Model conception of quantum phenomena and its capacities.

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Abstract

One can construct the model conception of quantum phenomena (MCQP) which relates to the axiomatic conception of quantum phenomena (ACQP), (i.e. to the conventional quantum mechanics) in the same way, as the statistical physics relates to thermodynamics. Such a possibility is based on a new conception of geometry, admitting to construct such a deterministic space-time geometry, where motion of free particles is primordially stochastic. The space-time geometry can be chosen in such a way that statistical description of random particle motion coincides with the quantum description. Capacities of MCQP for investigation of physical phenomena of microcosm are discussed. Methods of investigations in MCQP appear to be more subtle. For instance, investigation of the free Dirac equation in framework of MCQP shows that the Dirac particle is in reality a rotator, i.e. two particles rotating around their common center of inertia. In the framework of MCQP one can discover the force field, responsible for pair production.

1 Introduction

Sometimes investigation of a new class of physical phenomena is carried out by two stages. At first, the simpler axiomatic conception based on simple empiric considerations arises. Next, the axiomatic conception is replaced by the more developed model conception, where axioms of the first stage are obtained as properties of the model. Theory of thermal phenomena was developed according to this scheme. At first, the thermodynamics (axiomatic conception) appeared. Next, the statistical physics (model conception) appeared. Axioms of thermodynamics where obtained as properties of the chaotic molecule motion. This natural process of the physical theory development is connected with another characteristic property of the human cognition. Unfortunately, peoples make mistakes, which should be overcame.

There are two ways of the mistake overcoming: (1) compensation of the mistake and (2) correction of the mistake. Compensation of the mistake is a simpler process, than its correction. To compensate the mistake, there is no necessity to know, whether the mistake takes place and what it consists in. It is sufficient to invent some additional hypotheses, which would explain a class of considered physical phenomena. Unfortunately, at further expansion of the class of considered phenomena one needs to invent new hypotheses. As the theory is developed, the new hypotheses are accumulated, and the theory takes a tangly form.

To correct the mistake, one needs to concise that the mistake takes place and what does it consist in. It is much more difficult, than to compensate the mistake. But after correction of the mistake there is no necessity to invent new hypotheses. After correction of the mistake the theory becomes to be more perfect, than the theory appearing as a result of its compensation. In the Ptolemaic doctrine the mistake in our conception on the planetary system was only compensated. Copernicus had corrected this mistake. Influence of this correction on the science development is well known.

The contemporary quantum theory is the first (axiomatic) stage in the development of the microcosm physics. Formal evidences of this is an existence of quantum principles. Appearance of the next (model) stage, where the quantum principles are consequences of the model, seems to be unavoidable. The model conception is attractive also, because it gives boundaries of the quantum principles application. (Statistical physics determined, where thermodynamics stopped to be applicable.) Besides, the contemporary quantum theory is a compensating (Ptolemaic) theory, i.e. it is a theory constructed as a result of compensation of some ingrain mistakes. Formal criterion of this circumstance is existence of many additional hypotheses in the elementary particle theory. The number of these hypotheses is so large, that the quantum principles do not work essentially in the elementary particle theory.

What kind of mistakes do appear in the microcosm physics? There are two mistakes (1) inadequate space-time model, which is approximately valid in the macrocosm and essentially false in the microcosm and (2) inadequate statistical description of relativistic stochastic processes.

The true space-time geometry is such a geometry, where motion of microparticles is primordially stochastic, although the geometry in itself is not random (intervals between the events in such a geometry are deterministic, but not random). To construct such a geometry (T-geometry), one needs to go outside the framework of Riemannian geometry, which is the most general contemporary geometry fitting for the space-time description. Being flat, uniform and isotropic, the true geometry of the absolute space-time distinguishes from the Minkowski geometry only in some correction containing the quantum constant $\hbar$. This correction is essential only for short space-time intervals, i.e. only in microcosm.

Statistical description of the particle random motion generated by the space-time geometry leads to the quantum mechanical description (the quantum constant

$\hbar$ appears in the theory via geometry), in the same way as the statistical description of chaotic molecule motion leads to thermodynamics. Essential difference between the two statistical descriptions lies in the difference between the statistical description for relativistic and nonrelativistic cases. In the case of the statistical physics both regular and random components of the velocity are nonrelativistic, whereas in the case of geometric stochasticity the random velocity component is relativistic, although the nonrelativistic component may be nonrelativistic. As a result even the nonrelativistic quantum mechanics appears to be a hidden relativistic theory. There is essential difference between the relativistic and nonrelativistic statistical descriptions. The fact is that the nonrelativistic statistical description may be probabilistic, i.e. it can be carried out in terms of the probability density, whereas *the relativistic statistical description cannot be produced in terms of the probability theory.* The problem lies in the fact that physical objects to be statistically described are different in the relativistic and nonrelativistic theories.

In the nonrelativistic theory the physical object is a point, i.e. a pointlike (zero-dimensional) object in three-dimensional space, and the particle world line describes a history of in the pointlike object. In other words, the particle is primary and its world line is secondary. In the *consequent* relativistic theory the situation is inverse. The physical object is the world line, i.e. the one-dimensional line in the space-time, whereas the particle and the antiparticle are derivative objects (intersections of the world line with the surface $t =$const). In other words, in the consequent relativistic theory the world line is primary, whereas the particle and antiparticle are secondary. The term 'WL' will be used for the world line considered to be a primary physical object. The difference in the choice of the primary physical object is conditioned by different relation to the existence of absolute simultaneity in relativistic and nonrelativistic physics. Statistical description must be a description of primary physical objects. Foundation for such a description is the density of physical objects in the three-dimensional space (for particles) or in the space-time (for WLs). Density $\rho(x)$ of particles at the point x is defined by the relation

$$dN = \rho(x)dV \tag{1.1}$$

where dN is the number of particles in the 3-volume dV. The particle density is defined as a proportionality coefficient between dN and dV. The density $j^k(x)$ of WLs is defined by the relation

$$dN = j^k(x)\, dS_k \tag{1.2}$$

where dN is the flux of WLs through three-dimensional area dS_k in the space-time in vicinity of the point x. The quantity $j^k(x)$ is the proportionality coefficient between dN and dS_k in vicinity of the point x. The quantity $\rho(x)$ is a 3-scalar. It can serve as a basis for introduction of the probability density, whereas the 4-vector $j^k(x)$ is not a nonnegative quantity, and it cannot serve as a basis for introduction of the probability density, which must be nonnegative quantity.

It is a common practice to think that terms "probabilistic description" and "statistical description" are synonyms. It is a delusion, because the probabilistic description is a description, founded on a use of the probability theory, whereas the statistical description is a description dealing with many similar or almost similar objects. Such a set of similar objects is called statistical ensemble. Statistical description is an investigation of the statistical ensemble properties. Statistical description without a use of the probability density is possible. It is necessary only to investigate the statistical ensemble without a use of the probability theory. We shall consider statistical ensembles of dynamic or stochastic systems and use essentially the circumstance, that *the statistical ensemble is a dynamic system*, even if its *elements are stochastic systems*. Such an approach may be qualified as the dynamic conception of statistical description (DCSD). It is appropriate in any case (relativistic and nonrelativistic). Statistical ensemble of discrete dynamic or stochastic systems is a continuous dynamic system, i.e. some fluid. Wave function is a way of description of an ideal fluid [1]. In other words, the wave function appears as a property of some model (but not as a fundamental object whose properties are defined by axiomatics). Under some conditions the irrotational flow of the fluid is described by the Schrödinger equation [2, 3]. The model conception of quantum phenomena (MCQP) appears. In its foundation MCQP differs from the conventional quantum mechanics, which may be qualified as axiomatic conception of quantum phenomena (ACQP). The model conception is developed according to other laws, than the axiomatic one. This circumstance can be seen easily at comparison of development of thermodynamics and statistical physics, which can be qualified respectively as axiomatic conception of thermal phenomena (ACTP) and model conception of thermal phenomena (MCTP).

MCQP is a result of modification of ACQP, and it is the zeroth order modification (M0). We use the following classification of possible modifications. Modification of the exisitng conception on the descriptive (conceptual) level, when basic concepts and methods of description are modified, is the zeroth order modification (M0). Modification of the exisitng conception on the dynamical level, when dynamic equations, or some suppositions, concerning dynamics, are modified, but there is no modification on the descriptive level, is the first order modification (M1). The descriptive level is deeper, than the dynamical one, because the system of concepts of a physical theory is a foundation for dynamics, and any modification on the descriptive level (M0) generates usually some modifications (M1) of dynamics or methods of dynamics description. Test of the modification validity is produced usually by means of a test of predictions of dynamics. As a result a test of M0 appears to be indirect and more difficult, than test of M1.

Schemes of predictions or explanations of new physical phenomena which is used for a test of the theory modification validity looks as follows

$$\mathrm{M0}: \quad \begin{array}{c}\text{modified}\\ \text{basic}\\ \text{statements}\end{array} \rightarrow \begin{array}{c}\text{new methods}\\ \text{of investigations}\end{array} \rightarrow \begin{array}{c}\text{new}\\ \text{phenomena}\end{array}$$

$$\mathrm{M1}: \quad \begin{array}{c}\text{new}\\ \text{hypothesis}\end{array} \rightarrow \begin{array}{c}\text{new}\\ \text{phenomena}\end{array}$$

One can see that the test of M0 is less effective, than a test of M1. In practice the author of a new modification of the existing theory is suggested to answer the following question: "Are there such a physical phenomena, which could be explained by means of the modified theory and could not be explained by existing theory?" In the case of negative answer the modified conception is considered to be useless, and it is rejected. This question is a test only for M1, because it is not effective for the test of M0.

To show this, let us imagine that this question was asked to Copernicus, who suggested his doctrine, which was the zeroth order modification (M0) of the Ptolemaic doctrine. Copernicus could not answer this question positively. Moreover, in hundred years after appearance of the Copernicus doctrine there were no positive answer for this question. Only beginning since Isaac Newton one could answer this question positively. By the way, beneficial influence of the Copernicus doctrine on the further science development is unchallengeable. Advantage of the Copernicus doctrine was simplicity, disengagement and consistency, but not the formal utility.

Note that the experimental test of validity of the zeroth order modification of a physical theory was always a difficult problem, and appearance of M0 had lead sometimes to conflicts in the scientific community (Copernicus – Ptolemeus, statistical physics – thermodynamics).

2 Geometry

There are two different approaches to geometry: mathematical and physical ones. In the mathematical approach a geometry is a construction founded on a system of axioms about points and straights. Practically any system of axioms, containing concepts of a point and a straight, may be called a geometry. Well known mathematician Felix Klein [4] supposed that only such a construction on a point set is a geometry, where all points of the set have the same properties (uniform geometry). For instance, Felix Klein insisted that Euclidean geometry and Lobachevsky geometry are geometries, because they are uniform, whereas the Riemannian geometries are not geometries at all. As a rule the Riemannian geometries are not uniform, and their points have different properties. According to the Felix Klein viewpoint, they should be called as "Riemannian topographies" or as "Riemannian geographies". It is a matter of habit and taste how to call the geometry. But Felix Klein was quite right in the relation, that he suggested to differ between the Euclidean geometry and Riemannian one. The fact is that the principle of the Riemannian geometry construction is quite different from that of the Euclidean geometry construction.

The Riemannian geometry is obtained as a result of the proper Euclidean geometry deformation, when the infinitesimal Euclidean interval ds_{E}^2 is replaced by the Riemannian interval $ds^2 = g_{ik}dx^i dx^k$. Such a change is a deformation of the Euclidean space. Such an approach to geometry, when a geometry is a result of the proper Euclidean geometry deformation will be referred to as a physical approach to geometry. The obtained geometry will be referred to as a physical geometry. The physical geometry has no own axiomatics. It uses "deformed" Euclidean axiomatics. The physical geometry describes mutual disposition of events in the space-time (or space). It is described by setting the distance between any two points. The metric ρ (distance between points) is the only characteristic of a physical geometry. The world function $\sigma = \frac{1}{2}\rho^2$ [5] is more convenient for description of the physical geometry, because it is real even for the space-time, where $\rho = \sqrt{2\sigma}$ may be imaginary.

Construction of any physical geometry is determined by the *deformation principle* [6]. It works as follows. The proper Euclidean geometry $\mathcal{G}_{\mathrm{E}}$ can be described in terms and only in terms of the world function σ_{E}, provided σ_{E} satisfies some constraints formulated in terms of σ_{E} [6]. It means that all geometric objects $\mathcal{O}_{\mathrm{E}}$ can be described σ-immanently (i.e. in terms of σ_{E} and only of σ_{E}) $\mathcal{O}_{\mathrm{E}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{E}})$. Relations between geometric objects are described by some expressions $\mathcal{R}_{\mathrm{E}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{E}})$. Any physical geometry $\mathcal{G}_{\mathrm{A}}$ can be obtained from the proper Euclidean geometry by means of a deformation, when the Euclidean world function σ_{E} is replaced by some other world function σ_{A} in all definitions of Euclidean geometric objects $\mathcal{O}_{\mathrm{E}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{E}})$ and in all Euclidean relations $\mathcal{R}_{\mathrm{E}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{E}})$ between them. As a result we have the following change

$$\mathcal{O}_{\mathrm{E}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{E}}) \to \mathcal{O}_{\mathrm{A}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{A}}), \qquad \mathcal{R}_{\mathrm{E}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{E}}) \to \mathcal{R}_{\mathrm{A}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{A}})$$

The set of all geometric objects $\mathcal{O}_{\mathrm{A}}$ and all relations $\mathcal{R}_{\mathrm{A}}$ between them forms a physical geometry, described by the world function σ_{A}. Index 'E' in the relations of physical geometry $\mathcal{G}_{\mathrm{A}}$ means that axiomatics of the proper Euclidean geometry was used for construction of geometric objects $\mathcal{O}_{\mathrm{E}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{E}})$ and of relations between them $\mathcal{R}_{\mathrm{E}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{E}})$. The same axiomatics is used for all geometric objects $\mathcal{O}_{\mathrm{A}} = \mathcal{O}_{\mathrm{E}}(\sigma_{\mathrm{A}})$ and relations between them $\mathcal{R}_{\mathrm{A}} = \mathcal{R}_{\mathrm{E}}(\sigma_{\mathrm{A}})$ in the geometry $\mathcal{G}_{\mathrm{A}}$. But now this axiomatics has another form, because of deformation $\sigma_{\mathrm{E}} \to \sigma_{\mathrm{A}}$. It means that the proper Euclidean geometry $\mathcal{G}_{\mathrm{E}}$ is the basic geometry for all physical geometries $\mathcal{G}$ obtained by means of a deformation of the proper Euclidean geometry. If basic geometry is fixed (it is this case that will be considered further), the geometry on the arbitrary set Ω of points is called T-geometry (tubular geometry). The T-geometry is determined [7, 8] by setting the world function σ:

$$\sigma: \quad \Omega \times \Omega \to \mathbb{R}, \qquad \sigma(P,P) = 0, \qquad \forall P \in \Omega \tag{2.1}$$

In general, no other constraints are imposed, although one can impose any additional constraints to obtain a special class of T-geometries. T-geometry is symmetric, if in addition

$$\sigma(P,Q) = \sigma(Q,P), \qquad \forall P, Q \in \Omega \tag{2.2}$$

Consequent application of *only deformation principle* admits one to obtain any physical geometry (T-geometry), which appears to be automatically as consistent as the Euclidean geometry, which lies in its foundation. The Riemannian geometries form a special class of T-geometries, determined by the constraint, imposed on the world function

$$\sigma_{\mathrm{R}}\left(x,x'\right)=\frac{1}{2}\left(\int\limits_{\mathcal{L}_{[xx']}}\sqrt{g_{ik}dx^{i}dx^{k}}\right)^{2}\qquad(2.3)$$

where σ_{R} is the world function of the Riemannian space, and $\mathcal{L}_{[xx']}$ means a geodesic segment between the points x and x'. Riemannian geometry is determined by the dimension n and $n\left(n+1\right)/2$ functions g_{ik} of one point x, whereas the class of all possible T-geometries is essentially more powerful, because it is determined by one function σ of two points x and x'.

In general, the deformation principle admits one to obtain such geometries, where non-one-dimensional tubes play the role of the straight lines. The real space-time geometry is such a kind. But creators of the Riemannian geometry supposed that a geometry with tubes instead of straights was impossible. The restriction (2.3) on Riemannian geometries was introduced to forbid deformation transforming one-dimensional Euclidean straights to many-dimensional tubes. But in nonuniform physical geometry one fails to suppress the tubular character of straights. In the Riemannian geometry one succeeds to make this, only refusing from the consequent application of the deformation principle and using additional means of the geometry construction. As a result the Riemannian geometry appears to be not quite consequent construction. This is displayed, in particular, in lack of absolute parallelism, whereas in any physical geometry constructed in accordance with the deformation principle the absolute parallelism takes place.(see details in [6]).

The tubular character of timelike straights in the real space-time is connected with the stochastic character of the free particles motion in such a space-time, because the straight (tube) $\mathcal{T}_{P_0P_1}$, passing through the points P_0 and P_1, is determined by the relation

$$\mathcal{T}_{P_0P_1}=\left\{R|\overrightarrow{P_0P_1}||\overrightarrow{P_0R}\right\}$$

according to which the tube $\mathcal{T}_{P_0P_1}$ is a set of such points R, that vectors $\overrightarrow{P_0P_1}$ and $\overrightarrow{P_0R}$ are parallel. The tubular character of the straight (thick straight) means that there are many directions $\overrightarrow{P_0R}$, parallel to the vector $\overrightarrow{P_0P_1}$. On the other hand, the motion of a free particle in the curved space-time is described by the equation of a geodesic

$$d\dot{x}^{i}=-\Gamma_{kl}^{i}\dot{x}^{k}dx^{l},\qquad dx^{l}=\dot{x}^{i}d\tau\qquad(2.4)$$

where Γ_{kl}^{i} is the Christoffel symbol. Equation (2.4) describes the parallel transport of the velocity vector $\dot{x}^{i}$ of the particle along the direction $dx^{i}=\dot{x}^{i}d\tau$, determined by the velocity vector $\dot{x}^{i}$. If there are many vectors parallel to the velocity vector $\dot{x}^{i}$, the parallel transport (2.4) appears to be not single-valued, and the world line becomes to be random.

The flat uniform isotropic space-time is described by the world function [9]

$$\sigma=\sigma_{\mathrm{M}}+D\left(\sigma_{\mathrm{M}}\right),\qquad D\left(\sigma_{\mathrm{M}}\right)=\frac{\hbar}{2bc}\geq10^{-21}\mathrm{cm}^{2},\quad\text{if}\quad\sigma_{\mathrm{M}}>\frac{\hbar}{2bc}\qquad(2.5)$$

where σ_{M} is the world function of the Minkowski space, c is the speed of the light. The distortion function $D(\sigma_{\mathrm{M}})$ describes the character of quantum stochasticity. In the space with unvanishing distortion $D(\sigma_{\mathrm{M}})$ the particle mass is geometrized [9], and $b \leq 10^{-17}$g/cm is the constant, describing connection between the geometric mass μ and usual mass m by means of the relation $m = b\mu$. Form of the distortion function $D(\sigma_{\mathrm{M}})$ is determined by the demand that the stochasticity generated by distortion is the quantum stochasticity, i.e. the statistical description of the free stochastic particle motion is equivalent to the quantum description in terms of the Schrödinger equation [9].

3 Statistical description

Let the statistical ensemble $\mathcal{E}_{\mathrm{d}}[\mathcal{S}_{\mathrm{d}}]$ of deterministic classical particles $\mathcal{S}_{\mathrm{d}}$ be described by the action $\mathcal{A}_{\mathcal{E}_{\mathrm{d}}[\mathcal{S}_{\mathrm{d}}(P)]}$, where P are parameters describing $\mathcal{S}_{\mathrm{d}}$ (for instance, mass, charge). Let under influence of some stochastic agent the deterministic particle $\mathcal{S}_{\mathrm{d}}$ turn to a stochastic particle $\mathcal{S}_{\mathrm{st}}$. The action $\mathcal{A}_{\mathcal{E}_{\mathrm{st}}[\mathcal{S}_{\mathrm{st}}]}$ for the statistical ensemble $\mathcal{E}_{\mathrm{st}}[\mathcal{S}_{\mathrm{st}}]$ is reduced to the action $\mathcal{A}_{\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}]} = \mathcal{A}_{\mathcal{E}_{\mathrm{st}}[\mathcal{S}_{\mathrm{st}}]}$ for some set $\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}]$ of identical interacting deterministic particles $\mathcal{S}_{\mathrm{d}}$. The action $\mathcal{A}_{\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}]}$ as a functional of $\mathcal{S}_{\mathrm{d}}$ has the form $\mathcal{A}_{\mathcal{E}_{\mathrm{d}}[\mathcal{S}_{\mathrm{d}}(P_{\mathrm{eff}})]}$, where parameters P_{eff} are parameters P of the deterministic particle $\mathcal{S}_{\mathrm{d}}$, averaged over the statistical ensemble, and this averaging describes interaction of particles $\mathcal{S}_{\mathrm{d}}$ in the set $\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}]$ [12, 11]. It means that

$$\mathcal{A}_{\mathcal{E}_{\mathrm{st}}[\mathcal{S}_{\mathrm{st}}]} = \mathcal{A}_{\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}(P)]} = \mathcal{A}_{\mathcal{E}_{\mathrm{d}}[\mathcal{S}_{\mathrm{d}}(P_{\mathrm{eff}})]} \tag{3.1}$$

In other words, stochasticity of particles $\mathcal{S}_{\mathrm{st}}$ in the ensemble $\mathcal{E}_{\mathrm{st}}[\mathcal{S}_{\mathrm{st}}]$ is replaced by interaction of $\mathcal{S}_{\mathrm{d}}$ in $\mathcal{S}_{\mathrm{red}}[\mathcal{S}_{\mathrm{d}}]$, and this interaction is described by a change

$$P \rightarrow P_{\mathrm{eff}} \tag{3.2}$$

in the action $\mathcal{A}_{\mathcal{E}_{\mathrm{d}}[\mathcal{S}_{\mathrm{d}}(P)]}$.

Action for the statistical ensemble of free deterministic particles has the form

$$\mathcal{A}[x] = -\int mc\sqrt{g_{ik}\dot{x}^i\dot{x}^k}d\xi_0 d\boldsymbol{\xi}, \qquad \dot{x}^i \equiv \frac{dx^i}{d\xi_0} \tag{3.3}$$

where $x = \{x^i\}$, $i = 0,1,2,3$ is a function of $\xi = \{\xi_0, \boldsymbol{\xi}\} = \{\xi_i\}$, $i = 0,1,2,3$.

The only parameter for the free particle is its mass m, and the change (3.2) in the nonrelativistic case has the form

$$m \rightarrow m_{\mathrm{eff}} = m\left(1 - \frac{\mathbf{u}^2}{2c^2} + \frac{\hbar}{2mc^2}\boldsymbol{\nabla}\mathbf{u}\right) \tag{3.4}$$

where $\mathbf{u} = \mathbf{u}(t, \mathbf{x})$ is the mean value of the stochastic velocity component. Quantum constant $\hbar$ appears here as coupling constant between the regular and stochastic components of the particle velocity. The velocity $\mathbf{u}$ is considered to be a new dependent variable, and dynamic equation for $\mathbf{u}$ is obtained as a result of the action variation with respect to $\mathbf{u}$ [11]. The velocity $\mathbf{u}$ is supposed to be small as compared with the speed of the light c.

In the relativistic case the change (3.2) takes the form

$$m^2 \to m_{\text{eff}}^2 = m^2 \left(1 + u_l u^l + \lambda \partial_l u^l\right), \qquad \lambda = \frac{\hbar}{mc} \tag{3.5}$$

where $u^l = \{u^0, \mathbf{u}\}$. Then the action (3.4) is transformed to the form

$$\mathcal{A}[x,\kappa] = -\int mcK\sqrt{g_{ik}\dot{x}^i\dot{x}^k}d\xi_0 d\boldsymbol{\xi}, \qquad K=\sqrt{1 + \frac{\hbar^2}{m^2c^2}\left(\kappa^l\kappa_l + \partial_l\kappa^l\right)} \tag{3.6}$$

where dependent variables $x = \{x^i\}$, $i = 0,1,2,3$ are a function of variables $\xi = \{\xi_0, \boldsymbol{\xi}\} = \{\xi_i\}$, $i = 0,1,2,3$. Dependent variables $\kappa = \{\kappa^i\}$, $i = 0,1,2,3$ are functions of x. The metric tensor g_{ik} =diag$\{c^2, -1, -1, -1\}$. Variables κ^l are connected with u^l by means of the relation

$$u^l = \frac{\hbar}{m}\kappa^l, \qquad l = 0,1,2,3 \tag{3.7}$$

On one hand, the action (3.6) describes a set of deterministic particles interacting between themselves via self-consistent vector field κ^l. On the other hand, the action (3.6) describes a quantum fluid. Rotational flow of this fluid is described by one-component wave function ψ, satisfying the Klein-Gordon equation [10, 11].

In general case the fluid flow is described by two-component wave function, satisfying the dynamic equation [11]

$$-\hbar^2\partial_k\partial^k\psi - \left(m^2c^2 + \frac{\hbar^2}{4}\left(\partial_l s_\alpha\right)\left(\partial^l s_\alpha\right)\right)\psi = \hbar^2\frac{\partial_l\left(\rho\partial^l s_\alpha\right)}{2\rho}\left(\sigma_\alpha - s_\alpha\right)\psi \tag{3.8}$$

where 3-vector $\mathbf{s} = \{s_1, s_2, s_3,\}$ is determined by the relations

$$\psi = \binom{\psi_1}{\psi_2}, \qquad \psi^* = \left(\psi_1^*, \psi_2^*\right), \qquad \rho = \psi^*\psi, \qquad s_\alpha = \frac{\psi^*\sigma_\alpha\psi}{\rho}, \qquad \alpha = 1,2,3 \tag{3.9}$$

Here $\boldsymbol{\sigma} = \{\sigma_1, \sigma_2, \sigma_3\}$ are Pauli matrices.

From physical viewpoint the quantization procedure (3.5), when the mass m is replaced by its mean value m_{eff}, looks rather reasonable. Indeed, the value of m_{eff} depends on the state of the stochastic velocity component. Stochastic velocity component has infinite number of the freedom degrees and consideration of influence of the mean value u^l on the regular component of the particle velocity appears to be very complicated. It is described by partial differential equations, whereas in absence of this influence the regular particle motion is described by the ordinary differential equations. From physical viewpoint such an interpretation of the quantization looks more reasonable, than conventional interpretation in terms of wave function and operators.

The wave function and spin appear here as a way of description of the ideal fluid [1], i.e. as fluid attributes. In other words, statistical description and hydrodynamic interpretation of the world function are primary, and wave function is secondary. Hierarchy of concepts is described by the following two schemes.

ACQP:	quantum principles	$\Rightarrow$	wave function	$\Rightarrow$	hydrodynamic interpretation
MCQP:	statistical description	$\Rightarrow$	fluid dynamics	$\Rightarrow$	wave function

Note that transition from ACQP to MCQP became possible only after solution of such a pure mathematical problem as integration of complete system of dynamic equations for ideal fluid.

Connection between the fluid and the Schrödinger equation is known since the beginning of the quantum mechanics construction [13, 14]. In after years many authors developed this interplay known as hydrodynamic interpretation of quantum mechanics [15, 16, 17, 18, 19, 20, 21, 22, 23]. But this interpretation was founded ultimately on the wave function as a fundamental object of dynamics. It cannot go outside the framework of quantum principles, because the connection between the hydrodynamic interpretation and the quantum mechanics was one-way connection. One could obtain the irrotational fluid flow from the dynamic equation for the wave function (Schrödinger equation), but one did not know how to transform dynamic equations for a fluid to the dynamic equation for a wave function. In other words, we did not know how to describe rotational fluid flow in terms of the wave function. In terms of the wave function we could describe only irrotational fluid flow.

To describe arbitrary fluid flow in terms of a wave function, one needs to integrate conventional dynamic equations for a fluid (Euler equations). Indeed, the Schrödinger equation

$$i\hbar\frac{\partial\psi}{\partial t}+\frac{\hbar^2}{2m}\boldsymbol{\nabla}^2\psi=0 \tag{3.10}$$

may be reduced to the hydrodynamic equations for the variables $\rho,\mathbf{v}$, describing the fluid state. Substituting $\psi=\sqrt{\rho}\exp\left(i\hbar\varphi\right)$ in (3.10) and separating real and imaginary parts of the equation, we obtain expressions for time derivatives $\partial_0\rho$ and $\partial_0\varphi$. To obtain expression for the time derivative $\partial_0\mathbf{v}$ of the velocity $\mathbf{v}=\frac{\hbar}{m}\boldsymbol{\nabla}\varphi$, we need to differentiate dynamic equation for $\partial_0\varphi$, forming combination $\partial_0\mathbf{v}=\boldsymbol{\nabla}\left(\frac{\hbar}{m}\partial_0\varphi\right)$. The reverse transition from hydrodynamic equations to dynamic equations for the wave function needs a general integration of hydrodynamic equations. This integration is simple in the partial case of irrotational flow, but it is a rather complicated mathematical problem in the general case, when a result of integration has to contain three arbitrary functions of three arguments. Without producing this integration, one cannot derive description of a fluid in terms of the wave function, and one cannot manipulate dynamic equations, transforming them from representation in terms of ρ, $\mathbf{v}$ to representation in terms of wave function and back. This problem has not been solved for years. It had been solved in the end of eighties, and the first application of this integration can be found in [24]. Systematical application of this integration for description of quantum phenomena began in 1995 [2, 25].

4 Capacities of model conception of quantum phenomena

To evaluate comparative capacities of axiomatic and model approaches, let us imagine that we know only thermodynamic and know nothing on statistical physics and molecular structure of the matter. The question arises whether it is possible to investigate the crystal structure and nature of crystal symmetry in the framework of the axiomatic approach (thermodynamics). Such a possibility seems to be rather problematic, because this problem is rather difficult even in the framework of the model approach (statistical physics). Researchers trying to understand the structure and interaction of elementary particles in the framework of the axiomatic approach (ACQP) are in the position of persons investigating the crystal structure by the thermodynamic methods. They has no other possibility, as to invent exotic hypotheses and to test their validity in experiment.

MCQP as any model conception possesses *more subtle and flexile methods of investigation.* For instance, the change (3.5) carries out essentially the quantization procedure, i.e. transition from classical description to the quantum one. Let us imagine that the quantization (3.5) is not exactly true, and one needs to correct it slightly. In the framework of MCQP one needs only to change the form of the expression (3.5). How to realize such a modification in the framework of ACQP is not clear, because ACQP is connected closely with linearity of dynamic equations in terms of the wave function.

The hydrodynamic interpretation having a long history [13, 14] should rank among new methods of investigation. But in the framework of ACQP the hydrodynamic interpretation is secondary as it follows from the above mentioned schemes. In the framework of MCQP the hydrodynamic interpretation is primary, and possesses more subtle methods of investigation. In the framework of ACQP a transition to semiclassical approximation is carried out by means of transition to the limit $\hbar \to 0$ with some additional conditions. In MCQP this transition is realized by means of dynamic disquantization [26], which is a relativistic dynamic procedure. At the dynamic disquantization one removes transversal components $\partial_{\perp k} = \partial_k - j_k j^l \left(j_s j^s\right)^{-1} \partial_l$ of derivative ∂_k, which are orthogonal to the flux 4-vector j^k. As a result of dynamic disquantization the system of partial differential equations turns to a system of ordinary differential equations. The continuous system can be interpreted in terms of a discrete dynamic system (with finite number of the freedom degrees). In the nonrelativistic case the dynamic disquantization is equivalent to $\hbar \to 0$. In the relativistic case the quantum constant $\hbar$ remains in the discrete dynamic system. It admits one to obtain a more subtle interpretation.

This method was applied for investigation of dynamic system $\mathcal{S}_{\mathrm{D}}$, described by the Dirac equation [26]. It appears that the classical analog of the Dirac particle

$\mathcal{S}_{\mathrm{D}}$ is a rotator (but not a single particle), i.e. two particles rotating around their common center of inertia. This explains freely angular and magnetic momenta of the Dirac particle. Besides, it appears (quite unexpectedly) that the internal (rotational) degrees of freedom of the dynamic system $\mathcal{S}_{\mathrm{D}}$ are described in nonrelativistic manner [26, 25, 27]. Investigation of the dynamic system $\mathcal{S}_{\mathrm{D}}$ was produced without any additional supposition. It was investigated simply as a dynamic system by means of relativistically covariant methods.

As another example, we refer to the problem of the pair production, which is the central problem in the high energy physics. ACQP cannot say anything on the pair production mechanism and on the agents, responsible for this process, whereas MCQP can say something pithy on this problem. MCQP vests responsibility for the pair production on the κ-field (3.7), describing stochastic component of the particle motion. In MCQP the pair production is taken into account on the descriptive (before-dynamic) level, i.e. the pair production is taken in to account by consideration of ML as a primary physical object, whereas in ACQP the pair production is taken into account only on the dynamic level, i.e. by means of dynamic equations. Let us imagine that the particle world line is turns in the time direction. Depending on situation, such a turn describes either pair production, or pair annihilation. The κ-field creates conditions for such a turn and the pair production. The fact is that at such a turn in time direction the world line becomes spacelike ($m^2 < 0$) in the vicinity of the turning point. If one forbids the world line to be spacelike, the pair production becomes to be impossible. Such a possibility to change the particle mass and to make it imaginary is rather rare property among the force fields. For instance, the electromagnetic field of any magnitude cannot change the particle mass, and hence, to produce pairs. According to relation (3.5) the expression containing κ-field enter in the effective squared mass as a factor. If this expression is negative, the mass becomes imaginary, and the pair production (annihilation) becomes to be possible [11]. These examples show that MCQP and its subtle investigation methods can be useful at investigation of the microcosm phenomena properties.

Thus, MCQP makes the first successes, but not in the sense that it explains some new experiments, which could not be explained before. MCQP uses the more subtle dynamic methods of investigation (hydrodynamic interpretation of relativistic processes [10, 11], dynamic quantization and disquantization [26]), which cannot be used by ACQP because of its axiomatic character.

MCQP is essentially more flexible conception, than ACQP, as far as all in MCQP is determined by the space-time geometry, and the set of all possible geometries is described by a function of two arguments. The world function (2.5), determining the microcosm structure is only the first rough approximation. If it is necessary, the expression (2.5) can be modified in such a way, to take into account influence of the matter distribution in the space-time (curvature) and existence of new metric fields, generated by the possible asymmetry of the world function [28, 29]. Asymmetric world function describes the space-time, where the past and the future are unequal geometrically. One cannot imagine such a thing in the framework of Riemannian geometry. Expansion of the symmetric world function $\sigma(x, x')$ over powers of $\eta^i =$

$x^i - x'^i$ has the form

$$\sigma(x, x') = \frac{1}{2} g_{ik}(x') \eta^i \eta^k + \frac{1}{6} \sigma_{ikl}(x') \eta^i \eta^k \eta^l + ... \qquad (4.1)$$

where $g_{ik}(x')$ describes the gravitational field, and $\sigma_{ikl}(x')$ is expressed via derivatives of metric tensor $g_{ik}(x')$. For asymmetric world function the same expansion has the form [28, 29]

$$\sigma(x, x') = \sigma_i(x') \eta^i + \frac{1}{2} \sigma_{ik}(x') \eta^i \eta^k + \frac{1}{6} \sigma_{ikl}(x') \eta^i \eta^k \eta^l + ... \qquad (4.2)$$

where three coefficients $\sigma_i(x')$, $\sigma_{ik}(x')$ and $\sigma_{ikl}(x')$ are independent, and each of them is connected with some metric (geometric) field. Coefficient $\sigma_i(x')$ describes a "vector field" which is strong and effective at small space-time intervals. Coefficient $\sigma_{ik}(x')$ describes the second rank tensor field (gravitational field) which is strong and effective at middle space-time intervals. Finally, $\sigma_{ikl}(x')$ is connected with the third rank tensor field, which is strong and effective at large space-time intervals. Maybe, this field is connected with astrophysical problem of dark matter, when one fails to explain observed motion of stars and galaxies by means of only gravitational field.

At construction of MCQP *one did not use any new hypotheses.* On the contrary, flexibility and subtlety of MCQP methods are connected with remove of unwarranted constraints and correction of mistakes in the approach to geometry and to statistical description. In other words, MCQP satisfies the Newton's criterion: "Hypothesis non fingo." *Only choice of true space-time geometry is determined properties of physical phenomena in microcosm.* This choice must be done in any case. But this choice may be true, or not completely true.

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