The non-linear wave theory, adequate of Standard Model

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Abstract

A solitary stable wave – soliton - is defined as a spatially confined (localized), non-dispersive and non-singular solution of a non-linear wave theory. For any non-linear wave theory the solitons are the same fundamental solutions, as the usual waves are the fundamental solutions of the linear equations. For elementary particle physics a localized and stable wave is a perfect model for elementary particles, opening up in a non-linear field theory the possibility of what would have to be a wave packet in a linear one. As it is known the newer fundamental non-Abelian gauge theories are non-linear and have the soliton solutions. In the framework of the quantum field theory it is not difficult to find the relations between solitons and elementary particles that go very deep and are entirely unexpected from the classical point of view.

In the present paper is offered the theory of the waves with new type of non-linearity, emergent thanks to the transformations of the gauge type. The peculiar solitons are the constituents of this theory, which are identical with the objects of Standard Model. In particular they have masses, which appear due to the spontaneous breakdown of symmetry of the initial waves; they can be only in two states – bosonic and fermionic; they can have positive and negative charges, etc, etc.

The mathematical description of the present theory can be interpreted within the framework of the Copenhagen tradition, but, as it is shown below, non-linear theeory interpretation is much more consecutive and productive.

Introduction to the theory

The Standard Model theory (SM) is the gauge theory or the theory of massless vector fields, in which the particles acquire the masses thanks to the spontaneous breakdown of the physical vacuum symmetry. To understand the connection of the present theory with SM, we examine one simple example, which will be described in detail and generalized in following chapters of this book.

As one of the examples of the creation of massive field (i.e. particles) from the massless vector field it can serve the case of the of electron-positron pair photoproduction:

$$\gamma + N \to e^+ + e^- + N \ , \qquad (1)$$

Actually, the gamma-quantum (for simplicity sake, photon) γ is the massless boson, whose field is converted as vector. The nucleus field N initiates transformation of this photon into two massive particles e^+, e^- - electron and positron, whose fields are spinors, which are converted differently in comparison with the vector field. Thus, it can say that equation (1) describes the process of the symmetry breaking of initial massless vector field with the result - the creation of massive spinor particles. Simultaneously, equation (1) shows that the transition from boson to spinor field is connected with some specific transformation. To find the last one we consider this process as the Feynman diagram (fig. 1):

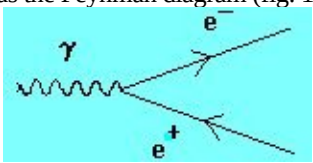

Fig.1

We know nothing about what happened in the "birthpoint" of the pair. We only see here the beginning and the end of the process.

But **what transformation could take place with massless photon in a field of an atom nucleus, which has led to the appearance of two, relatively motionless particles, both with mass and spin, which are equal to half of energy and spin of a photon, and also with mutually opposite electric charges?** Let's try to answer this question.

The real photon structure is unknown to us. But a photon is the quantum of electromagnetic (EM) wave and therefore the bending of a trajectory of EM wave in the strong EM field must have place in this case.

So, we can suggest that under above conditions the photon EM wave, as some string, can start to move along the closed curvilinear trajectory, forming the objects, which as a single whole must have mass and therefore cannot move with the light speed.

Below we show that such objects, depending on the kind of trajectory, will have all the characteristics and parameters of real elementary particles and have described by known relativistic equations of Dirac and Yang-Mills (the details see in the mentioned chapters).

According to above suggestion in simplest case of Fig. 1 a photon, as EM wave string, should to be twirled into a ring, and then it should be divided into other two rings, which can move now with a speed less than the speed of light. Thus, a "linear" photon - i.e. photon obeys the linear wave equation - must became the non-linear photon and then produces two non-linear waves, which must obey other equation.

Obviously, a twirled photon will have the mass that is equal to energy of a "linear" photon, divided on a square of light speed, and, as it is easy to show, the

spin, equal to one. Apparently, after photon division we receive two particles with rest mass equal to half of mass of a twirled photon and with spin equal to half of the spin of a photon. Let's try to find the basis of theoretic description of this process (see in detail the chapter 2).

Let us return to Fig.1 and recall the description of the corresponding particles. As we know, photon is described by means of the quantized equation of Maxwell. The electron and positron are described by the equations of Dirac. Thus, conditionally speaking, we see how to the left the equation of Maxwell of the quantized electromagnetic waves "flies" into the strong electromagnetic nuclear field of atom. Then we see how to the right two equations of Dirac (one for the electron, and another for the positron) "depart".

Thus, according to our scheme it follows that the Dirac equations are the EM field equations of two parts of the twirled quantized EM wave. We can say also that in the intersection point of the Feynman diagram lines a rotation transformation is realized. We can assume that this transformation is identical to the gauge transformation because the last one is (see e.g. (Ryder, 1985)) the transformation of field rotation in the inner symmetry space of particle.

Does this assumption contradict to the modern quantum field theory?

At first we know that (Gsponer, 2002) "the conventional view is that spin 1 and spin ½ particles belong to distinct irreducible representations of the Poincare group, so that there should be no connection between the Maxwell and Dirac equations describing the dynamics of these particles". How this is in agreement with the fact that the offered elementary particle theory is electromagnetic?

It is of course true that the Dirac equation is not equivalent to classical Maxwell equations (although for a long time it is established that they can be formally presented in the identical mathematical form). But in the present theory there is not a question about Maxwell theory, but about the special non-linear electromagnetic wave theory. The wave function of the Dirac equation appears here as a result of transformation and breaking of photon vector wave function to the spinor wave functions in fully accordance with equation (1).

Let's remember in this connection, that the Dirac equation in the fiftieth years of the previous century was named the "semi-vector" equation, and their wave function was named the "semi-vector" (see, for example, (Goenner, 2004)), because the last one is connected with the vector field by certain mathematical relations (see e.g. (Ryder, 1985)).

Secondly, it seems there is a difficulty: the Maxwell time depending equations contain six vectors and six equations (the source equations are possible to consider as the initial conditions); at the same time the spinor Dirac electron equation contains two wave functions and two equations, and the bispinor - accordingly four.

But we must recall that in the present theory the question is about the *electromagnetic waves*, not about EM field generally. As it is known EM wave does

not contain the longitudinal field components and, moreover, this property is Lorentz-invariant. Due to the last fact we can explain here why Dirac equation contents always two or four components' wave functions. Actually, there are only two possibilities: 1) one plane polarized EM wave contains two wave field components and can generate one spinor only; 2) in the general case, one circular polarized EM wave contains four field components and so can generate two spinors, i.e. one bispinor.

Obviously, to adjust these requirements, it is necessary the division of the twirled photon to be a special process. But how can the twirled photon string be divided so that two antisymmetrical by charge particles with spin half appear? Unique opportunity of such process is the division of the twirled photon into two twirled half-periods of photon according to following scheme (fig. 2):

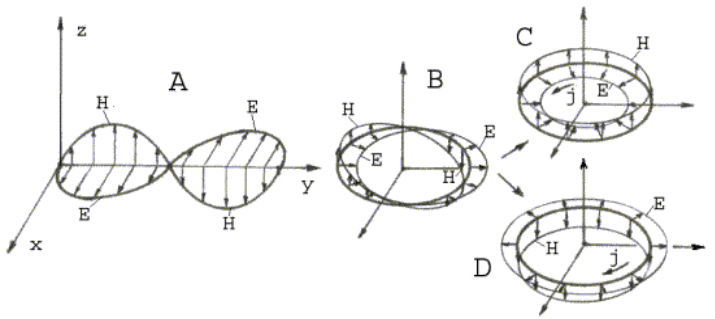

Fig. 2

Here the "linear" photon is twirled in non-linear one, which, for one's part, breaks in two non-linear half-periods. In other words we can say that from one vector particle we receive two semi-vector particles (two spinors), which according to figure 2 are fully antisymmetric (note here that the problem of particle size don't exists; see further the second section of introduction)

Below (see the chapter 2) it is shown consistently from mathematics point of view, how an electromagnetic equation of the twirled wave (not the classical Maxwell-Lorentz equations, but some non-linear equation of EM field !) is derived from the linear EM wave equation. Then from the last the equations for two - retarded and advanced - twirled half-period are deduced, **which in the matrix form are the Dirac electron and positron equations**. Using these results we can explain here also why on the Feynman diagram (fig.1) the positron represents as though it moves back in the time: since an electron and positron are the advanced and regarded twirled waves respectively, theirs complex description differs by sign of phase.

During the wave twirling, three vectors – electric, magnetic and Poynting vector – comprise the trihedron, corresponding to trihedron of the curve unit vectors – normal, binormal and tangential, which are known in the differential geometry as Frenet-Serret trihedron. In the research it is shown that the electrical current of electron (positron) is an additional part of the Maxwell displacement current, which

appears due to the transport of electrical wave vector along the curvilinear trajectory. It also appears, that this additional term corresponds to connection coefficients of Ricci (in case of leptons) or of Cristoffel (in case of hadrons), which characterize the turns of field vectors at their motion in curvilinear space. Note also that in the general case of circularly polarized wave the magnetic current appears, as this was predicted by Dirac (but in any case the magnetic charge is equal to zero).

Further it is also shown (see the chapter 3), that all quantum-mechanical values and characteristics (including statistical interpretation of wave function, bilinear forms, etc., etc.) in electrodynamics of curvilinear EM waves have simple physical sense, which however don't contradict to the quantum field theory interpretation.

Since electron and positron correspond to two twirled half-period waves of one photon, it follows from this fact that in Universe the numbers of positive and negative charges must be always fifty-fifty (this leads to the charge conservation law and the neutrality of Universe).

In the framework of CWED in the electron equation the term of the interaction among particles appears automatically in the moment of breaking of the neutral twirled photon into two charged particles. It corresponds to the expression of the minimal interaction.

Are there still the basis to accept this approach? Yes, there are, and very serious ones.

1. In this case the optical-mechanical analogy of Hamilton, from which the quantum theory began, finds its substantiation. Actually the offered theory is the optics of curvilinear waves, which simultaneously can describe the motion of the matter objects.

2. The appearance in the Dirac electron equation of Pauli's matrixes, which describe the rotation in classical mechanics in 2D space, receives an explanation as well as the appearance of Gell-Mann matrixes in the Yang-Mills equations, which describe the rotation in 3D space.

3. The necessity of a nucleus electromagnetic field receives an explanation: it serves as the medium with the big refraction number, leaning on which the EM wave bents (obviously this requirement is identical to the requirement of conservation of system momentum).

4. The formed EM particles are simultaneously both waves and particles; i.e. the wave-particle dualism is inherent to them.

5. Since the twirled photon has integer spin (it is a boson), but the twirled semi-photons have spin half (it is a fermion), we automatically receive an explanation of division of all elementary particles into bosons and fermions.

6. It is easy to see, that the fig. 2 reflects the process of spontaneous symmetry breakdown of an initial photon and appearance of mass of elementary particles, which have place in presence of a nucleus field, as some support and catalyst of the reaction (playing here the role of Higgs boson).

7. In the theory of the static spherical electron of the Lorentz classical theory there are no the electromagnetic forces, capable to constrain the repulsion of electron parts from each other and it is necessary to enter Poincare's forces of non electromagnetic origin. It is easy to see, that here, owing to presence of a current, there is the magnetic part of full Lorentz force directed against electrostatic forces of repulsion and counterbalancing them. Thus, such electron does not demand the introduction of extraneous forces of an unknown origin and is stable.

About some other consequences, which follow from the suggestion about photon twirling, we will briefly talk below.

In the research it is also shown (see the chapter 5) that for the initial “linear” **circular polarized** photon, which twirls at plane, its division can produce the neutral massive leptons of the same type as neutrino and antineutrino, which are also described by Dirac equations. Thanks to the circular polarization of initial photon, two twirled half-periods of such photons have the inner helicity and differ in the cherality.

In this case neutrino as twirled helicoids represents Moebius's strip: its field vector at end of one coil (360^o) has the opposite direction in relation to the initial vector state, and only at two coils (720^o), comes back to the starting position. This property of the EM-lepton vector corresponds to the same property of wave function of Dirac lepton theory.

It is interesting that according to R. Feynman (Feynman, 1987) the particle, which has the Moebius strip topology, must obey the Pauli exclusion principle. Thus in the framework of the present theory the twirled semi-photon particles must obey to Fermi-Dirac statistic.

Such lepton has mass, but doesn’t have electrical charge. Really, the mass of a particle is defined by integral from density of energy, which is proportional to the second degree of field strength. In this case the integral is always distinct from zero if the field strength is distinct from zero. At the same time the particle charge is defined by integral from density of a current, which is proportional to the first degree of field strength. Obviously, there is a chance, when the sub-integral expression is not equal to zero, but the integral is equal to zero. It is easy to check, that we will receive such result here, since the sub-integral function changes under the harmonious law.

Further (see the chapter 6) in research it is described the appearance of spatial particles, as the superposition of the twirled semi-photons. The equations of such particles coincide with Yang-Mills equations for hadrons, so the 2D superposition of two twirled semi-photon strings generates the mesons, and 3D superposition of three twirled semi-photon strings leads to appearance of baryons, e.g. proton.

In this case a Frenet-Serret trihedron moves in three-dimensional space, turning and twisting continuously. Therefore the current of each loop of above objects will no more be constant as it took place for a circular trajectory, and will change its value. Hence, the charge of each loop will be less than the charge of electron.

If to identify the separate elements of superposition (i.e. the knots) with quarks, we can receive an explanation of the experimental facts, inexplicable in frame of SM. First, there is a clear relationship between quarks and leptons. Secondly, becomes understandable the confinement of quarks and gluons. Thirdly, the distinction of elementary particles into three groups - leptons, mesons and baryons – receives the simple explanation. Fourthly, the fractionality of charges of quarks receives an explanation too, as many others.

In the research it is also shown the possibility of other more complex particle formation (chapter 7) as well as the particle parameters calculation.

About particle size and "hidden variables" in quantum theory

Within the framework of the present theory the electron is the electromagnetic field of a special configuration, concentrated in small volume with characteristic size of Compton wavelength.

Does the presence of the electron "size" in framework of non-linear theory contradict to its absence in the Dirac theory? No, since in both cases this is the same equation - the Dirac electron equation.

But how the same equation can contain and simultaneously not contain a "size"? Here we approach to very interesting result of the present theory, which solves numerous disputes, doubts and questions, continuing many years: are there in the quantum mechanics "hidden parameters"; is it possible to enter them, not destroying the quantum mechanics, etc. It appears here that von Neumann was partially right, who has proved that it is impossible the hidden parameters to enter into the given scheme of QM, but also de Broglie, D. Bohm and others are right, which have shown, that the Neumann's proof is limited by framework of existing interpretation.

The non-linear wave theory shows **that nothing more must be entered into the existing equations of Standard Model, because everything, what is necessary, here already exists.**

In the Dirac electron equation already there is a size of electron, but it is "hidden" not by the features of the quantum theory, but by the form, in which we represent and interpret it. Let's explain this statement.

The current term of the non-linear electron equation is connected with parallel transport of a field vectors along a curvilinear trajectory. It is defined by the curvature of a trajectory (or, in other representation, the Ricci coefficient of rotations), which are expressed by Compton electron wavelength: $\lambda_C = \hbar / m_e c$ (where m_e is the electron mass and c is the light speed). As it follows from the research for the curvature of a trajectory we have term $1/r_e = 2 m_e c / \hbar$, which defines in the same time the free mass term of Dirac electron equation $m_e c / \hbar$, which as we see doesn't content any size. (Note that the polarisation of physical vacuum modifies or renormalizes the electron "bare" size by following way: $r_e \to r_0 = 2 r_e \cdot \alpha$, where

$r_0 = e^2 / m_e c^2$ is the classical radius, $\alpha = e^2 / \hbar c$ is electromagnetic constant, which in the framework of non-linear wave theory is connected with the polarisation of physical vacuum).

Thus, until we do not know that the Dirac equation the electron radius contains, it really is the "hidden" parameter. But, on the other hand, it is "hidden" only because we use the canonized form of the Dirac equation. So, the existing of radius does not contradict to the quantum mechanics in any way. Therefore, as it shown in the chapter 4, an electron can be described both as point (with use of renormalisation) and non-point particle without violation any theory.

In this way we can explain the other "hidden" parameters of electron - for example, the parameters of so-called "Zittertbewegung" - "trembling" or, more correctly, oscillatory motion of relativistic electron, found out by E. Schroedinger. It is not difficult to understand that the origin of "Zittertbewegung" is the rotation of electron fields (since the rotation is here the sum of two perpendicular oscillations).

Thus, it can say that the present theory includes quantum mechanics as the formal linear mathematical structure, and, certainly, does not cancel any of its results, but only explains them and yields additional results.

It remains only to note that this work is devoted mainly to description of the single free particles. It is proposed that the systems of the identical particles and the related problems would be considered in other book.

(In the paper Gauss's system is used).