_{\mathrm{q}}$ transforms to classical dynamic system $\mathcal{S}_{\mathrm{cl}}$, described by the action

$$\mathcal{S}_{\mathrm{cl}}: \qquad \mathcal{A}_{\mathcal{S}_{\mathrm{cl}}}[a, S] = \int \left\{ -a^2 \partial_0 S - \frac{a^2}{2m} (\boldsymbol{\nabla} S)^2 \right\} dt d\mathbf{x} \tag{2.4}$$

This dynamic system has infinite number of the freedom degrees. Dynamic equations have the form

$$\delta S: \qquad \partial_0 a^2 + \boldsymbol{\nabla} \left(\frac{a^2}{2m} \boldsymbol{\nabla} S \right) = 0 \tag{2.5}$$

$$\delta a: \qquad -a \partial_0 S - \frac{(\boldsymbol{\nabla} S)^2}{2m} = 0 \tag{2.6}$$

Introducing new variables

$$\rho = a^2, \qquad \mathbf{v} = \frac{1}{2m} \boldsymbol{\nabla} S \tag{2.7}$$

one can represent equations (2.5), (2.6) as hydrodynamic equations for irrotational flow of the ideal fluid without pressure

$$\partial_0 \rho + \boldsymbol{\nabla} (\rho \mathbf{v}) = 0, \qquad \partial_0 \mathbf{v} + (\mathbf{v} \boldsymbol{\nabla}) \mathbf{v} = 0 \tag{2.8}$$

The dynamic system $\mathcal{S}_{\mathrm{cl}}$ has infinite number of the freedom degrees. It describes a pure statistical ensemble of free classical particles. It means, that the action (2.1) of the dynamic system $\mathcal{S}_{\mathrm{q}}$ describes a statistical ensemble of Schrödinger particles (but not a single particle). In our consideration (2.1) - (2.8) we have presented a formal scheme of the proof, that wave function describes a pure statistical ensemble (but not a single particle). All subtleties of this proof can be found in the special papers [18, 19, 20].

Remark. Statistical ensemble $\mathcal{E} = \mathcal{E}[\mathcal{S}]$, consisting of dynamic systems $\mathcal{S}$ is by definition a pure statistical ensemble of elements $\mathcal{S}$. If any element $\mathcal{S}$ is a statistical ensemble $\mathcal{S} = \mathcal{E}_{\mathcal{S}}[\mathcal{Q}]$, consisting of elements $\mathcal{Q}$, then $\mathcal{E}[\mathcal{S}[\mathcal{Q}]]$ is a pure statistical ensemble of elements $\mathcal{S}$, and it is a mixed statistical ensemble of elements $\mathcal{Q}$. In the nonrelativistic statistical description, which may be carried out in terms of the probability density, the pure statistical ensemble and the mixed one do not distinguish between themselves. In the relativistic statistical description the pure statistical ensemble and the mixed one are different, in general. In the quantum mechanics the pure statistical ensemble is described by the wave function, whereas the mixed statistical ensemble is described by the density operator.

From viewpoint of the statistical description this fact is explained as follows. Statistical ensemble $\mathcal{S}[\mathcal{Q}]$ is a nonrelativistic dynamical system. Hence, the statistical ensemble $\mathcal{E}[\mathcal{S}[\mathcal{Q}]]$ can be described in terms of the probability density, whereas the systems $\mathcal{Q}$ are relativistic, in general. It means, that the statistical ensemble $\mathcal{S}[\mathcal{Q}]$ cannot be described in terms of the probability density, in general.

One can see from the above consideration, that quantum effects may be described as a result of a statistical description of stochastically moving particles. As far as the microparticle motion stochasticity can be considered as a property of the space-time geometry [21], the quantum effects can be considered as geometrical effects. Besides, it appears, that the stochastic motion of microparticles is a general case of the particle motion, whereas the deterministic particle motion is a very special case of the stochastic particle motion, when the stochasticity vanishes. In the contemporary conception of particle dynamics the deterministic particle motion is considered to be the main way of the particle motion, whereas the stochastic particle motion is reduced to the deterministic particle motion by means of a special mathematical operation, known as the statistical description.

In such a situation, when the stochastic motion is a general case of particle motion, it seems to be more reasonable to include the statistical description in the definition of the particle motion. In other words, evolution of a statistical ensemble of particles is considered as a basic way of description of the particle motion. The particles of the statistical ensemble may be deterministic or stochastic, the way of their description is the same. If the particles of the ensemble are deterministic, the statistical ensemble has some special properties, which admit one to reduce the statistical ensemble motion to a motion of a single particle. Advantage of such an approach is existence of a single method for description of all particles. Transition to such a method of the particle description [22] is a logical reloading.

After such a logical reloading we shall use the term *physical system*, which is a collective concept with respect to concept of stochastic system and that of dynamic system. Motion of all physical systems is described in the same way by means of a statistical ensemble of physical systems. We shall use also the terms: *stochastic* *physical system* instead of *stochastic system*, and *deterministic physical system* instead of *dynamic system.* These terms are a bit longer, but they reflects the fact, that the stochastic system and dynamic system are two different partial cases of the physical system.

3 Statistical description of stochastic particles

The united method of description of dynamic systems and stochastic ones is presented in [22]. Here we present only a short scheme of this method application in the example of a free quantum particle.

Statistical ensemble $\mathcal{E}[\mathcal{S}_{\rm cl}]$ of free nonrelativistic classical particles $\mathcal{S}_{\rm cl}$ is described by the action

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\rm cl}]}[\mathbf{x}] = \int \int_{V_\xi} \frac{m}{2}\dot{\mathbf{x}}^2 \rho_0(\boldsymbol{\xi})\, dt d\boldsymbol{\xi}, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{3.1}$$

where $\mathbf{x} = \mathbf{x}(t,\boldsymbol{\xi})$, $\boldsymbol{\xi} = \{\xi_1, \xi_2, \xi_3\}$ are parameters, labelling the particles of the statistical ensemble, and ρ_0 is a weight factor.

If the particles of the ensemble are stochastic, the stochasticity is taken into account by additional dynamical variables in the action. The action for the statistical ensemble $\mathcal{E}[\mathcal{S}_{\rm st}]$ of stochastic particles $\mathcal{S}_{\rm st}$ is written in the form

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\rm st}]}[\mathbf{x},\mathbf{u}] = \int \int_{V_\xi} \left\{ \frac{m}{2}\dot{\mathbf{x}}^2 + \frac{m}{2}\mathbf{u}^2 - \frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u} \right\} \rho_0(\boldsymbol{\xi})\, dt d\boldsymbol{\xi}, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{3.2}$$

The variable $\mathbf{x} = \mathbf{x}(t,\boldsymbol{\xi})$ describes the regular component of the particle motion. The variable $\mathbf{u} = \mathbf{u}(t,\mathbf{x})$ describes the mean value of the stochastic velocity component, $\hbar$ is the quantum constant. The second term in (3.2) describes the kinetic energy of the stochastic velocity component. The third term describes interaction between the stochastic component $\mathbf{u}(t,\mathbf{x})$ and the regular component $\dot{\mathbf{x}}(t,\boldsymbol{\xi})$. The operator

$$\boldsymbol{\nabla} = \left\{ \frac{\partial}{\partial x^1}, \frac{\partial}{\partial x^2}, \frac{\partial}{\partial x^3} \right\} \tag{3.3}$$

is defined in the space of coordinates $\mathbf{x}$.

Description of a stochastic physical system distinguishes from that of a deterministic physical system only by additional terms and by additional dynamic variables in the Lagrangian function. The additional dynamic variables describe stochasticity of the particle motion.

Dynamic equations for the dynamic system $\mathcal{E}[\mathcal{S}_{\rm st}]$ are obtained as a result of variation of the action (3.2) with respect to dynamic variables $\mathbf{x}$ and $\mathbf{u}$.

To obtain the action functional for $\mathcal{S}_{\rm st}$ from the action (3.2) for $\mathcal{E}[\mathcal{S}_{\rm st}]$, we should omit integration over $\boldsymbol{\xi}$ in (3.2). We obtain

$$\mathcal{A}_{\mathcal{S}_{\rm st}}[\mathbf{x},\mathbf{u}] = \int \left\{ \frac{m}{2}\dot{\mathbf{x}}^2 + \frac{m}{2}\mathbf{u}^2 - \frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u} \right\} dt, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{3.4}$$

where $\mathbf{x} = \mathbf{x}(t)$ and $\mathbf{u} = \mathbf{u}(t, \mathbf{x})$ are dependent dynamic variables. The action functional (3.4) is not well defined for $\hbar \neq 0$, because the operator $\boldsymbol{\nabla}$ is defined in some 3-dimensional vicinity of point $\mathbf{x}$, but not at the point $\mathbf{x}$ itself. As far as the action functional (3.4) is not well defined, one cannot obtain dynamic equations for $\mathcal{S}_{\text{st}}$. By definition it means that the particle $\mathcal{S}_{\text{st}}$ is stochastic. Setting $\hbar = 0$ in (3.2), we transform the action (3.2) into the action (3.1), because in this case $\mathbf{u} = 0$ in virtue of dynamic equations.

The quantum constant $\hbar$ has been introduced in the action (3.2), in order the description by means of the action (3.2) be equivalent to the quantum description by means of the Schrödinger equation [9]. If we substitute the term $-\hbar\boldsymbol{\nabla}\mathbf{u}/2$ by some function $f(\mathbf{u}, \boldsymbol{\nabla}\mathbf{u})$, we obtain statistical description of other stochastic system with other form of stochasticity, which does not coincide with the quantum stochasticity. In other words, the form of the last term in (3.2) describes the type of the stochasticity.

To obtain dynamic equations for the statistical ensemble $\mathcal{E}[\mathcal{S}_{\text{st}}]$ of stochastic systems $\mathcal{S}_{\text{st}}$, one needs to vary the action (3.2). Variation of (3.2) with respect to $\mathbf{u}$ gives

$$\begin{aligned}
\delta\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\text{st}}]}[\mathbf{x}, \mathbf{u}] &= \int\int_{V_\xi} \left\{ m\mathbf{u}\delta\mathbf{u} - \frac{\hbar}{2}\boldsymbol{\nabla}\delta\mathbf{u} \right\} \rho_0(\boldsymbol{\xi})\, dt d\boldsymbol{\xi} \\
&= \int\int_{V_\mathbf{x}} \left\{ m\mathbf{u}\delta\mathbf{u} - \frac{\hbar}{2}\boldsymbol{\nabla}\delta\mathbf{u} \right\} \rho_0(\boldsymbol{\xi}) \frac{\partial(\xi_1, \xi_2, \xi_3)}{\partial(x^1, x^2, x^3)} dt d\mathbf{x} \\
&= \int\int_{V_\mathbf{x}} \delta\mathbf{u} \left\{ m\mathbf{u}\rho + \frac{\hbar}{2}\boldsymbol{\nabla}\rho \right\} dt d\mathbf{x} - \int\oint \frac{\hbar}{2}\rho\delta\mathbf{u} dt d\mathbf{S}
\end{aligned}$$

where

$$\rho = \rho_0(\boldsymbol{\xi}) \frac{\partial(\xi_1, \xi_2, \xi_3)}{\partial(x^1, x^2, x^3)} = \rho_0(\boldsymbol{\xi}) \left(\frac{\partial(x^1, x^2, x^3)}{\partial(\xi_1, \xi_2, \xi_3)} \right)^{-1} \qquad (3.5)$$

We obtain the following dynamic equation

$$\delta\mathbf{u}: \qquad m\rho\mathbf{u} + \frac{\hbar}{2}\boldsymbol{\nabla}\rho = 0 \qquad (3.6)$$

where $\rho = \rho(t, \mathbf{x})$ is defined by the relation (3.5). Resolving (3.6) with respect to $\mathbf{u}$, we obtain the equation

$$\mathbf{u} = \mathbf{u}(t, \mathbf{x}) = -\frac{\hbar}{2m}\boldsymbol{\nabla}\ln\rho, \qquad (3.7)$$

which reminds the expression for the mean velocity of the Brownian particle with the diffusion coefficient $D = \hbar/2m$.

Variation of the action (3.2) with respect to $\mathbf{x}$ is produced at fixed form of $\mathbf{u}$, but $\mathbf{u} = \mathbf{u}(t, \mathbf{x})$, and argument $\mathbf{x}$ of the function $\mathbf{u}$ should be varied. Variation of

(3.2) with respect to $\mathbf{x}$ gives

$$\delta\mathcal{A}_{\mathcal{S}_{\mathrm{st}}}\left[\mathbf{x},\mathbf{u}\right]=\int\left\{m\dot{\mathbf{x}}\delta\dot{\mathbf{x}}+\delta\left(\frac{m}{2}\mathbf{u}^{2}-\frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u}\right)\right\}\rho_{0}\left(\boldsymbol{\xi}\right)dtd\boldsymbol{\xi},\tag{3.8}$$

One obtains dynamic equation

$$\delta\mathbf{x}:\qquad -m\frac{d^{2}\mathbf{x}}{dt^{2}}+\boldsymbol{\nabla}\left(\frac{m}{2}\mathbf{u}^{2}-\frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u}\right)=0\tag{3.9}$$

Substituting (3.7) in (3.9) and considering ρ as a function of $t,\mathbf{x}$, one obtains

$$m\frac{d^{2}\mathbf{x}}{dt^{2}}=-\boldsymbol{\nabla}U_{\mathrm{B}}\tag{3.10}$$

where d/dt means the substantial derivative with respect to time t

$$\frac{dF}{dt}\equiv\frac{\partial\left(F,\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(t,\xi_{1},\xi_{2},\xi_{3}\right)}$$

$\boldsymbol{\nabla}$ is gradient in the space of coordinates x, and U_{B} is so-called Bohm potential

$$U_{\mathrm{B}}\left(t,\mathbf{x}\right)=-\frac{m}{2}\mathbf{u}^{2}+\frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u}=U\left(\rho,\boldsymbol{\nabla}\rho,\boldsymbol{\nabla}^{2}\rho\right)=\frac{\hbar^{2}}{8m}\frac{\left(\boldsymbol{\nabla}\rho\right)^{2}}{\rho^{2}}-\frac{\hbar^{2}}{4m}\frac{\boldsymbol{\nabla}^{2}\rho}{\rho}=-\frac{\hbar^{2}}{2m}\frac{1}{\sqrt{\rho}}\boldsymbol{\nabla}^{2}\sqrt{\rho}\tag{3.11}$$

One obtains

$$m\frac{d^{2}\mathbf{x}}{dt^{2}}=\frac{\hbar^{2}}{2m}\boldsymbol{\nabla}\left(\frac{1}{\sqrt{\rho}}\boldsymbol{\nabla}^{2}\sqrt{\rho}\right)\tag{3.12}$$

However, the relation (3.5) determines the variable ρ as a function of variables $x^{\alpha,\beta}\equiv\partial x^{\alpha}/\partial\xi_{\beta}$, and one needs to take into account this circumstance in the dynamic equation (3.12).

Let us introduce auxiliary quantity

$$R=R\left(x^{\mu,\nu}\right)=\frac{\rho_{0}\left(\boldsymbol{\xi}\right)}{\rho}=\frac{\partial\left(x^{1},x^{2},x^{3}\right)}{\partial\left(\xi_{1},\xi_{2},\xi_{3}\right)}=\det\left|\left|x^{\alpha,\beta}\right|\right|,\qquad\alpha,\beta=1,2,3\tag{3.13}$$

which is 3-linear function of $x^{\alpha,\beta}$. Let us take into account the identity

$$\frac{\partial x^{\alpha}}{\partial\xi_{\beta}}\frac{\partial R}{\partial x^{\alpha,\gamma}}\equiv x^{\alpha,\beta}\frac{\partial R}{\partial x^{\alpha,\gamma}}\equiv\delta_{\gamma}^{\beta}R$$

Here and later on there is a summation over repeating indices: $0-3$ for Latin indices and $1-3$ for Greek ones. Convoluting this identity with $\partial\xi_{\mu}/\partial x^{\beta}$, one obtains

$$\frac{\partial\xi_{\mu}}{\partial x^{\beta}}x^{\alpha,\beta}\frac{\partial R}{\partial x^{\alpha,\gamma}}\equiv\delta_{\gamma}^{\beta}R\frac{\partial\xi_{\mu}}{\partial x^{\beta}},\qquad\frac{\partial\xi_{\mu}}{\partial x^{\gamma}}=\frac{1}{R}\frac{\partial R}{\partial x^{\mu,\gamma}}$$

Then one obtains expression for derivative $\partial/\partial x^{\alpha}$ in terms of derivatives $\partial/\partial\xi_{\beta}$

$$\frac{\partial F}{\partial x^{\alpha}}=\frac{\partial\xi_{\beta}}{\partial x^{\alpha}}\frac{\partial F}{\partial\xi_{\beta}}=\frac{1}{R}\frac{\partial R}{\partial x^{\alpha,\beta}}\frac{\partial F}{\partial\xi_{\beta}}, \tag{3.14}$$

where F is an arbitrary quantity. Then in terms of independent variables $t,\boldsymbol{\xi}$ (Lagrangian representation) dynamic equations (3.12) can be written in the form

$$m\frac{d^{2}x^{\alpha}}{dt^{2}}=\frac{\hbar^{2}}{2mR}\frac{\partial R}{\partial x^{\alpha,\beta}}\frac{\partial}{\partial\xi_{\beta}}\left[\frac{1}{\sqrt{R}}\frac{\partial R}{\partial x^{\mu,\nu}}\frac{\partial}{\partial\xi_{\nu}}\left(\frac{1}{R}\frac{\partial R}{\partial x^{\mu,\sigma}}\frac{\partial}{\partial\xi_{\sigma}}\frac{1}{\sqrt{R}}\right)\right],\qquad\alpha=1,2,3 \tag{3.15}$$

The mean velocity $\mathbf{u}$ of stochastic component (3.7) in terms of Lagrangian variables has the form

$$u^{\alpha}\left(t,\boldsymbol{\xi}\right)=-\frac{\hbar}{2m\rho_{0}\left(\boldsymbol{\xi}\right)}\frac{\partial R}{\partial x^{\alpha,\beta}}\frac{\partial}{\partial\xi_{\beta}}\frac{\rho_{0}\left(\boldsymbol{\xi}\right)}{R},\qquad\alpha=1,2,3 \tag{3.16}$$

Dynamic equation (3.15) contains only derivatives of $\mathbf{x}$ with respect to t and ξ_{α}. This equation is rather bulky.

In the Euler representation (in terms of independent variables $t,\mathbf{x}$) this equation takes a simpler form. To obtain dynamic equations in the Euler dynamic variables $t,\mathbf{x}$, let us return to dynamic equation (3.12), which can be written in the form

$$\frac{d\mathbf{v}}{dt}=\frac{\partial\mathbf{v}}{\partial t}+\left(\mathbf{v}\boldsymbol{\nabla}\right)\mathbf{v}=-\frac{1}{m}\boldsymbol{\nabla}U_{\mathrm{B}},\qquad\mathbf{v}=\mathbf{v}\left(t,\mathbf{x}\right) \tag{3.17}$$

Using the relation (3.5), let us represent the quantity $\rho\mathbf{v}$ in the form

$$\rho\mathbf{v}\left(t,\mathbf{x}\right)=\rho_{0}\left(\boldsymbol{\xi}\right)\frac{\partial\left(t,\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(t,x^{1},x^{2},x^{3}\right)}\frac{\partial\left(\mathbf{x},\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(t,\xi_{1},\xi_{2},\xi_{3}\right)}=\rho_{0}\left(\boldsymbol{\xi}\right)\frac{\partial\left(\mathbf{x},\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(t,x^{1},x^{2},x^{3}\right)} \tag{3.18}$$

Then using identity

$$\frac{\partial}{\partial t}\left(\rho_{0}\left(\boldsymbol{\xi}\right)\frac{\partial\left(\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(x^{1},x^{2},x^{3}\right)}\right)+\frac{\partial}{\partial x^{\alpha}}\left(\rho_{0}\left(\boldsymbol{\xi}\right)\frac{\partial\left(x^{\alpha},\xi_{1},\xi_{2},\xi_{3}\right)}{\partial\left(t,x^{1},x^{2},x^{3}\right)}\right)\equiv 0 \tag{3.19}$$

one obtains the continuity equation for variables $\rho=\rho\left(t,\mathbf{x}\right)$ and $\mathbf{v}=\mathbf{v}\left(t,\mathbf{x}\right)$

$$\frac{\partial\rho}{\partial t}+\frac{\partial}{\partial x^{\alpha}}\left(\rho v^{\alpha}\right)=0 \tag{3.20}$$

Equations (3.17), (3.20) together with (3.11) form dynamic equations for the statistical ensemble of stochastic particles in Euler dynamical variables.

Any reference to the stochastic velocity distribution or to some other probability distribution is absent. Influence of this distribution on the mean motion of the particles is described by the form of Bohm potential U_{B} (3.11). The situation reminds the case of the gas dynamics, where the action of the Maxwell velocity distribution on the gas motion is described by the internal gas energy. Of course, such a description is not comprehensive, however, it is sufficient for a description of the mean motion of the stochastic particle. As a result we obtain a *purely dynamic description* of the stochastic particle motion.

4 Problems of relativistic quantum theory, generated by the nonrelativistic concept of particle state.

The quantum mechanics is a kind of axiomatic conception, whereas the statistical foundation of quantum mechanics is a model conception. The same situation we have in the theory of thermal phenomena: thermodynamics is an axiomatic conception, whereas the statistical foundation of thermodynamics (kinetic gas theory) is a model conception.

Any model conception has more parameters, than the axiomatic conception has. The model conception is more detailed. It is more open for modifications, than the corresponding axiomatic conception.

Linearity of the quantum dynamic equations in terms of the wave function is considered as a basic property, generating a use of linear operators in the quantum mechanics formalism. In the relativistic quantum field theory the linearity is considered as a very important property of quantum mechanics. One one hand, the linearity of differential equations simplifies their solution, and this property seems to be very important. On the other hand, the linearity is a mathematical property of a theory, which does not describe any physical property. In classical physics linear equations appear as a corollary of small deviations from a stationary state. Linearity of the quantum theory is one of quantum principles. It is a basis for introduction of linear operators in the quantum mechanics formalism.

In the statistical description of quantum mechanics the linearity ceases to be a principle. From viewpoint of statistical foundations of the quantum mechanics the linearity is an incidental property of nonrelativistic dynamic equations, written in terms of the wave function. It is a very useful property, but it should be hardly considered as a principle.

Conventional relativistic quantum field theory is considered to be a result of uniting of relativistic principles and those of quantum mechanics. The main property of the relativistic quantum field theory is the pair production phenomenon, which is absent in the nonrelativistic quantum mechanics. Mechanism of pair production is not clear. It is considered as an enigmatic quantum effect, which has not a classical analog. From classical view point the pair production effect is a turn-round of the world line in time. There are no classical fields, which could carry out such a turn-round.

Nevertheless, in the quantum field theory practically any nonlinear term in the Klein-Gordon equation

$$g^{ik}\partial_i\partial_k\psi + \frac{m^2c^2}{\hbar^2}\psi = 0 \tag{4.1}$$

is considered as a source of the pair production. For instance, it is considered that the pair production is described by the nonlinear Klein-Gordon equation

$$g^{ik}\partial_i\partial_k\psi + \frac{m^2c^2}{\hbar^2}\psi = \lambda\psi^*\psi\psi \tag{4.2}$$

where λ is some constant.

Unfortunately it is a delusion, generated by nonrelativistic concept of the particle, when a particle and antiparticle are considered as different physical objects, described by different dynamical systems. This approach is reflected mathematically in the identification of the particle energy with its Hamiltonian [23]. This identification takes place in the nonrelativistic case, when there is no pair production. However in the relativistical theory the particle and the antiparticle should be considered as different states of one physical object (world line). In this case the particle and antiparticle are described by the same dynamical system, and identification of energy of a free particle with its Hamiltonian leads to inconsistency of the relativistic quantum field theory.

This inconsistency appears in the nonstationarity of the vacuum state. (At the second quantization of the Schrödinger equation, where there is no antiparticles, the vacuum state is stationary. It is simply an empty space). Along with nonstationary vacuum state the equation (4.2) can be secondary quantized only by means of perturbative methods. Application of the method of the secondary quantization, where particle and antiparticle are considered as different states of the same physical object, leads to a stationary vacuum state. Besides, in this case the perturbative methods of consideration are not needed, in general, [24]. In this case the free particle energy distinguishes from its Hamiltonian. However, at such a method of the second quantization the pair production effect disappear, the nonlinear term in (4.2) cannot be responsible for pair production. For generation of pair production the term, describing interaction (selfaction), is to have a very special form.

However, why does one obtain pair production at the conventional method of the second quantization of equation (4.2)? In inconsistent conception one can obtain any desirable result. More concretely, at the conventional method of the second quantization a single physical object (world line) is cut into parts (particles and antiparticles). After calculation of their evolution (scattering matrix) these parts are united into whole world lines. The procedure of uniting is approximate, because one uses perturbative methods. As a result some parts of the whole world line remains to be separated. These separated parts of the world line imitate pair production.

A generalization of the foundation of the nonrelativistic quantum mechanics on the relativistic case is produced by a replacement of the nonrelativistic Lagrangian in (3.8) with a relativistic one.

5 Generalization of statistical description on the case of arbitrary stochasticity

To overcome problems, generated by the nonrelativistic concept of the particle state, when particle and antiparticle are considered as independent physical objects, one needs to carry out a logical reloading and to use a relativistic concept of a particle. Besides, one needs to ignore linearity of the conventional quantum theory and to change properly a character of stochasticity of indeterministic particles, responsible for quantum effects.

The action (3.8) for the statistical ensemble of free nonrelativistic stochastic particles may be easily generalized to the case of arbitrary stochastic systems. Let $\mathcal{S}_{\rm d}$ be a deterministic physical system having the finite number of the freedom degrees. The state of $\mathcal{S}_{\rm d}$ is described by the generalized coordinates $\mathbf{x} = \{x^1, x^2, ...x^n\}$. The action has the form

$$\mathcal{A}_{\mathcal{S}_{\rm d}}[\mathbf{x}] = \int L_{\rm d}(t, \mathbf{x}, \dot{\mathbf{x}}, P)\, dt, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{5.1}$$

where $\mathbf{x} = \mathbf{x}(t)$ and P are some parameters of the system (for instance, masses, charges, etc.)

Statistical ensemble $\mathcal{E}[\mathcal{S}_{\rm d}]$ of dynamic systems $\mathcal{S}_{\rm d}$ is described by the action

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\rm d}]}[\mathbf{x}] = \int\int_{V_\xi} L_{\rm d}(t, \mathbf{x}, \dot{\mathbf{x}}, P)\, \rho_0(\boldsymbol{\xi})\, dtd^n\xi, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{5.2}$$

where $\mathbf{x} = \mathbf{x}(t, \boldsymbol{\xi}) = \{x^1(t, \boldsymbol{\xi}), x^2(t, \boldsymbol{\xi}), ...x^n(t, \boldsymbol{\xi})\}$. The variables $\boldsymbol{\xi} = \{\xi_1, \xi_2, ...\xi_n\}$ label elements $\mathcal{S}_{\rm d}$ of the statistical ensemble. The quantity $\rho_0(\boldsymbol{\xi})$ is the weight factor. The number k of the labelling variables is chosen to be equal to the number n of generalized coordinates, in order one can to pass to the independent variables $t, \mathbf{x}$, resolving relations $\mathbf{x} = \mathbf{x}(t, \boldsymbol{\xi})$ in the form $\boldsymbol{\xi} = \boldsymbol{\xi}(t, \mathbf{x})$. If we are not going to pass to independent variables $t, \mathbf{x}$, the integer number $k > 0$ may be chosen arbitrary.

If some disturbing agent influences on the deterministic system $\mathcal{S}_{\rm d}$, it turns into the stochastic system $\mathcal{S}_{\rm st}$ and the action (5.2) turns into the action $\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\rm st}]}$

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\rm st}]}[\mathbf{x}, u] = \int\int_{V_\xi} L(t, \mathbf{x}, \dot{\mathbf{x}}, P_{\rm eff}(u))\, \rho_0(\boldsymbol{\xi})\, dtd^n\xi, \qquad \dot{\mathbf{x}} \equiv \frac{d\mathbf{x}}{dt} \tag{5.3}$$

where $\mathbf{x} = \mathbf{x}(t, \boldsymbol{\xi})$ and $u^k = \left\{u^k(t, \mathbf{x})\right\}$, $k = 0, 1, ...n$, are dependent variables. The new dependent variables u^k describe the mean value of the stochastic component of the generalized velocity $\dot{\mathbf{x}}$. It is supposed, that the disturbing agent changes the values of the parameters of dynamic system $S_{\rm d}$. The Lagrangian $L(t, \mathbf{x}, \dot{\mathbf{x}}, P_{\rm eff}(u))$ for the statistical ensemble of the corresponding stochastic systems $\mathcal{S}_{\rm st}$ is obtained from the Lagrangian $L_{\rm d}(t, \mathbf{x}, \dot{\mathbf{x}}, P)$ for the statistical ensemble of the dynamic system $\mathcal{S}_{\rm d}$ by means of the replacement [25]

$$P \to P_{\rm eff}(u) \tag{5.4}$$

in the expression (5.2). Passing to description of stochastic system $\mathcal{S}_{\rm st}$, we *do not introduce any probabilistic structures, and the description remains to be purely dynamic.* Character of stochasticity is determined by the form of the change (5.4).

In the case, when the dynamic system $\mathcal{S}_{\rm d}$ is the free uncharged relativistic particle, the only parameter P is the particle mass m. If the disturbing agent is the distortion of the space-time geometry, the replacement (5.4) has the form

$$m \to m_{\rm eff} = \sqrt{m^2 + \frac{\hbar^2}{c^2}\left(g_{kl}\kappa^k\kappa^l + \partial_k\kappa^k\right)} \tag{5.5}$$

where c is the speed of the light, g_{kl} =diag$\{c^2,-1,-1,-1\}$ is the metric tensor,

$$\kappa^k=\frac{m}{\hbar}u^k,\qquad k=0,1,2,3 \tag{5.6}$$

and $u^k\left(t,\mathbf{x}\right)=u^k\left(x\right)$ is the mean value of the stochastic component of the particle 4-velocity. Here and later on there is a summation over repeating indices: $0-3$ for Latin indices and $1-3$ for Greek ones.

In the relativistic case the action for the statistical ensemble (5.3) has the form

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\mathrm{st}}]}\left[x,\kappa\right]=-\int\int_{V_{\boldsymbol{\xi}}}mcK\sqrt{g_{ik}\dot{x}^i\dot{x}^k}\rho_0\left(\boldsymbol{\xi}\right)d\tau d\boldsymbol{\xi},\qquad \dot{\mathbf{x}}\equiv\frac{d\mathbf{x}}{d\tau} \tag{5.7}$$

$$K=\sqrt{1+\lambda^2\left(g_{kl}\kappa^k\kappa^l+\partial_k\kappa^k\right)},\qquad \lambda=\frac{\hbar}{mc} \tag{5.8}$$

where $x=\left\{x^k\right\}=\left\{x^k\left(\tau,\boldsymbol{\xi}\right)\right\}$, $k=0,1,2,3.$ The quantity g_{kl} =diag$\{c^2,-1,-1,-1\}$ is the metric tensor. The independent variables $\boldsymbol{\xi}=\{\xi_1,\xi_2,\xi_3\}$ label the particles of the statistical ensemble. The dependent variables $\kappa^k=\kappa^k\left(x\right)$, $k=0,1,2,3$ form some force field, connected with the stochastic component of the particle 4-velocity, and λ is the Compton wave length of the particle.

In the nonrelativistic approximation, one may neglect the temporal component $\kappa^0=\frac{m}{\hbar}u^0$ with respect to the spatial one $\boldsymbol{\kappa}=\frac{m}{\hbar}\mathbf{u}$. Setting $\tau=t=x^0$ in (5.7), (5.8) we obtain in the nonrelativistic approximation instead of (5.7)

$$\mathcal{A}_{\mathcal{E}[\mathcal{S}_{\mathrm{st}}]}\left[\mathbf{x},\mathbf{u}\right]=\int\int_{V_{\boldsymbol{\xi}}}\left\{-mc^2+\frac{m}{2}\dot{\mathbf{x}}^2+\frac{m}{2}\mathbf{u}^2-\frac{\hbar}{2}\boldsymbol{\nabla}\mathbf{u}\right\}\rho_0\left(\boldsymbol{\xi}\right)dtd\boldsymbol{\xi},\qquad \dot{\mathbf{x}}\equiv\frac{d\mathbf{x}}{dt} \tag{5.9}$$

The action (5.9) coincides with the action (3.2) except for the first term, which does not contribute to dynamic equations.

In the relativistic case, varying (5.7) with respect to κ^i, we obtain the dynamic equations

$$\frac{\delta\mathcal{A}}{\delta\kappa^i}=-\lambda^2\frac{mcK\sqrt{g_{ik}\dot{x}^i\dot{x}^k}\rho_0\left(\boldsymbol{\xi}\right)}{K}g_{ik}\kappa^k+\lambda^2\partial_i\frac{mcK\sqrt{g_{ik}\dot{x}^i\dot{x}^k}\rho_0\left(\boldsymbol{\xi}\right)}{2K}=0 \tag{5.10}$$

These equations are integrated in the form

$$\kappa=\frac{1}{2}\log\frac{C\sqrt{g_{ik}\dot{x}^i\dot{x}^k}\rho_0\left(\boldsymbol{\xi}\right)}{K},\qquad C=\mathrm{const} \tag{5.11}$$

where the quantity κ is a potential for the field κ^k

$$\partial_k\kappa=g_{kl}\kappa^l,\qquad k=0,1,2,3 \tag{5.12}$$

The dynamic equation (5.11) may be rewritten in the form

$$e^{2\kappa}=C\frac{\sqrt{g_{ik}\dot{x}^i\dot{x}^k}\rho_0\left(\boldsymbol{\xi}\right)}{\sqrt{1+\lambda^2g^{ls}e^{-\kappa}\partial_k\partial^ke^{\kappa}}},\qquad C=\mathrm{const} \tag{5.13}$$

which is an analog of nonrelativistic dynamic equation (3.7).

The fundamental difference between the nonrelativistic description (3.7) and the relativistic description (5.13) is as follows. The nonrelativistic equation (3.7) does not contain temporal derivatives, and the field $\mathbf{u}$ is determined uniquely by its source (the particle density ρ). The relativistic equation (5.13) contains temporal derivatives, and the κ-field $u^k = \hbar\kappa^k/m$ can exist without its source. The relativistic κ-field $u^k = \hbar\kappa^k/m$ can escape from its source. Besides, the κ-field changes the effective particle mass, as one can see from the relations (5.5) or (5.7), (5.8). If $\boldsymbol{\kappa}^2$ is large enough, or $\partial_k\kappa^k < 0$ and $\left|\partial_k\kappa^k\right|$ is large enough, the effective particle mass may be imaginary. In this case the mean world line may turn-round in the time direction, and this turn-round may appear to be connected with the pair production, or with the pair annihilation.

In the nonrelativistic case the mean stochastic velocity $\mathbf{u}$ may be eliminated and replaced by its source (the particle density ρ). In the relativistic case the κ-field has in addition its own degrees of freedom, which cannot be eliminated, replacing the κ-field by its source. The κ-field can travel from one space-time region to another.

The uniform formalism of dynamics (with the statistical ensemble as a basic object of dynamics) admits one to describe such a physical phenomena, which cannot be described in the framework of the conventional dynamic formalism, when the basic object is a dynamic system. In particular, one can describe the pair production effect, which cannot been described in the framework of the conventional relativistic mechanics, as well as in the framework of the nonrelativistic quantum mechanics.

6 Concluding remarks

Thus, it is very important to develop a physical conception, using adequate concepts. A proper logical reloading, using adequate physical concepts, leads to a successful physical theory. Effective logical reloading in the development of the microcosm physics contains the following points:

(1) Dynamical conception of the statistical description, where the concept of the probability density is not used because of its nonrelativistic character.

(2) Statistical ensemble is considered as a basic object of dynamics. It admits one to describe motion of all particles in a uniform way.

(3) Refuse from the property of linearity, which is valid for the nonrelativistic quantum mechanics, but not for the relativistic one.

(4) Relativistic concept of the particle state, when particle and antiparticle are two different states of one physical object (world line) instead of nonrelativistic particle state, when particle and antiparticle are considered as two different objects, described by different dynamic systems.

All these statements are not hypotheses. They are simply statements of the particle dynamics. These statements are free from constraints of nonrelativistic concepts.

In general, the present paper is devoted to conceptual problems of the microcosm physics. We do not go into details and do not try to explain concrete physical effects, keeping in mind, that the physical effects can be calculated and explained easily, basing on true physical principles. However, if not all physical principles are true, or if we are not able to use physical principles correctly (for instance, we use nonrelativistic concepts instead of relativistic ones), our conclusions become to be incorrect. In this case we are forced to invent hypotheses, which compensate our mistakes for some concrete physical phenomenon, but these hypotheses may fail to explain another physical phenomenon.

When invention of hypotheses becomes to be a system of scientific investigations, one obtains a system of fittings instead of effective scientific investigations. In this case the researchers cease to trust in effective applications of physical principles. They trust only in effective hypotheses with subsequent experimental test. A use of quantum mechanics and quantum principles lead to such a situation, when theorists do not work with physical principles, reposing on happy hypotheses. The mentality of contemporary physicists-theorists, dealing with physical phenomena of microcosm, differs from the mentality of physicists of the nineteenth century, when physicists trusted, that one can discover such physical principles, which could explain all physical phenomena. One can discover this mentality in reports of many reviewers of articles, devoted to obtaining of logical conclusions from well known and well tested physical principles. The reviewers do not try to find a logical mistake in the author's considerations. The reviewers demand an experimental test of the undesirable logical conclusions of the author. Such a demand is justified, if the author uses some new hypothesis. In the case, when the author does not use any hypotheses, it is an occurrence of the fitting mentality.

Let me illustrate my statement by a concrete example. I have submitted my paper in a well known physical journal. In this paper the equation (4.2) was quantized in the representation, when particle and antiparticle were considered as two different states of one physical object (world line). As a result corresponding dynamic equations can be solved exactly (without perturbative methods), but there are no pair production. The reviewer wrote something like that: "The paper cannot be published, because the author states himself, that the pair production is absent."

This decision of the reviewer reflects the fitting mentality of the contemporary scientific community, when only result of investigation is of importance. Whether or not the conception is inconsistent, and whether a particle and an antiparticle can interact, being a different dynamic systems, is of no importance. Investigators want to explain pair production, and they are ready to explain this even by means of inconsistent conception. Such an approach has a disappointing consequence.

One can see results of such a fitting mentality in the physics of microcosm. Contemporary theory of elementary particles is an axiomatic conception. As any axiomatic conception it cannot describe arrangement of elementary particles. It can only classify elementary particles and predict new elementary particles, but it cannot explain their arrangement. For instance, the statement, that proton consists of quarks is a result, based on experimental data (but not on physical principles). The contemporary theory of elementary particles reminds the periodical system of chemical elements, which also classifies chemical elements and predicts new chemical elements, but it could not explain arrangement of atoms of chemical elements. (The periodical system of chemical elements contributes nothing to the atom construction theory, although it has been created before investigations of atomic structure). One may say, that the contemporary theory of elementary particles is rather a chemistry, than a physics of elementary particles [26]. It means, that the microcosm physics development as an axiomatic conception cannot be effective, if we want to understand the elementary particles arrangement (but not only their systematization).

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