# Concept of unified local field theory and nonlocality of matter

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**Abstract**

The concept of unified local field theory is considered. According to this concept the quantum description and the classical one must be the levels for investigation of some world solution of the unified field model. It is shown that in the framework of the unified local field theory there are nonlocal correlations between space separate events. Thus the experiments of Aspect type for testing of the Bell inequalities and for showing of the nonlocal correlations do not reject a possibility for description of matter with the unified local field theory. Advantages of such theory for new technologies are considered.

## 1   Historical introduction

The whole history of pre-quantum physics naturally led to the idea of unified field theory for description of matter. All particles of matter and their apparent mutual influence must be represented by some solution of the appropriate field model which must be nonlinear. Also this model must be local, i.e. it is represented by some purely differential system of equations. This is an essence of the ideas which was inspiring for many scientists in their working. Let us mention just a few: A. Einstein, L. de Broglie, H. Weil, A. Eddington, G. Mie, E. Schrödinger, M. Born, L. Infeld, J. Plebansky, etc.

However, the impressive success of quantum mechanics has eclipsed the idea of unified field theory which was in the air. The quantum mechanics is essentially linear theory which is easier for investigation than nonlinear one. But the quantum mechanics gives the probabilistic predictions only.

Now opinions of physicists on the question about fundamental character of the quantum mechanical description are divided. One part believe that the indeterministic character of quantum mechanics reflects some fundamental quality of nature. Other part believe that this indeterminacy comes from an incompleteness of the appropriate description for matter, such as we have the indeterminacy in statistical mechanics.

Einstein, Podolsky, and Rosen in their famous article [1] advanced the arguments for the standpoint that quantum mechanical description of reality is
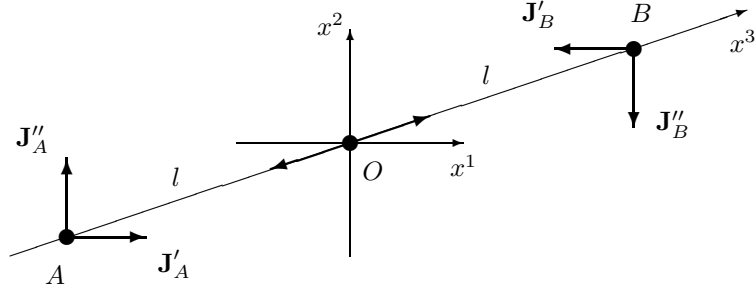
Figure 1: Towards an experiment for demonstration of nonlocal correlations.

incomplete. Here we repeat the essence of the EPR paradox for the example which was given by Bohm and Aharonov [2].

Let us consider the experimental scheme (see figure 1), in which a source (at the point $O$) gives birth to the pair one-half spin particles from a zero spin state. Then these particles move in opposite directions (along the axis $x^3$). Travelling considerable distance ($l$), they come to detectors (at the points $A$ and $B$), which determine the spin states of the particles. Stern-Gerlach magnets can be used as these detectors which finally determine the vector of angular momentum for the particles ($\mathbf{J}_A$ and $\mathbf{J}_B$). Suppose we can arbitrarily take the axis $x^1$ or $x^2$ for orientation of the magnets to measure the appropriate projection of spin.

According to the quantum mechanical description for this experiment, the spin states of the individual particles are indeterminate until the measurement event. But as soon as we have measured the spin state for one particle then the spin state for another particle becomes determinate immediately. This resulting situation is connected with the conservation law of full angular momentum for the system of two particles.

Let an orientation of the magnet (along the axis $x^1$ or $x^2$) at the point $A$ be chosen by a chance switch. Now if the detector at the point $A$ gives the value of angular momentum $\mathbf{J}'_A$ or $\mathbf{J}''_A$ (at figure 1) then another detector immediately gives $\mathbf{J}'_B$ or $\mathbf{J}''_B$ respectively. Because we can take the distance $l$ as arbitrary long, this situation looks as contradiction with the thesis for locality of interactions. Thus quantum mechanics predicts nonlocal correlations between the events. Well known Aspect experiment [3] for testing of also well known Bell inequalities [4] determines that there are the nonlocal correlations.

At first glance the existence of this nonlocal correlations rejects a possibility for description of matter by the unified local field theory. However, actually, this is not the fact. In the following section we show that the nonlocal correlations between the events must exist in the unified local field theory of matter.

## 2    Fundamental concept of matter

Actually the concept of unified local field theory for the material world is similar to the concept of ether, if we understand it in the broad sense but not narrow mechanical one. This concept supposes only two basic properties: continuity and locality. Mathematically these properties are expressed in the fact that we consider some purely differential field model or some system of equations with partial derivatives. To describe naturally the interactions between material objects, this system of equations must be nonlinear. Also we believe that there is a model solution which is determinate in the whole three-dimensional space at each point of time. Thus, according to this concept, we can consider some Cauchy problem or the problem with initial and boundary condition for obtaining the world evolution.

Within the framework of such theory a single elementary particle is represented by some space-localized solution. Moreover, because elementary particles have wave properties, this solution must have the appropriate wave part. The wave part is considered here in the sense of time Fourier expansion for the solution in own coordinate system of the particle, where this part has the form of standing wave.

There is the simplest example for such standing wave even for customary linear wave equation. These well known solutions of the wave equation in spherical coordinate system include spherical harmonics. For the spherically symmetric case we have the standing wave

$$\frac{\sin(\underline{\omega}\, r)}{\underline{\omega}\, r}\,\sin(\underline{\omega}\, x^0)$$

which is formed by the sum of divergent and convergent spherical waves. With the help of Lorentz transformation we can obtain the appropriate solution in the form of moving nondeliquescent wave packet. Then the own frequency $\underline{\omega}$ transforms to wave vector $k_\mu$ such that $|k_\mu\, k^\mu| = \underline{\omega}^2$.

A single elementary particle solution of a nonlinear field model may be called also as *solitron*. This term has a similar sense that "solitary wave" or "soliton". But usually the term "soliton" is used in mathematical context for the case of special solutions.

It is significant, the concept of unified field theory supposes that all variety and evolution of the material world are represented by some space-time field configuration which is an exact solution of the nonlinear field model. It is evident that this solution is very very complicated but it is determinate in space-time by the field model with initial and boundary conditions. In the vicinity of a separate elementary particle this world solution is close to the appropriate single elementary particle solution, but each elementary particle behaves as the part of the world solution. Thus the behavior of each elementary particle is connected with the whole space-time field configuration for the world solution.

For certain conditions it is possible to consider the world solution part connecting with the separate elementary particle as the appropriate solitron solution with slowly variable velocity. (For the case of nonlinear electrodynamics see, for

example, the article [5].) This level for investigation of the world solution relates to the classical (not quantum) physics.

It is evident that although the model is local, the world solution is nonlocal in character because it is determined on the whole space-time applicable domain. This means, in particular, that there are undoubtedly nonlocal correlations between space separate parts of the common world solution. This sentence may be explained with the help of the following simplest example.

Let us consider the customary plane wave on axis $x^3$ with fixed wave-length $\lambda$. Let this wave be the solution of the customary linear wave equation and at the point $O$ with coordinates $(x^1, x^2, x^3) = (0, 0, 0)$ the field evolution has the form $a \sin[(2\pi/\lambda) x^0]$. Then at the point $Q$ $(0, 0, q)$ the field evolution has the form $a \sin[(2\pi/\lambda)(x^0 - q)]$ and at the point $P$ $(p, 0, 0)$ the field evolution is the same that at the point $O$. Thus here there is the nonlocal correlation between the field evolution at the points $O$, $Q$, and $P$. Totality of such nonlocal correlations is, in fact, the solution in space-time for local field model. The possible world solution (which is extremely more complicated than the plane wave) is also the continuous set of nonlocal correlations for the field evolution at the points of three-dimensional space.

Of course, if we make some excitation for field at the point $O$ then a propagation of this excitation from this point will have a finite speed. But in the scope of the world solution we are not able to make this excitation or to modify arbitrarily this world solution. Any excitations of the field at the point $O$ belong to the world solution which is a single whole. That is, in this case we must consider also all excitations coming to this point and we will have some standing wave near it. Thus the world solution is rather a very complicated system of standing waves than progressing ones. The initial condition is a common cause of all field excitations and after a long evolution the different correlations may exist, even the strange ones. It can only be said quite positively that the world solution can be represented by Fourier integral (or series) on orthogonal space-time harmonics which are essentially nonlocal. (Here we must remember how a dominant role is played by orthogonal functions in quantum approach.)

Let us consider once more the example with two particles scattering in the opposite directions, shown on figure 1. According to the concept under consideration there is the appropriate two-particle or two-solitron solution of the field model. Of course, according to this approach, in reality there is only the world solution but in our case we have the experimental scheme which is prepared specially for investigation of some aspects of the world solution part approximated by the two-particle solution. In particular, this solution must satisfy the conservation law of full angular momentum. Just this is confirmed by the result of the experiment. It is obvious that the magnitude of distance between the detectors is not essential here.

The key to understanding the appearance of momentary distant interaction in this experiment is contained in the concept of chance choice. Within the framework of the world solution a chance choice is absent, but both experimenter and experimental apparatus are a part of this world solution. That is the orientation of particle spin detectors in the experiment under consideration is

predetermined by the world solution. We speak about the chance choice because we do not know the world solution.

As experimentalists, we think that we establish the initial conditions for the process under investigation but may be this is too conceitedly and the veritable initial condition is established earlier. But as theorists, we can already calculate many correlations between the space-time events.

Thus we can suppose that the quantum mechanical description is the level for investigation of the world solution. This level takes into consideration, in particular, the global or nonlocal aspects of this solution.

Nonlocality was founded in quantum mechanics from the outset. In Schrö-dinger's picture a free elementary particle (which has a determinate momentum) is related with a plane wave having a constant amplitude on the whole space. In this case the quantum mechanical description does not determine a position of the particle. That is we have the representation of the free elementary particle by non space-localized wave that accentuates just nonlocal aspect of matter.

As we see, there is nonlocality also in the framework of unified local field theory. But such theory supposes a solitron model for a free elementary particle which is intuitively more preferable. Furthermore, according to this concept there is the deterministic description of matter.

The separate question is that the world solution concept excludes a free will for a person. But we can suppose that a possible will agent is outside of space-time world solution. This will agent can be called an individual spirit which is a part of some spiritual world. We can also suppose that the individual spirit can partially modify the world solution using some dynamical boundary conditions. But these modifications must be nonlocal in general.

Nowadays an educated individual knows that there are the laws of nature but he believes that the initial conditions may be established by an independent deliberate action. (A man sets free a massive body and it rushes to the earth with a constant acceleration but the man chooses the space-time point for beginning of the movement.) If we accept this point of view then we must assume that there is something outside the material world and it realizes the choice. This choice might be realized by the individual spirit. But a possible border between the material world and the spiritual one is fuzzy. Some philosophical systems suppose even that a powerful spirit can modify the laws of the material world because it is constructed by consciousness. In connection with this topic we should remember also the discussion between A. Einstein and R. Tagore [6].

In any case we have the repeatable experimental confirmations for existence of the material world laws and these experiments do not exclude the description based on the concept of unified local field theory. In particular, nonlinear electrodynamics of Born-Infeld type with dyon singularities [5] (see also [7, 8, 9, 10]) may be considered in this connection. In this theory there is a field configuration, named bidyon, which can be a model for a particle with spin.

# 3 Prospects for applications

At present we consider a single atom and even a single electron as objects of technology. There is a concept of a single electron transistor [11] and we can seriously consider prospects for building an Avogadro-scale computer acting on $\sim 10^{23}$ bits [12]. In such computer using the nuclear magnetic resonance one nuclear spin must store one bit of information (see article [12] and the references contained therein).

Traditional computation can do many useful things and this ability can become very much stronger with the possible Avogadro-scale technology. But the traditional computation needs a determinate controlling. Such controlling is possible if we have the unified field theory of matter in the sense that was stated above.

This is one of the possible applications of the approach under review. But, of course, a realization for the paradigm of unified field theory will discover abilities which we do not know at the present time.

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