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Photon Space

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Abstract. Some directions and problems connected with incompleteness of modern theoretical physics are considered. It is marked that the basic successes are achieved in the areas concerning to Euclidian space. It is shown that priorities are, first, creation of photon space physics, second, association of Euclidian spaces physics and physics of photon space due to creation of the uniform theory of gravitational and electromagnetic fields. It is marked that only in case of such association the understanding of physics of a dark matter, the dark energy, the latent mass is possible. The main problem in creation of photon space physics, i.e. the physics of a reference system moving with light velocity is shown.

For creation of photon space physics on the basis of the generalized coordinates use the opportunity of a clear representation of electromagnetic radiation quantum is shown. It is established that equation Lagrange in a classical variant passes in the wave equation for vector - potential, and at quantization in Schrodinger equation for a quantum of electromagnetic radiation in space of the generalized coordinates. The solution of Schrodinger equation is given. It is shown that in space of the generalized coordinates (in photon space) the vacuum energy is a constant, not dependent on the changing parameter of a quantum - its frequencies, and the length of a quantum is exponential falls with increase in volumetric density of its energy.

Interaction of a photon and material particle (electron and atom) in photon space is considered. It is shown that this process needs to be described in the uniform reference system moving with light velocity in space of a vector - potential. On the basis of the Noether's theorem it is shown that in a vector - potential space (in photon space) the volumetric density of photon energy, its velocity and a ring current density of a material particle are conserved. On the basis of the Schrodinger's equation solving for a photon and electron cooperating in vector - potential space it is shown the electron during interaction should represent the quantum oscillator with a discrete set energies. Electron fluctuations or Dirac's electron "jitter" are realized with a light velocity. The problem of an electron magnetic moment (spin) occurrence in a vector - potential space is considered. Conditions of the atom currents quantization in vector - potential space, and also the Heisenberg's uncertainty principle in photon space are submitted. The Lamb's frequency shift in vector - potential space is found. Energy of multiphoton system in photon space is considered also.

Keywords: Photon space, nonlinear Schrodinger's equation for a photon, an electromagnetic field, generalized coordinates, Dirac's electron "jitter", magnetic moment, spin, electronic and atomic ring currents.

1 Introduction

Now the theoretical physics well describes the basic phenomena occuring in Euclidian space. Actually the mechanics and electrodynamics are completely created. It is not necessary to expect large opening in quantum mechanics where the basis are Schrodinger's and Dirac's equations. Top of modern physics is so-called the Standard model describing interaction of elementary particles known now [1].

However in theoretical physics there is one difficulty connected to interaction of a photon and a material particle, for example, of an electron.

Calculation of this process is difficult since it assumes that the equations of an impulse and energy conservation in these processes are incompatible. But in the nature processes there is the interaction of photons and material particles are widely submitted therefore all difficulties have the theoretical, human character connected to limitation of our knowledge.

Let's consider, for example, the phenomenon of a photon and a material particle interaction in more detail in the elementary case when a material particle (in particular the electron) originally is based.

The law of an impulse conservation at absorption of a photon by a motionless electron looks like $\frac{\hbar\omega}{c} = mV$, where V is velocity of an electron after absorption of a photon, m - its relativistic mass, ω - photon frequency, $\hbar$ - Planck's reduced constant, c - light velocity in vacuum.

The law of energy conservation in the relativistic form can be written as:

$$\hbar\omega = mc^2 - m_0c^2 = mc^2\left(1 - \frac{m_0}{m}\right) = mc^2\left(1 - \sqrt{1 - \frac{V^2}{c^2}}\right) \tag{1.1}$$

where m_0 is the rest mass of the electron.

Having divided the law of the energy conservation on the law of impulse conservation we obtain $\frac{V}{c} = \left(1 - \sqrt{1 - \frac{V^2}{c^2}}\right)$, i.e. $V = c$ that is impossible at least in Euclidian space.

The obtained result is not casual. The matter is that the photon exists in the reference system moving with light velocity. To describe interaction of a photon and an electron, it is necessary that the electron also should be examined in the reference system moving with a light velocity. In it there is a physical sense of the result.

To create the theory of a photon and a material particle interaction it is necessary to describe them in uniform reference system. But the material particle which is taking place in Euclidian space cannot be described in the reference system moving with a light velocity. It contradicts the special relativity.

Thus process of a photon and an electron interaction essentially cannot be described in uniform Euclidian space.

There is a technique of the calculation of a photon and a material particle interaction with the help of Dirac’s equation solving by a method of the perturbation theory [2]. This technique is well unified due to Feynman’s work [3].

But in process of the Dirac’s equation solving by the method of the perturbation theory at interaction of a photon and an electron there arise poorly proved with the physical point of view so-called virtual states of the electrons [4]. With the purpose of avoiding the impulse and energy conservation equations incompatibility at the first stage, as a first approximation of perturbation theory, at the solving of Dirac's equation, the opportunity of infringement of the energy conservation equation is supposed. Though, finally, conservation of energy is restored.

However already in the second approximation of the perturbation theory there is a divergence terms. It is the consequence of that a cooperating electron and photon are in different reference systems.

2 Incompleteness of Physics

Thus, the physical science is divided into two parts badly connected between themselves, fig. 1.

The first part is connected to Euclidian space. The main laws of this part of physics are Newton’s laws in mechanics, Maxwell’s laws in electrodynamics, the laws of a gravitational field, Schrodinger’s and Dirac’s equations for the material particles, etc. The physics of Euclidian spaces is well advanced because the humanity lives in this space.

$$ds^2 = g_{ik}dX^i dX^k \tag{2.1}$$

where g_{ik} is a metric tensor, function of coordinates, $cdt = X^0$ - time coordinate, c – the light velocity in vacuum, t - time, X^1, X^2, X^3 - spatial coordinates.

All laws of physics, strictly speaking, it is necessary to write down in Riemann’s space. For example, the law of universal gravitation in this space looks like [21]:

$$F = k\frac{m_1 m_2}{r^2\sqrt{1 - \frac{r_g}{r}}} \tag{2.2}$$

where $k = 6,67 \cdot 10^{-8} \dfrac{cm^3}{g \cdot c^2}$ is a gravitational constant, r_g - gravitational radius. This law allows to calculate force F of an attraction of two bodies in masses m_1 and m_2, taking place on distance r from each other. At the Earth which creates in ours Riemann's space the curvature of space - time the gravitational radius is $r_g = 0,443\ cm$ [21].

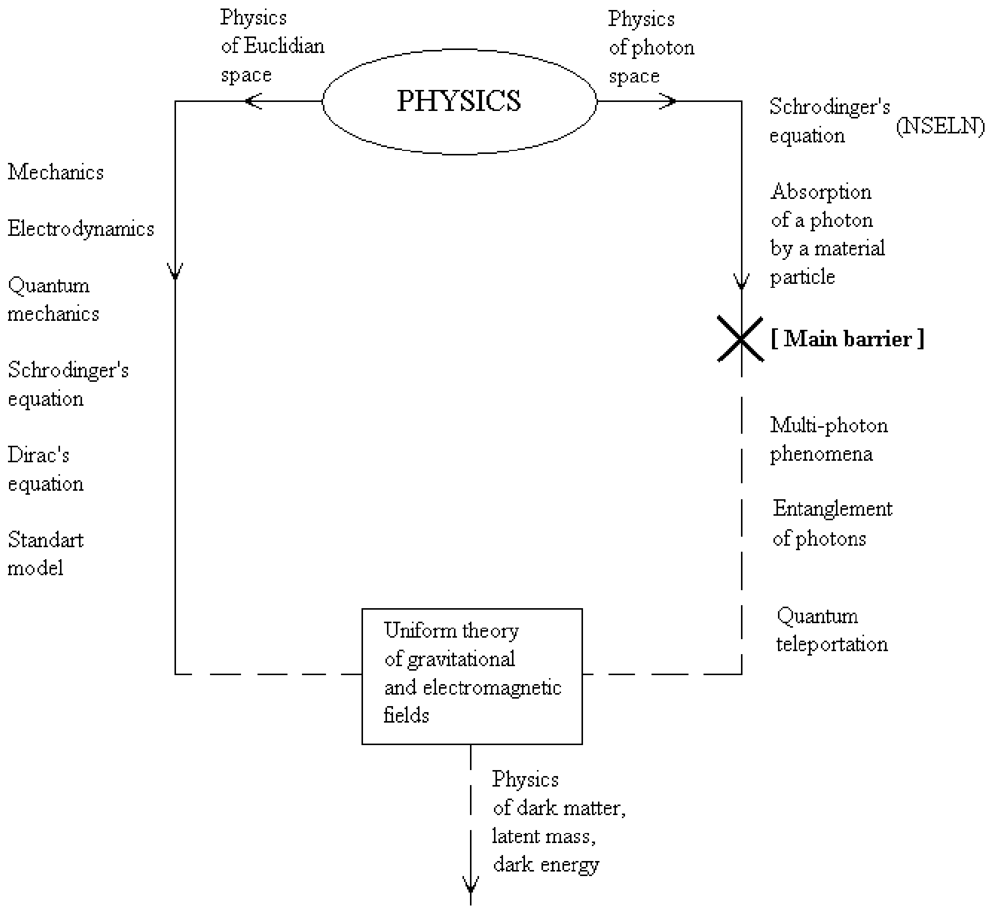

Figure 1. Directions of the modern physics development

The gravitational radius is very small in comparison with physical radius of the Earth therefore it is possible to use the approximate formula:

$$F = k\frac{m_1 m_2}{r^2} \tag{2.3}$$

i.e. we pass in Euclidian space. However it is real that the Euclidian space is absent since it practically always is a small curvature of space - time.

Under Euclidian space we understand Riemann's space where curvature of space - time we neglect. The term Riemann's space we consider inappropriate to use in an electrodynamic problem. Such space could be named Minkowski's space where metric tensor has components $g_{00} = 1, g_{11} = g_{22} = g_{33} = -1$. But Minkowski's space, as well as Euclidian space, is only approximation to real Riemann's space therefore we are stopped on term Euclidian space.

In connection with recent successful experiments on registration of gravitational waves very important result has been received. By comparison of distance from the source of gravitational waves calculated by the attenuation of experimentally registered gravitational waves and by the red displacement of electromagnetic radiation it has been established [22] that dimension of our Riemann's space-time is $\sim 4 \pm 0{,}1$. Thus our space-time is described by four coordinates: time and three spatial coordinates.

There is also other part of physics - physics of reference system which moves with light velocity or physics of photon space. This physics can be created, for example, in a vector - potential space (see below).

The basic equation of this part of physics is nonlinear Schrodinger's equation with logarithmic nonlinearity (NSELN) in space a vector – potential, see paragraph 3.3. The material particle is badly represented in a vector - potential space. Unique parameter which can be used for the characteristic of a material particle in this space it is a quantum ring current. Interaction of a photon and a quantum ring current in a vector - potential space completely certain and quite solved task.

However in this space cannot be submitted mass of a particle, and it Euclidian coordinates.

The problem of Euclidian space and photon space (in particular a vector - potential space) unification is connected to creation of the uniform theory of gravitational and electromagnetic field.

Undoubtedly this theory exists since in the nature process of a photon and a mass particle interaction is widely submitted. Absence of such theory it is insufficiency, incompleteness of the modern physical theory created by the human.

What global problems are faced by modern theoretical physics?

There are two.

1. First, to continue to create physics in system of photon space, i.e. in the reference system moving with a light velocity. Some steps in this direction have already been made, see below. There is a basic unresolved problem of the given direction of development of physics - the main barrier, fig. 1 - absence of two- and multi-soliton solutions of nonlinear Schrodinger's equation with logarithmic nonlinearity.

The finding of such solution apparently will take place in the near future at comprehension of a problem importance. In this case the problems connected to entanglement of photons, quantum teleportation etc. will be completely solved.

2. The second problem of physics has global character. This problem is connected to creation of the uniform theory of gravitational and electromagnetic fields (including a task of gravitational field quantization), and finally associations of two directions of physics development: physics of the Euclidian space and physics of photon space. Apparently only after such association probably full understanding, for example, physics of a dark matter, the dark energy [23], the latent mass, etc.

Association of photon space and Riemann's spaces probably will allow to create the uniform theory of gravitational and electromagnetic fields. We shall consider a possible way of such association.

The square of an interval in photon space (or in space of a vector of potential) looks like:

$$ds^2 = g_{ik} dA^i dA^k \tag{2.4}$$

where $A^0 = ct$ is a time component of a vector - potential, A^1, A^2, A^3 - its spatial components. In article we practically assume the components of a metric tensor $g_{00} = 1, g_{11} = g_{22} = g_{33} = -1$. However for association of a photon space and Riemann's spaces it is impossible to be limited by such metric tensor. It is necessary to examine the curved photon space.

Association of the Riemann's space and the curved photon space probably will allow formulates the uniform theory of gravitational and electromagnetic fields. The basic invariant in such uniform space apparently looks like:

$$ds^4 = g_{iklm} dX^i dX^k dA^l dA^m \tag{2.5}$$

where g_{iklm} is a metric tensor of the fourth rank for an uniform space.

Further we shall not stop on a problem of the uniform space research.

3 Photon in Euclidian Space

First of all we shall consider movement of a photon in Euclidian space.

The opportunity of clear representation of an electromagnetic radiation quantum always excited physicists [5]. How the light quantum is located in space? Whether it has the beginning and the end? Apparently nevertheless has but then why in a spectrum of a quantum is only one frequency?

Attempts to find answers to these questions have led physicists to opinion what evidently to present quantum in Euclidian space, it is impossible. In [4] it is underlined that the concept of the photon coordinates at all has no physical sense. However, the elementary wave description of a photon in Euclidian space can be received with the help of Schrodinger's equation in this space. Using the formula for the Hamiltonian of a quantum as $H = ck$, where k is module of a quantum impulse, we can find the operational form of the Schrodinger's equation as $\hat{E}\psi = c\hat{k}\psi$, where ψ - a quantum wave function in Euclidian space. Using the following designations of operators [1]: operator of energy $\hat{E} = i\hbar\frac{\partial}{\partial t}$, where t is a time, and operator of impulse $\hat{k}_X = -i\hbar\frac{\partial}{\partial X}$ (for example, for the quantum flying along an axis X) we shall find $\frac{\partial\psi}{\partial t} + c\frac{\partial\psi}{\partial X} = 0$. Information value of the found wave equation is very small since the solution of this equation can be any function of a kind $\psi = \psi\left(X - ct\right)$. For example, it is impossible to carry out a normalization of this wave function.

According to the special theory of a relativity all particles at the movement with velocity $\boldsymbol{V}$ have reduction of the size under the law [6] $l = l_0\sqrt{1 - \frac{V^2}{c^2}}$ where l is the size of a moving particle, l_0 - the size of a particle rested in the given reference system. For a photon if it to consider as a particle [5] moving with a light velocity the length in Euclidian space is equal to zero $l = 0$. But if to examine a photon in the inertial reference system moving with a light velocity in which it actually is rested it is possible to receive spatial display of a photon.

In the reference system moving with a light velocity in a vector - potential space it is possible to investigate various processes. In particular, in the given work processes of a photon and material particles (electron, atom) interaction, occurrence of the electron magnetic moment are examined. However, this reference system has the restrictions. First of all there cannot be a mass, and a size in Euclidian coordinates. The mass in this reference system aspire to infinity $m = \frac{m_0}{\sqrt{1 - \frac{V^2}{c^2}}}$, and the size of any material particle to zero. However, fields, currents, energy, frequency, etc. in it can be present, and it is frequently enough for the analysis of some processes.

We shall consider this question in more detail having starting the classical description of electromagnetic radiation.

3.1 The Generalized Coordinates

Let's consider representation of a photon in photon space. For this purpose it is necessary to understand what coordinates of this space.

$$w = T + U = \frac{E^2 + H^2}{8\pi} \tag{3.1}$$

where $\boldsymbol{E}$ is a vector of electric field strength, $\boldsymbol{H}$ - a vector of magnetic field strength, $T = \frac{E^2}{8\pi}$ and $U = \frac{H^2}{8\pi}$.

The Lagrangian of a free electromagnetic field (at absence of a charges and currents) looks like [6]:

$$l = T - U = \frac{E^2 - H^2}{8\pi} \tag{3.2}$$

For the Lagrangian l the equation of Euler - Lagrange [4] is correct:

$$\frac{d}{dt}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right) = \frac{\partial l}{\partial \mathbf{q}} \tag{3.3}$$

where $\dot{\mathbf{q}}$ is a vector of generalized velocity, $\mathbf{q}$ - a vector of generalized coordinate. We shall note that the generalized arguments in the equation (3.3) cannot be connected to mechanical velocities and Euclidean coordinates.

As the generalized speed we shall accept the electromagnetic field strength $\dot{\mathbf{q}} = \mathbf{E}$. It is allowable since the general formula [6] is correct:

$$w = \dot{\mathbf{q}}\frac{\partial l}{\partial \dot{\mathbf{q}}} - l = \mathbf{E}\frac{\partial l}{\partial \mathbf{E}} - l = \mathbf{E}\frac{2\mathbf{E}}{8\pi} - \frac{E^2 - H^2}{8\pi} = \frac{E^2 + H^2}{8\pi} \tag{3.4}$$

Let's find the generalized coordinate. We shall assume $\mathbf{q} = f\left(\mathbf{E},\mathbf{H}\right)$. In this case the equation (3.3) will be transformed to:

$$\frac{d\mathbf{E}}{dt} = \mathbf{E}\frac{\partial \mathbf{E}}{\partial \mathbf{q}} - \mathbf{H}\frac{\partial \mathbf{H}}{\partial \mathbf{q}} \tag{3.5}$$

Passing in (3.5) from full derivatives to partial derivatives we have:

$$\frac{\partial \mathbf{E}}{\partial t} + \frac{\partial \mathbf{E}}{\partial \mathbf{q}}\dot{\mathbf{q}} = \mathbf{E}\frac{\partial \mathbf{E}}{\partial \mathbf{q}} - \mathbf{H}\frac{\partial \mathbf{H}}{\partial \mathbf{q}} \tag{3.6}$$

Reducing in (3.6) the identical terms we shall find:

$$\frac{\partial \mathbf{E}}{\partial t} = -\mathbf{H}\frac{\partial \mathbf{H}}{\partial \mathbf{q}} \tag{3.7}$$

Using the Maxwell's equation $\mathrm{rot}\boldsymbol{H} = \frac{1}{c}\frac{\partial \mathbf{E}}{\partial t}$ [6] for the free electromagnetic field we get:

$$d\mathbf{q} = -\frac{1}{c}\frac{\mathbf{H}d\mathbf{H}}{\mathrm{rot}\mathbf{H}} \tag{3.8}$$

We used the initial conditions $\mathbf{q} = 0$ at $\mathbf{H} = 0$. It is allowable since in the right part (3.8) in the numerator at $\mathbf{H} \to 0$ is magnitude higher order of a minority than in the denominator.

Solving the equation (3.8) we get the generalized coordinate:

$$\mathbf{q} = -\frac{1}{c}\int \frac{\mathbf{H}d\mathbf{H}}{\mathrm{rot}\mathbf{H}} \tag{3.9}$$

We have found that the generalized coordinate depends only on a magnetic field strength $\mathbf{q} = f\left(\mathbf{H}\right)$.

We research physical sense of the generalized coordinate. Using the Maxwell equation $\mathrm{rot}\boldsymbol{E} = -\frac{1}{c}\frac{\partial \mathbf{H}}{\partial t}$ it is possible to write down $\mathrm{rot}\frac{\partial \boldsymbol{q}}{\partial t} = -\frac{1}{c}\frac{\partial \mathbf{H}}{\partial t}$ or $\mathrm{rot}\mathbf{q} = -\frac{\mathbf{H}}{c}$. Taking into account $\mathbf{H} = \mathrm{rot}\mathbf{A}$ we shall find $\mathbf{q} = -\frac{\mathbf{A}}{c}$. Thus, as the generalized coordinate it used the vector-potential $\boldsymbol{A}$ with the opposite sign (normalized on the velocity of light in used system of units).

Before carrying out the further transformations we shall show that Euler-Lagrange's equation (3.3) at the generalized velocity and the generalized coordinate passes to the wave equation for vector-potential $\boldsymbol{A}$.

Let's transform the right part of the equation (3.3):

$$\frac{\partial l}{\partial \mathbf{q}} = \frac{\partial\left(T - U\right)}{\partial \mathbf{q}} = -\frac{\partial U}{\partial \mathbf{q}} = -\frac{\boldsymbol{H}}{4\pi}\frac{\partial \boldsymbol{H}}{\partial \mathbf{q}} = \frac{c}{4\pi}\mathrm{rot}\boldsymbol{H} = -\frac{c}{4\pi}\Delta\boldsymbol{A} \tag{3.10}$$

The determination of the vector-potential $\mathbf{H} = \mathrm{rot}\mathbf{A}$ is also a known formula of vector analysis $\mathrm{rotrot}\mathbf{A} = \mathrm{graddiv}\mathbf{A} - \Delta\mathbf{A}$, and also Coulomb's gauge $\mathrm{div}\mathbf{A} = 0$.

The transformations of the equation (3.3) left part with use $\mathbf{E} = -\frac{1}{c}\frac{\partial \mathbf{A}}{\partial t}$ (the scalar potential is equal to zero as charges are absent) for a free electromagnetic field result:

$$\frac{d}{dt}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right) = \frac{d}{dt}\left(\frac{\partial l}{\partial \mathbf{E}}\right) = \frac{1}{4\pi}\frac{d\mathbf{E}}{dt} = -\frac{1}{4\pi c}\frac{\partial^2 \mathbf{A}}{\partial t^2} \tag{3.11}$$

Equating (3.10) and (3.11) we shall find the wave equation for vector-potential of a free electromagnetic field $\Delta\mathbf{A} - \frac{1}{c^2}\frac{\partial^2 \mathbf{A}}{\partial t^2} = 0$.

3.2 Quantization of an Electromagnetic Field

We carry out quantization of the electromagnetic field on the method suggested in [7].

For the basis we shall take the Lagrange's equation (3.3) having written down it as:

$$\frac{\partial}{\partial t}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right) + \dot{\mathbf{q}}\frac{\partial}{\partial \mathbf{q}}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right) = \frac{\partial l}{\partial \mathbf{q}} \tag{3.12}$$

Let's transform (3.12) taking into account $\dot{\mathbf{q}} = \mathbf{E}$ and $\frac{\partial l}{\partial \dot{\mathbf{q}}} = \frac{\mathbf{E}}{4\pi}$:

$$\frac{\partial \mathbf{E}}{\partial t} + \frac{\partial}{\partial \mathbf{q}}\left(\frac{E^2}{2}\right) = -4\pi\frac{\partial U}{\partial \mathbf{q}} \tag{3.13}$$

For integration of the equation (3.13) on the generalized coordinate $\boldsymbol{q}$ we use complex potential of the generalized velocity:

$$s = s_0 + \frac{\hbar}{i}s_1 \tag{3.14}$$

where the use of the reduced Planck's constant $\hbar$ will be proved further.

Let's determine the real part of potential:

$$\frac{1}{4\pi}\mathbf{E} = \frac{\partial s_0}{\partial \mathbf{q}} \tag{3.15}$$

Integrating once the equation (3.13) we find:

$$\frac{\partial s_0}{\partial t} + \frac{E^2}{8\pi} = -U \tag{3.16}$$

The constant of integration is accepted equal to zero that is reached by a choice of the initial level of potential.

The equation (3.16) is the Hamilton – Jacobi's equation [8] therefore the size s_0 can be assumed as the real part of volumetric density of the action $s_0 = \int l dt$.

Using (3.15) it is possible to write down function T and to determine function U as:

$$T = 2\pi\left(\frac{\partial s_0}{\partial \mathbf{q}}\right)^2 \quad \text{and} \quad U = -s_1 \tag{3.17}$$

In this case the equation (3.16) looks like:

$$\frac{\partial s_0}{\partial t} + 2\pi\left(\frac{\partial s_0}{\partial \mathbf{q}}\right)^2 - s_1 = 0 \tag{3.18}$$

We shall introduce by analogy to [9] the wave function of photon as $\Psi = \exp\left(i\frac{s}{\hbar}\right)$, where $s = \int l dt$ is volumetric density of action in space of the generalized coordinates.

The formula (3.14) can be assumed as the first two components of the volumetric density of action $s = s(t, \mathbf{q})$ expansion into a degrees $\frac{\hbar}{i}$ series. We shall notice that units of measurements of the Planck's constant and the volumetric density of action $s = s(t, \mathbf{q})$ must correspond to units of measurements of the generalized coordinates.

Taking into account (3.14) we shall transform wave function to the kind:

$$\Psi = \exp\left(i\frac{s}{\hbar}\right) = \exp(s_1)\exp\left(\frac{i}{\hbar}s_0\right) = |\Psi|\exp\left(\frac{i}{\hbar}s_0\right) \tag{3.19}$$

where $\left|\Psi\right| = \exp\left(s_1\right)$.

3.3 Schrodinger's Equation for a Photon

We shall show that the equation:

$$i\hbar\frac{\partial\Psi}{\partial t} + 2\pi\hbar^2\frac{\partial^2\Psi}{\partial q^2} + \ln\left|\Psi\right|\Psi = 0 \tag{3.20}$$

it is possible to suppose as the Schrodinger's equation for photon.

Let's show that the equation (3.20) is equivalent to the equation (3.18).

Preliminary we use the formula associating the generalized coordinate with vector - potential $\mathbf{q} = -\frac{\mathbf{A}}{c}$. Substituting it in (3.20) we shall find:

$$i\hbar\frac{\partial\Psi}{\partial t} + 2\pi\left(\hbar c\right)^2\frac{\partial^2\Psi}{\partial A^2} + \ln\left|\Psi\right|\Psi = 0 \tag{3.21}$$

Let's notice that in the equation (3.21) the fourth degree so-called Planck's charge $e_P = \sqrt{\hbar c}$ generated from fundamental physical constants is used.

Therefore the equation (3.21) can be written as:

$$i\hbar\frac{\partial\Psi}{\partial t} + 2\pi e_P^4\frac{\partial^2\Psi}{\partial A^2} + \ln\left|\Psi\right|\Psi = 0 \tag{3.22}$$

Thus the Planck's charge concerns not to the charged particle, and to a photon. The probability to find out a particle with Planck's charge is smallest. A role of the Planck's charge is another. It represents as though photon "memory" that the photon has arisen due to a charges and currents.

Let's note that the equation (3.22) contains only two constants: Planck's constant describing energy of a photon and Planck's charge reflecting principle of occurrence of a photon's genesis. The "memory" what size was of the particle charge generated a photon it does not remain.

In spite of the fact that the equation (3.20) is nonlinear this nonlinearity takes place only in space of the generalized coordinates. Nonlinearity of the Schrodinger's equation (3.20) is consequence of the nonlinear dependence on parameters the generalized coordinate (3.9). In Euclidean coordinates the process of electromagnetic quantum propagation has linear character. For example, in quantum-mechanical systems a linear principle of superposition [10] is correct.

The equation (3.20) is essentially relativistic since it describes a photon in the reference system moving with a light velocity (in generalized coordinate $\mathbf{q} = -\frac{\mathbf{A}}{c}$). Therefore, in photon space there is no necessity for the equation such as Dirac's equation in Euclidian space.

For the proof of equivalence of the equations (3.18) and (3.20) we shall use the formula (3.19) $\Psi = \exp\left(i\frac{s}{\hbar}\right)$. The derivate on time is:

$$\frac{\partial\Psi}{\partial t} = \frac{i}{\hbar}\Psi\frac{\partial s}{\partial t} \tag{3.23}$$

The second derivative on the generalized coordinate:

$$\frac{\partial^2\Psi}{\partial q^2} = -\frac{1}{\hbar^2}\Psi\left(\frac{\partial s}{\partial q}\right)^2 + \frac{i}{\hbar}\Psi\frac{\partial^2 s}{\partial q^2} \tag{3.24}$$

Substituting (3.23) and (3.24) in (3.20) we shall find:

$$\frac{\partial s}{\partial t} + 2\pi\left(\frac{\partial s}{\partial q}\right)^2 - 2\pi\hbar i\frac{\partial^2 s}{\partial q^2} = \ln\left|\Psi\right| \tag{3.25}$$

Using (3.14) we have:

$$\frac{\partial s_0}{\partial t} + 2\pi\left(\frac{\partial s_0}{\partial q}\right)^2 - s_1 - \hbar i\left(\frac{\partial s_1}{\partial t} + 4\pi\frac{\partial s_0}{\partial q}\frac{\partial s_1}{\partial q} + 2\pi\frac{\partial^2 s_0}{\partial q^2}\right) = 2\pi\hbar^2\left(\left(\frac{\partial s_1}{\partial q}\right)^2 + \frac{\partial^2 s_1}{\partial q^2}\right) \quad (3.26)$$

Ignoring the second order of magnitude on $\hbar^2$ and equating to zero separately real and imaginary parts of the equation (3.26) we come to the equation (3.18), and also to the equation:

$$\frac{\partial s_1}{\partial t} + 4\pi\frac{\partial s_0}{\partial q}\frac{\partial s_1}{\partial q} + 2\pi\frac{\partial^2 s_0}{\partial q^2} = 0 \quad (3.27)$$

Let's substitute in the equation (3.27) formula (3.15) and also we shall take into account $\dot{\mathbf{q}} = \mathbf{E}$:

$$\frac{\partial s_1}{\partial t} + \dot{\mathbf{q}}\frac{\partial s_1}{\partial \mathbf{q}} + \frac{1}{2}\frac{\partial \dot{\mathbf{q}}}{\partial \mathbf{q}} = 0 \quad (3.28)$$

Taking into account $\frac{\partial s_1}{\partial t} = \frac{1}{2|\Psi|^2}\frac{\partial |\Psi|^2}{\partial t}$, and $\frac{\partial s_1}{\partial \mathbf{q}} = \frac{1}{2|\Psi|^2}\frac{\partial |\Psi|^2}{\partial \mathbf{q}}$ we shall find:

$$\frac{\partial |\Psi|^2}{\partial t} + \frac{\partial \dot{\mathbf{q}}|\Psi|^2}{\partial \mathbf{q}} = 0 \quad (3.29)$$

If the equation (3.29) is equation of continuity the size $\mathbf{j} = \dot{\mathbf{q}}|\Psi|^2$ is current density of size $|\Psi|^2$ for a photon in space of the generalized coordinates. There is a problem of the size $|\Psi|^2$ interpretation. The equation (3.20) is Schrodinger's equation for a photon i.e. according to this equation it is supposed that the photon is some particle having certain volume in space of generalized coordinates. Each element of the photon can be in the certain element of a space with some probability. Therefore $|\Psi|^2$ is possible to be assumed as some density of probability for a photon element being present in the given place of a space of the generalized coordinates. The equation (3.29) reflects the following position: change of the density of probability of a photon element presence in some volume of space of the generalized coordinates generates a current of this density of probability through the volume border.

Thus the equations (3.18) and (3.29) are equivalent to the Schrodinger's equation (3.20) for a photon of an electromagnetic radiation.

3.4 Solving of the Schrodinger's Equation for a Photon in Photon Space

Let's find the solution of the Schrodinger's equation (20) for unit photon in the photon space.

We use the stationary solution of the equation (3.20) as [11]:

$$\Psi = f(\mathbf{kq} - \omega t)\exp\left[i(\mathbf{rq} - \delta t)\right] \quad (3.30)$$

where $\boldsymbol{r}$ and δ are constants, and also function $|\Psi| = f(\mathbf{kq} - \omega t)$ is still unknown. Stationary we name the solution which during evolution does not change the form.

Substituting (3.30) in (3.20) we shall get:

$$2\pi\hbar^2 k^2\frac{d^2 f}{d\xi^2} + i\hbar\frac{df}{d\xi}(-\omega + 4\pi\hbar\mathbf{kr}) + f\hbar\left(\delta - 2\pi\hbar r^2\right) + f\ln f = 0 \quad (3.31)$$

In the equation (3.31) differentiation is carried out on the variable $\xi = \mathbf{kq} - \omega t$. As function $f = |\Psi|$ represents real size the equation (3.31) should not have imaginary members. Therefore having accepted $\omega = 4\pi\hbar\mathbf{kr}$ we shall get:

$$2\pi\hbar^2 k^2\frac{d^2 f}{d\xi^2} + f\hbar\left(\delta - 2\pi\hbar r^2\right) + f\ln f = 0 \quad (3.32)$$

Solving the equation (3.32) we have:

$$f = C_1\exp\left[\frac{C_2(\mathbf{kq} - \omega t)^2}{2}\right] \quad (3.33)$$

where C_1 and C_2 are constants. Having substituted (3.33) in (3.32) we find:

$$2\pi\hbar^2 k^2 C_2 + \hbar\delta - 2\pi\hbar^2 r^2 + \operatorname{In} C_1 + \left(2\pi\hbar^2 k^2 C_2 + \frac{1}{2}\right) C_2 \xi^2 = 0 \quad (3.34)$$

The last component in the equation (3.34) is infinitely growing as $t \to \infty$, and the fixed generalized coordinate $\boldsymbol{q}$ is physically impossible. Therefore the expression in brackets should be equal to zero. Hence $C_2 = -\frac{1}{4\pi(\hbar k)^2}$. Then:

$$C_1 = \exp\left(2\pi(\hbar r)^2 - \hbar\delta + \frac{1}{2}\right) \quad (3.35)$$

Thus the solution of the equation (3.20) can be written according to (3.30) and (3.33) as:

$$\Psi = \exp\left(2\pi(\hbar r)^2 - \hbar\delta + \frac{1}{2}\right) \exp\left[-\frac{(\mathbf{kq} - \omega t)^2}{8\pi(\hbar k)^2}\right] \exp\left[i(\mathbf{rq} - \delta t)\right] \quad (3.36)$$

We shall designate the photon speed in vacuum (the speed of the enveloping curve wave) in space of the generalized coordinates as $\mathbf{c} = \frac{\omega}{\mathbf{k}}$. Using the earlier found formula $\omega = 4\pi\hbar\mathbf{kr}$ we shall get $c = 4\pi\hbar r$. Hence wave function (3.36) can be written as:

$$\Psi = \exp\left(\frac{c^2}{8\pi} - \hbar\delta + \frac{1}{2}\right) \exp\left[-\frac{(\mathbf{q} - \mathbf{c}t)^2}{8\pi\hbar^2}\right] \exp\left[i\left(\frac{\mathbf{cq}}{4\pi\hbar} - \delta t\right)\right] \quad (3.37)$$

For calculation we use the initial moment of time $t = 0$, and also we shall assume the photon frequency δ such that equality $c^2 = 8\pi\hbar\delta - 4\pi$ was carried out. Besides we shall designate $\mathbf{z} = \frac{\mathbf{q}}{2\hbar}$. In this case the formula (3.37) becomes simpler:

$$\Psi = \exp\left[-\frac{z^2}{2\pi}\right] \exp\left[i\left(\frac{\mathbf{cz}}{2\pi}\right)\right] \quad (3.38)$$

Let's carry out the analysis of dimensions. From the equation (3.20) there is $[\hbar] = [t] = [q]$. From (3.37) we have $[ct] = [q]$. Thus photon velocity in space of the generalized coordinates is size dimensionless.

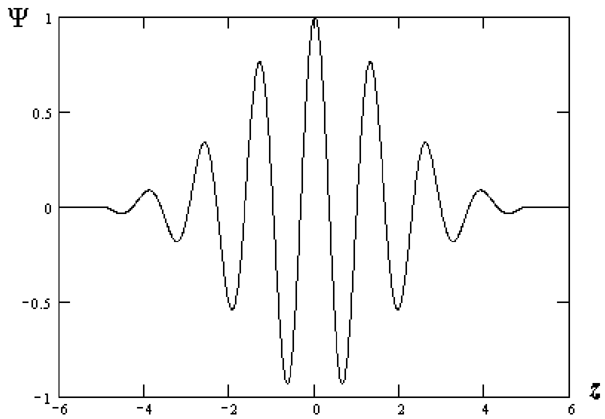

Figure 2. The photon wave function in space of the generalized coordinates

In fig. 2 the calculation of photon wave function of electromagnetic radiation executed under the formula (3.38) at velocity of the photon propagation $c = 30$ is shown.

There is a question how in space of the generalized coordinates the graph of wave function corresponds with the graph in Euclidean space?

As has been shown earlier as the generalized coordinate, the vector-potential is actually used. We shall bring an auxiliary attention to the question. How the kind of an electrostatics laws changes at transition to coordinate - scalar potential ϕ? Obviously the strength of a solitary charge e field in this case is $E = \frac{1}{e}\phi^2$. The kind of the law changed. If in Euclidean space the strength falls in inverse proportion to a square of coordinate, in space of scalar potential the strength grows with growth of coordinate.

Hence, transition to the generalized coordinates should cardinally change the kind of photon wave function. The description of quantum in space of the generalized coordinates apparently is more adequate than in Euclidean space.

The Schrodinger's equation (3.20) is the soliton equation [11]. Unfortunately, now it is known only the one-soliton solution (3.37) of this equation. The finding two-soliton solution of the equation (3.20), apparently, will allow solve a problem of a quantum entanglement (a quantum teleportation) [12]. Only thus it is possible to find out character of the waves connection in the two-wave solution of the photon equation (3.20).

3.5 Problem of a Vacuum and Photon Length

Let's find volumetric density of photon energy. Using (3.17) we shall receive:

$$w = T + U = 2\pi\left(\frac{\partial s_0}{\partial \mathbf{q}}\right)^2 - s_1 \tag{3.39}$$

In due time the quantum only moves in space of the generalized coordinates, not changing the form. Therefore taking into account (3.19) and using in the formula $\mathbf{q} = \mathbf{c}t$ we shall find $s_1 = \ln\left|\Psi\right| = 2\pi\left(\hbar r\right)^2 - \hbar\delta + \frac{1}{2}$.

Comparing (3.19) and (3.36) we shall find $s_0 = \hbar\left(\mathbf{rq} - \delta t\right)$. Hence the size T is $T = 2\pi\left(\frac{\partial s_0}{\partial \mathbf{q}}\right)^2 = 2\pi\left(\hbar r\right)^2$.

Thus the full volumetric density of quantum energy is:

$$w = \hbar\delta - \frac{1}{2} \tag{3.40}$$

According to (3.40) it is possible to assume that the size $\hbar\delta$ is sum of volumetric density of the photon energy and volumetric density of the vacuum energy in space of the generalized coordinates. Then the constant $w_V = \frac{1}{2}$ is a vacuum energy in space of the generalized coordinates. We shall note that as against Euclidean spaces in space of the generalized coordinates the volumetric density of the vacuum energy is constant.

Apparently, one of the reasons of evident representation impossibility of a light quantum in the Euclidean space consists that the quantum energy $\hbar\omega$ (we use the standard designation of quantum frequency) is propagated in the vacuum which energy depends on the photon energy $\frac{\hbar\omega}{2}$. Therefore it is impossible to set an initial level of reading of quantum energy. At the beginning and at the end of quantum the photon energy apparently is lost (transformed, dissolved, etc.) into the vacuum energy that deprives photon of the evident representation.

It has been earlier marked that $\left|\Psi\right|^2$ is possible to be interpreted as some density of probability of a photon element presence in the given place of space of the generalized coordinates.

Therefore for the size $\left|\Psi\right|^2$ the following normalizing equation is correct:

$$\frac{\int_{-\infty}^{+\infty} \left|\Psi\right|^2 d\mathbf{q}}{\int_{-\frac{\mathbf{q}_0}{2}}^{+\frac{\mathbf{q}_0}{2}} d\mathbf{q}} = \frac{2}{\mathbf{q}_0} \int_0^{+\infty} \left|\Psi\right|^2 d\mathbf{q} = 1 \tag{3.41}$$

where $\mathbf{q}_0$ is a quantum length in space of the generalized coordinates.

Substituting in (3.41) the formula for $\left|\Psi\right| = \exp\left(2\pi\left(\hbar r\right)^2 - \hbar\delta + \frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q} - \mathbf{c}t\right)^2}{8\pi\hbar^2}\right]$ that follows from (3.37) we shall find the photon length under condition $t = 0$:

$$\mathbf{q}_0 = 2\int_0^{+\infty} \left|\Psi\right|^2 d\mathbf{q} = 2\exp 2\left(2\pi\left(\hbar r\right)^2 - \hbar\delta + \frac{1}{2}\right)\int_0^{+\infty} \exp\left[-\frac{\mathbf{q}^2}{4\pi\hbar^2}\right] d\mathbf{q} \tag{3.42}$$

Hence, the module of the quantum length is:

$$q_0 = 2\pi\hbar \exp 2\left(2\pi\left(\hbar r\right)^2 - \hbar\delta + \frac{1}{2}\right) \tag{3.43}$$

At finding (3.43) the formula $\int_0^{\infty} \exp\left(-x^2\right) dx = \frac{\sqrt{\pi}}{2}$ is used.

Using the formula (3.40) for the volumetric density of a quantum energy, and also $c = 4\pi\hbar r$, see (3.37) we shall find the quantum length as:

$$q_0 = 2\pi\hbar \exp 2\left(\frac{c^2}{8\pi} - w\right) \tag{3.44}$$

From (3.44) we find that photon length in space of the generalized coordinates quantized. Besides the quantum length is exponential falls with increase in volumetric density of the quantum energy w.

In fig. 3 dependence of the relative quantum length $\frac{q_0}{2\pi\hbar}$ on the volumetric density of the quantum energy w is shown at photon velocity $c = 30$.

At $w \to \infty$ the length of quantum tend to zero. If to assume that the length of quantum is more $q_0 \geq 2\pi\hbar = h$ should be $\frac{c^2}{8\pi} \geq w$ ($h = 2\pi\hbar$ is the minimal photon length equal to Planck's constant). Thus, the maximal volumetric density of the photon energy is $w_{\max} = \frac{c^2}{8\pi}$. At $c = 30$ the maximal volumetric density of the quantum energy is $w_{\max} = 35.81$. All calculations are made in space of the generalized coordinates.

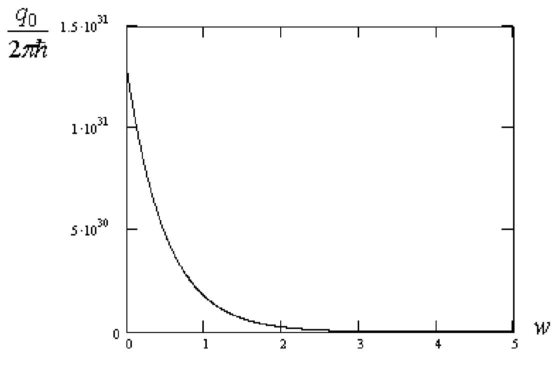

Figure 3. Dependence of the relative photon length on volumetric density of its energy

4 Material Particle in Photon Space

At calculation of a photon and material particle interaction there is a line of problems. In particular, interaction of radiation and free electrons can take place in the various ways. It can be coherent direct reradiation of a photon on a free electron or reradiation of a photon with change of a direction of its movement (Thomson's scattering), not coherent scattering (Compton's effect) that is typical for high energies quantums: X-ray and γ radiation. The basic paradigm of quantum electrodynamics consists that a photon or quantum an indivisible particle. Consequence of it is two-stage character of a photon and electron interaction. First the photon is completely absorbed by an electron, and then the electron radiates a photon.

4.1 Conservative Parameters in a Photon (Vector – Potential) Space

First of all we shall find out what parameters in a vector - potential (photon) space are preserved, i.e. are invariant. For this purpose we use Noether's theorem [13] in this space.

The volumetric density of action in a vector – potential space is $s\left(\mathbf{q},\dot{\mathbf{q}},t\right)=\int l dt$ where $\mathbf{q}=-\frac{\mathbf{A}}{c}$ is generalized (for Lagrange's equation $\frac{d}{dt}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)=\frac{\partial l}{\partial \mathbf{q}}$ (3.3)) independent coordinate connected to vector - potential $\boldsymbol{A}$, l - Lagrangian of systems a photon - electron [2, 14], t - time. The variation of action is size $\delta s\left(\mathbf{q},\dot{\mathbf{q}},t\right)=\delta\int l dt$, and according to a principle of the least action [6] (in the nature this principle is always realized) $\delta l=0$.

$$\delta l=\frac{\partial l}{\partial \mathbf{q}}\delta\mathbf{q}+\frac{\partial l}{\partial \dot{\mathbf{q}}}\delta\dot{\mathbf{q}}+\frac{\partial l}{\partial t}\delta t \tag{4.1}$$

We carry out infinitesimal displacement initially time, and then the generalized coordinate. Using Lagrange's equation we shall replace the first term in (4.1):

$$\begin{aligned}\delta l&=\frac{d}{dt}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}+\frac{\partial l}{\partial \dot{\mathbf{q}}}\delta\dot{\mathbf{q}}+\frac{\partial l}{\partial t}\delta t=\frac{d}{dt}\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}+\frac{\partial l}{\partial \dot{\mathbf{q}}}\left(\frac{d\left(\delta\mathbf{q}\right)}{dt}\right)+\frac{\partial l}{\partial t}\delta t=\\&=\frac{d}{dt}\left(\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}\right)+\frac{\partial l}{\partial t}\delta t=\frac{d}{dt}\left(\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}\right)+\frac{dl}{dt}\delta t^{/}\end{aligned} \tag{4.2}$$

where $\delta t\to\delta t^{/}$ is some infinitesimal time displacement.

Taking into account $\frac{d\left(\delta t\right)}{dt}=\delta 1=0$ we have $\frac{dl}{dt}\delta t=\frac{dl}{dt}\delta t+l\frac{d\left(\delta t\right)}{dt}=\frac{d\left(l\delta t\right)}{dt}$, and hence $\frac{dl}{dt}\delta t^{/}=\frac{d\left(l\delta t^{/}\right)}{dt}$. Thus:

$$\delta l=\frac{d}{dt}\left(\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}\right)+\frac{d\left(l\delta t^{/}\right)}{dt}=\frac{d}{dt}\left(\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\delta\mathbf{q}+l\delta t^{/}\right) \tag{4.3}$$

We carry out infinitesimal displacement of the generalized coordinate:

$$\delta\mathbf{q}\to\delta\mathbf{q}^{/}=\delta\mathbf{q}+\frac{\partial\mathbf{q}}{\partial t}\delta t^{/}=\delta\mathbf{q}+\dot{\mathbf{q}}\delta t^{/} \tag{4.4}$$

Using (4.4) the formula (4.3) can be written as:

$$\delta l=\frac{d}{dt}\left(\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\left(\delta\mathbf{q}^{/}-\dot{\mathbf{q}}\delta t^{/}\right)+l\delta t^{/}\right)=\frac{dQ}{dt} \tag{4.5}$$

Let's assume that changes of variations $\delta t\to\delta t^{/}$ and $\delta\mathbf{q}\to\delta\mathbf{q}^{/}$ result in a variation of action (or Lagrangian) in zero $\delta l=0$. Hence the size (it sometimes name a Noether's charge) is:

$$Q=\left(\frac{\partial l}{\partial \dot{\mathbf{q}}}\right)\left(\delta\mathbf{q}^{/}-\dot{\mathbf{q}}\delta t^{/}\right)+l\delta t^{/}=\left(l-\frac{\partial l}{\partial \dot{\mathbf{q}}}\dot{\mathbf{q}}\right)\delta t^{/}+\frac{\partial l}{\partial \dot{\mathbf{q}}}\delta\mathbf{q}^{/}=const \tag{4.6}$$

According to Noether's theorem the factors at variations of time $\delta t^{/}$ and the generalized coordinate $\delta \mathbf{q}^{/}$ are conserved.

According to (3.4) the size $l-\frac{\partial l}{\partial \dot{\mathbf{q}}}\dot{\mathbf{q}}=-w$ i.e. is equal to the volumetric density of the photon energy with the opposite sign. According to (3.2) and $\dot{\boldsymbol{q}}=\boldsymbol{c}=\boldsymbol{E}$ the size $\frac{\partial l}{\partial \dot{\mathbf{q}}}=\frac{\dot{\mathbf{q}}}{4\pi}=\frac{\mathbf{c}}{4\pi}$ i.e. is proportional to the light velocity in space of the generalized coordinates.

Thus, the formula (4.6) can be copied as:

$$Q=-w\delta t^{/}+\frac{\mathbf{c}}{4\pi}\delta \mathbf{q}^{/}=const \tag{4.7}$$

Hence, according to the Neother's theorem the volumetric density of a photon energy w and its velocity $\boldsymbol{c}$ in space of the generalized coordinates (or a vector − potential or photon space) are conserved.

Not stopping on a deduction we shall note that Neother's theorem allows to find and other conservative sizes in a vector - potential space. In particular the density of a ring current $\boldsymbol{j}$ is conserved [15].

4.2 Schrodinger's Equations for an Electron in Photon Space

Let's consider process of a photon and electron interaction in the reference system moving with light velocity in a vector - potential (photon) space.

Application of Dirac's equation to electron movement has led, in particular, to representation about so-called electron "jitter" [16, 17, 18]. Dirac in this occasion spoke "There is the electron which is imagined to us slowly moving actually should make oscillatory movement of very big frequency and small amplitude which is summed to uniform movement observable by us. As a result of this oscillatory movement the electron velocity is always equaled the light velocity." [18].

Let's show that presence of electron "jitter" with light velocity is a necessary condition of the electron and photon interaction opportunity. Under the electron "jitter" we mean not its mechanical oscillations which cannot be described in a vector - potential space, and oscillations, first of all, its wave function.

In paragraph 3.3 nonlinear Schrodinger's equation for wave function of the photon Ψ propagating in space of vector - potential has been found:

$$i\hbar\frac{\partial \Psi}{\partial t}+2\pi\hbar^{2}\frac{\partial^{2}\Psi}{\partial q^{2}}+\ln\left|\Psi\right|\Psi=0 \tag{4.8}$$

All sizes are written in a vector - potential (photon) space. As against Schrodinger's equation in Euclidian space the equation (4.8) is relativistic. Therefore, in a vector - potential space is not necessity to write down the separate relativistic equation such as Dirac's equation [19].

Let's consider a photon and electron interaction in space of vector - potential. Let wave function of a photon before interaction be Ψ_{0}.

The solution of the equation (8) for wave function Ψ_{0} looks like (3.37):

$$\Psi_{0}=\exp\left(\frac{\boldsymbol{c}^{2}}{8\pi}-\hbar\delta_{0}+\frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q}-\boldsymbol{c}t\right)^{2}}{8\pi\hbar^{2}}\right]\exp\left[i\left(\frac{\boldsymbol{c}\mathbf{q}}{4\pi\hbar}-\delta_{0}t\right)\right] \tag{4.9}$$

where δ_{0} is initial photon frequency.

After interaction with electron a wave function of a photon to become equal Ψ. It can be presented as the sum of wave function Ψ_{1} of not coherent scattering photon and some small perturbation determined by interaction of a photon and electron. We shall assume this interaction is characterized by the wave function Ψ_{2}, so $\Psi_{2} << \Psi_{1}$:

$$\Psi=\Psi_{1}+\Psi_{2} \tag{4.10}$$

We do not postulate any preliminary properties of electron. All its properties will be defined by an opportunity of its interaction with a photon.

Having substituted (4.10) in (4.8), we shall get:

$$i\hbar\frac{\partial\left(\Psi_1+\Psi_2\right)}{\partial t}+2\pi\hbar^2\frac{\partial^2\left(\Psi_1+\Psi_2\right)}{\partial q^2}+\ln\left|\Psi_1+\Psi_2\right|\left(\Psi_1+\Psi_2\right)=0 \quad (4.11)$$

Let's allocate in (4.11) the Schrodinger's equation for a secondary photon:

$$i\hbar\frac{\partial\Psi_1}{\partial t}+i\hbar\frac{\partial\Psi_2}{\partial t}+2\pi\hbar^2\frac{\partial^2\Psi_1}{\partial q^2}+2\pi\hbar^2\frac{\partial^2\Psi_2}{\partial q^2}+\ln\left|\Psi_1\right|\left(\Psi_1+\Psi_2\right)+\ln\left|1+\frac{\Psi_2}{\Psi_1}\right|\left(\Psi_1+\Psi_2\right)=0 \quad (4.12)$$

In connection with that the secondary photon (as well as primary before interaction) after interaction exists separately it is possible to write:

$$i\hbar\frac{\partial\Psi_1}{\partial t}+2\pi\hbar^2\frac{\partial^2\Psi_1}{\partial q^2}+\ln\left|\Psi_1\right|\Psi_1=0 \quad (4.13)$$

$$i\hbar\frac{\partial\Psi_2}{\partial t}+2\pi\hbar^2\frac{\partial^2\Psi_2}{\partial q^2}+\ln\left|\left(1+\frac{\Psi_2}{\Psi_1}\right)\right|\left(\Psi_1+\Psi_2\right)+\ln\left|\Psi_1\right|\Psi_2=0 \quad (4.14)$$

The equation (4.13) for a separate photon has the solution:

$$\Psi_1=\exp\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q}-\mathbf{c}t\right)^2}{8\pi\hbar^2}\right]\exp\left[i\left(\frac{\mathbf{cq}}{4\pi\hbar}-\delta t\right)\right] \quad (4.15)$$

where δ is a frequency of a scattering photon in vector – potential space. This frequency can differ from frequency of a primary photon δ_0 according to Compton's effect [4].

The equation (4.14) reflects interaction of the photon and electron in a vector – potential space. Taking into account $\Psi_2 << \Psi_1$ we shall transform the Schrodinger's equation (4.14) to a kind:

$$i\hbar\frac{\partial\Psi_2}{\partial t}+2\pi\hbar^2\frac{\partial^2\Psi_2}{\partial q^2}+\ln\left|\Psi_1\right|\Psi_2=0 \quad (4.16)$$

Let's note the Schrodinger's equation (4.16) as against Schrodinger's equation for a free photon (4.13) is linear. Wave function Ψ_2 characterizes the electron during its interaction with a photon.

4.3 "Jitter" of Electron in a Photon Space

The amplitude of wave function for a secondary photon according to (4.15) is:

$$\left|\Psi_1\right|=\exp\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q}-\mathbf{c}t\right)^2}{8\pi\hbar^2}\right] \quad (4.17)$$

Having substituted (4.17) in (4.16) we shall find:

$$i\hbar\frac{\partial\Psi_2}{\partial t}+2\pi\hbar^2\frac{\partial^2\Psi_2}{\partial q^2}+\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}-\frac{\left(\mathbf{q}-\mathbf{c}t\right)^2}{8\pi\hbar^2}\right)\Psi_2=0 \quad (4.18)$$

Using a standard method, we shall exclude in (4.18) derivative on time [19]:

$$i\hbar\frac{\partial\Psi_2}{\partial t}=E\Psi_2 \quad (4.19)$$

where E is full electron energy.

The equation (4.18) will be transformed to a kind:

$$2\pi\hbar^2\frac{\partial^2\Psi_2}{\partial q^2}+\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}-\frac{\left(\mathbf{q}-\mathbf{c}t\right)^2}{8\pi\hbar^2}+E\right)\Psi_2=0 \quad (4.20)$$

Using an independent variable as $\xi=\frac{\left(\mathbf{q}-\mathbf{c}t\right)}{2\sqrt{\pi}\hbar}$ we shall transform the equation (4.20) to a kind:

$$\frac{1}{2}\frac{\partial^2\Psi_2}{\partial\xi^2}+\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}-\frac{\xi^2}{2}+E\right)\Psi_2=0 \quad (4.21)$$

All used physical parameters depend on a variable $\xi=\frac{(\mathbf{q}-\mathbf{c}t)}{2\sqrt{\pi}\hbar}$ move with a light velocity c in space of vector - potential. Thus the reference system also moving with a light velocity c is used.

The equation (4.21) allows to draw a conclusion, electron cooperating with a photon, should move with a light velocity. It confirms Dirac's conclusion [18]. Solving the equation (4.21), we shall find character of this movement. Let's notice in (4.21) the wave function $\Psi_2=\Psi_2(\xi)$ depends on time.

Let's enter the following designation:

$$\lambda=2\left(\frac{\boldsymbol{c}^2}{8\pi}-\hbar\delta+\frac{1}{2}+E\right) \quad (4.22)$$

The equation (4.21) will be written as similar to [9]:

$$\frac{\partial^2\Psi_2}{\partial\xi^2}+\left(\lambda-\xi^2\right)\Psi_2=0 \quad (4.23)$$

The solution of the equation (4.23) is well-known [9]. It is assumed that electron cooperating with a photon is quantum oscillator oscillating with a light velocity that confirms the result obtained in Introduction 1.

The solution (4.23) exists only at the whole positive values of number n:

$$\Psi_{2n}=A_n\exp\left(-\frac{\xi^2}{2}\right)H_n(\xi) \quad (4.24)$$

where $n=0,1,2,\ldots$, and the size A_n - the factor determined by a condition of normalization,

$$H_n(\xi)=(-1)^n\exp\left(\xi^2\right)\frac{d^n\exp\left(-\xi^2\right)}{d\xi^n} \quad (4.25)$$

there are Hermit's polynomials.

The condition of normalization has a standard kind:

$$\int_{-\infty}^{+\infty}\Psi_{2n}^2 d\xi=1 \quad (4.26)$$

Substituting the formula (4.24) in condition (4.26) we shall find [9]:

$$A_n\int_{-\infty}^{+\infty}\exp\left(-\xi^2\right)H_n^2(\xi)d\xi=A_n 2^n n!\sqrt{\pi}=1 \quad (4.27)$$

Hence the factor $A_n=\frac{1}{2^n n!\sqrt{\pi}}$, and the solution (4.24) looks like:

$$\Psi_{2n}=\frac{1}{2^n n!\sqrt{\pi}}\exp\left(-\frac{\xi^2}{2}\right)H_n(\xi) \quad (4.28)$$

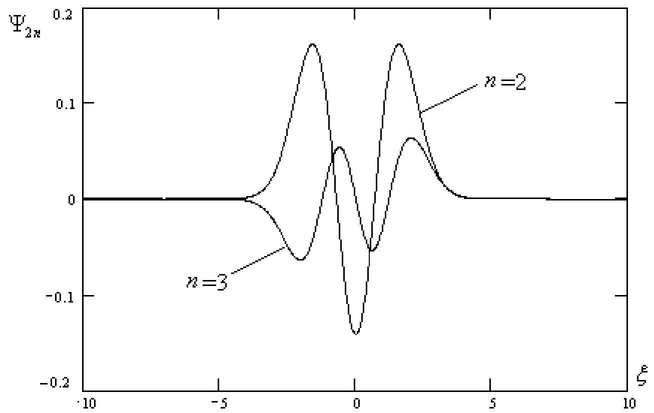

Figure 4. Wave function Ψ_{2n} for $n=2$ and $n=3$

In fig. 4 the graph of electron wave function is shown for $n=2$ and $n=3$. As can be seen from the graph the electron wave function cooperating with a photon has oscillating character. The amplitude of oscillations of wave function with increase n quickly falls.

Let's find values of energies which the electron - oscillator can have. For this purpose we shall find an own values of parameter λ_n.

Substituting the formula (4.28) in the differential equation (4.23) we have:

$$\frac{d^2H_n(\xi)}{d\xi^2}-2\xi\frac{dH_n(\xi)}{d\xi}+(\lambda_n-1)H_n(\xi)=0 \tag{4.29}$$

On the other hand Hermit's polynomials (4.25) are solutions of the equation [9]:

$$\frac{d^2H_n(\xi)}{d\xi^2}-2\xi\frac{dH_n(\xi)}{d\xi}+2nH_n(\xi)=0 \tag{4.30}$$

Comparing the equations (4.29) and (4.30) we get:

$$\lambda_n=2n+1 \tag{4.31}$$

Taking into account a designation (4.22) we find that full energy of electron - oscillator can have only discrete values:

$$E_n=n+\hbar\delta-\frac{c^2}{8\pi} \tag{4.32}$$

At the lowermost power level at $n=0$ the energy of electron is:

$$E_0=\hbar\delta-\frac{c^2}{8\pi} \tag{4.33}$$

Using the formula (4.33) it is possible to write (4.32) as:

$$E_n-E_0=n \tag{4.34}$$

The formula (4.34) represents a condition for change of energy at transition electron - oscillator, i.e. at its Dirac's "jitter", from one state in another in space of vector - potential. Energy of electronic "jitter" is quantized.

According to the energy conservation law it is possible to write:

$$E_n-E_0=n=\hbar\delta_0-\hbar\delta=\hbar\Delta\delta \tag{4.35}$$

The formula (4.35) allows calculating a difference of frequencies $\Delta\delta$ of primary and scattered photons and hence is analogue of the formula for change of frequency in Compton's effect [4] in the vector - potential space.

Due to the fact that Dirac's "jitter" of electron is supposed very big frequency and small amplitude in the equation (4.23) for numerical estimations it is possible to accept $\lambda >> \xi^2$. In this case the equation

(4.23) describes classical oscillatory process with the frequency proportional $\sqrt{\lambda_n}$, and according to (4.28) the amplitude of wave function of electron "jitter" is equal $\Psi_{2n} = \frac{1}{2^n n!\sqrt{\pi}}\exp\left(-\frac{\xi^2}{2}\right)$.

Let's consider the ratio $\left|\frac{\Psi_{2n}}{\Psi_1}\right|$ i.e. the ratio of the wave functions amplitudes of electron "jitter" and a photon. This ratio also characterizes a validity of the assumption $\Psi_2 << \Psi_1$.

Proceeding from formulas (4.17) and (4.28), with the account (4.33), it is possible to find:

$$\left|\frac{\Psi_{2n}}{\Psi_1}\right| \sim \frac{1}{2^n n!\sqrt{\pi}}\exp\left(E_0 - \frac{1}{2}\right) \tag{4.36}$$

In paragraph 3.5 it is shown the energy of zero oscillations for a photon is equal to $\frac{1}{2}$. Assuming energies of zero oscillations for a photon and electron during their interaction are equalized we have $\left|\frac{\Psi_{2n}}{\Psi_1}\right| \sim \frac{1}{2^n n!\sqrt{\pi}}$. Already for the second electron – oscillator power level the ratio is $\left|\frac{\Psi_{2n}}{\Psi_1}\right| \sim 0.07$. At increase n this ratio very quickly to tend to zero.

Proceeding from the lead analysis it is possible to assume also that Dirac's "jitter" of electron is connected to quantum waves (4.28) arising on an electron surface at its interaction with a photon and propagating with a light velocity ***c***. Fronts of these waves are conditionally shown on fig. 5, curves 1.

4.4 The Magnetic Moment of Electron in a Photon Space

Let's consider the physical reasons of the electron magnetic moment occurrence. Spin of electron i.e. it mechanical characteristic - the moment of momentum cannot be described in vector – potential space.

It is known that energy of a magnetic field and a current interaction in classical electrodynamics is expressed by the formula [6]:

$$U = -\frac{1}{c}\mathbf{jA} = \mathbf{jq} \tag{4.37}$$

where ***j*** is a current density with which the electromagnetic field cooperates.

This formula is similar to the formula $W = e\phi$ for energy of electron with a charge e in an electrostatic field with potential ϕ. The role of a charge in vector - potential space plays a current density ***j***.

The additional information about an electron we shall introduce assuming existence in it of constant ring currents. By these currents it is determined the electron magnetic moment $\boldsymbol{\mu}$. As in space of vector - potential there is no concept of mass in this space it is possible to identify electron only with density of a quantum ring current ***j***, and the formula (4.37) represents electron energy in a vector - potential space.

Let's transform the equation (4.16) using representation (4.19):

$$\frac{\partial^2\Psi_2}{\partial q^2} + \frac{1}{2\pi\hbar^2}\left(E + \ln\left|\Psi_1\right|\right)\Psi_2 = 0 \tag{4.38}$$

The equation (4.38) is stationary, i.e. not dependent on time.

Let's introduce into the equation (4.38) the energy electron magnetic moment (or ring currents) supposing:

$$\ln\left|\Psi_1\right| = \mathbf{jq} = jq\cos\theta = \pm jq \tag{4.39}$$

where θ is an angle between a direction of an electron current ***j*** and the generalized coordinate $\mathbf{q} = -\frac{\mathbf{A}}{c}$. We assume that the electron magnetic moment has two directions that meets $\theta = 0$ and $\theta = 180^0$ (***j*** against vector – potential ***A*** of a field, and ***j*** on a vector – potential of a field ***A***, fig. 5).

On fig. 5 the spherical electron form is given conditionally since in space of a vector - potential ***A*** the Euclidian coordinates are absent. Therefore to estimate the Euclidian velocity of an electron surface rotation it is incorrect. It is accepted an angle $\theta = 180^0$ (the substantiation is lower) i.e. the generalized coordinate $\boldsymbol{q}$ it is directed against of a ring electronic density current $\boldsymbol{j}$ ($\boldsymbol{q}$ and $\boldsymbol{A}$ by determination are directed opposite each other).

The electron magnetic moment $\boldsymbol{\mu}$ is always directed against its spin $\boldsymbol{S}$ and hence on a direction of an electron magnetic field strength $\mathbf{H} = \text{rot}\mathbf{A}$. We shall note that in space of a vector - potential the strength of magnetic field $\boldsymbol{H}$ (as a rotor on Euclidian coordinates) and electron spin $\boldsymbol{S}$ can be shown only conditionally.

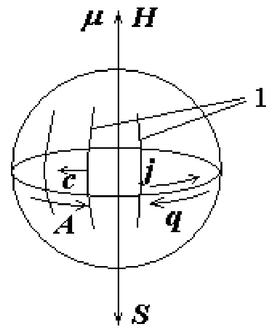

Figure 5. The scheme of the electron vector parameters

Thus the equation (4.38) will be transformed to a kind:

$$\frac{\partial^2 \Psi_2}{\partial q^2} + \frac{1}{2\pi\hbar^2}\left(E \pm jq\right)\Psi_2 = 0 \tag{4.40}$$

For the solving of the equation (4.40) we shall introduce a new variable:

$$\eta = \left(E \pm jq\right)\left(\frac{1}{2\pi\hbar^2 j^2}\right)^{\frac{1}{3}} \tag{4.41}$$

Passing to a variable η we shall find:

$$\frac{\partial^2 \Psi_2}{\partial \eta^2} + \eta\,\Psi_2 = 0 \tag{4.42}$$

The solution of the equation (4.42) looks like [9]:

$$\Psi_2\left(\eta\right) = A\Phi\left(-\eta\right) \tag{4.43}$$

where $\Phi\left(\eta\right) = \frac{1}{\sqrt{\pi}}\int_0^\infty \cos\left(\frac{u^3}{3} + u\eta\right)du$ so-called Airy's function, A - constant.

Normalizing wave function $\Psi_2\left(\eta\right)$ by a rule of the continuous spectrum functions normalization [9]:

$$\int_{-\infty}^{+\infty} \Psi_2^*\left(\eta\right)\Psi_2\left(\eta^/\right)dq = \delta\left(\eta^/ - \eta\right) \tag{4.44}$$

where $\delta\left(\eta^/ - \eta\right)$ is delta - function we find:

$$A = \left(\frac{1}{2\pi^{\frac{5}{2}}\hbar^2 j^{\frac{1}{2}}}\right)^{\frac{1}{3}} \tag{4.45}$$

Taking into account in a vector - potential space full electron energy actually is energy of its ring currents we accept for calculation $E \pm jq \approx \pm jq$.

On fig. 6 the graph of Airy's function plotted at a sign minus in the formula (4.40) i.e. at $\left|\Psi_1\right| = \exp\left(-jq\right)$ or $\theta = 180^0$ is shown.

State $\left|\Psi_1\right| = \exp(jq)$ or $\theta = 0$ is unstable since at increase q an exponent quickly increases. This state is unacceptable because a direction of electronic current density $\boldsymbol{j}$ and a direction of a vector - potential $\boldsymbol{A}$ (hence, and the generalized coordinate $\boldsymbol{q}$) are determined in stationary conditions by a direction of a uniform vector of magnetic field $\boldsymbol{H}$, fig. 5.

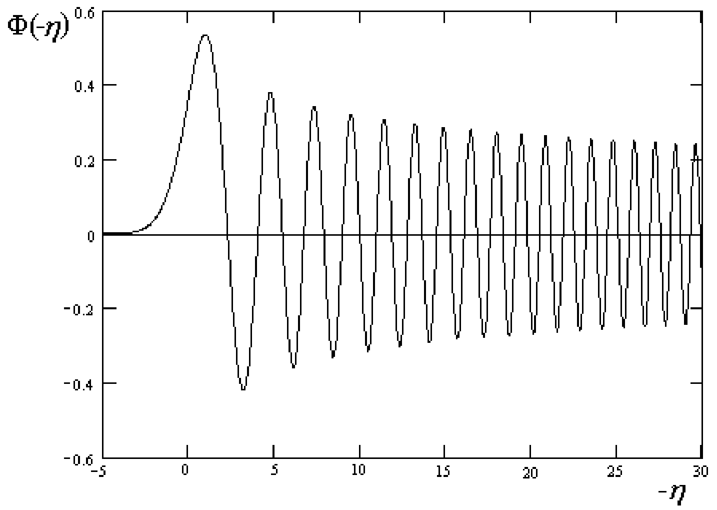

Figure 6. The graph of Airy's function determining the wave function of the electron magnetic moment

As can be seen from the graph the wave function $\Psi_2(\eta)$ of the magnetic moment in a vector - potential space has the oscillatory character. Apparently it also reflects occurrence of oscillations (Dirac's "jitter") in an electron surface. Due to quantum waves on the electron surface on its surface there are quantum currents, and hence the electron magnetic moment (and also its spin in Euclidian space).

4.5 Interaction of a Photon and Atom in Photon Space

The formula (4.34) can be considered as the first Bohr's condition in space of vector - potential for change of energy at transition of atom from one state in another. As against the Bohr's condition for Euclidian spaces the energies of atom states differ on an integer.

The second Bohr's condition can be received only using some additional information on atom. For a finding of this condition the formula (4.34) can be written as:

$$\Delta E_n = \sum_{i=1}^{n} \Delta E_i = n \tag{4.46}$$

where ΔE_i is energy of transition from i-th power level on $i-1$ power level.

The additional information on atom we shall enter assuming existence in it n constant ring currents which energies in a vector – potential space look like (4.37). For i-th atom current according to (4.37) we have:

$$\Delta E_i = j_i \Delta q_i \tag{4.47}$$

Substituting (4.47) in (4.46) we shall find the integral sum:

$$\sum_{i=1}^{n} j_i \Delta q_i = n \tag{4.48}$$

Passing to integral on a closed current cycle (trajectory) we shall find the second Bohr's condition in Sommerfeld's form [9]:

$$\oint jdq = n \tag{4.49}$$

Let's notice the role of an electron impulse in a vector - potential space plays the current density $\boldsymbol{j}$.

Meaning the given analogy it is possible to write down the Heisenberg's uncertainty principle in space of vector - potential:

$$\Delta j \cdot \Delta q \geq 1 \tag{4.50}$$

where Δj is uncertainty of a current density, Δq - uncertainty of the generalized coordinate (vector - potential).

The atom energy at the lowermost power level at quantum number $n = 0$ can be found under the formula (4.33) $E_0 = \hbar\delta - \frac{c^2}{8\pi}$. Near to atom there is a process of self-action of a vector - potential owing to what there is a uncertainty of energy ΔE_0. Occurrence of this uncertainty in a vector - potential space there is similarly to Lamb's effect [19] in the Euclidian space.

Let's estimate uncertainty of energy ΔE_0. Energy of process of a magnetic field self-action in classical electrodynamics is determined by the term $\frac{e^2}{2mc^2}\mathbf{A}^2 = \frac{1}{2}r_e A^2$ in atom Hamiltonian [19], where e is an electron charge, m - its mass, r_e - so-called classical electron radius.

Let's assume on a pulsation of the vector - potential $d\mathbf{A}$ arisen near to atom has effect the field with a vector - potential $\boldsymbol{A}$. Consequently the energy of interaction of a field pulsation and the itself field looks like $\frac{1}{2}r_e A dA$. Passing in a vector - potential space we have $\frac{1}{2}r_e c^2 q dq$, where r_e - in this case the constant which has been written in this space.

Occurrence of a field pulsation near to atom it is a random the process initiated by atom. Therefore, the element of energy of self-action dE_0 needs to be written down as:

$$dE_{q0} = \frac{1}{2}r_e c^2 \left|\Psi_{20}\right|^2 q dq \tag{4.51}$$

where the wave function Ψ_{2n} is determined by the formula (4.28) attributed to atom. Taking into account $H_0 = 1$ [9] in the conditional time moment $t = 0$ we find $\Psi_{20} = \frac{1}{\sqrt{\pi}}\exp\left(-\frac{q^2}{4\pi\hbar^2}\right)$.

Hence, the formula (4.51) looks like:

$$dE_{q0} = \frac{1}{2\pi}r_e c^2 \exp\left(-\frac{q^2}{2\pi\hbar^2}\right) q dq \tag{4.52}$$

The full energy of self-action of a field near an atom is integration (4.52):

$$dE_0 = \frac{1}{2\pi}r_e c^2 \int_{-\infty}^{\infty} \exp\left(-\frac{q^2}{2\pi\hbar^2}\right) q dq = r_e c^2 \hbar^2 \tag{4.53}$$

Thus the full energy of a field near an atom at a zero power level is:

$$E_0 + dE_0 = \hbar\delta - \frac{c^2}{8\pi} + r_e c^2\hbar^2 = \hbar\left(\delta + \Delta\delta\right) - \frac{c^2}{8\pi} \tag{4.54}$$

where the size $\Delta\delta = r_e c^2 \hbar$ is Lamb's shift of frequency in a vector - potential space.

4.6 Multiphoton System in a Photon Space

To find the wave function for multiphoton system in a vector - potential space inconveniently since it is necessary to know a multisoliton solution of the Schrodinger's equation (4.8). Therefore we shall be limited to finding of the set n photons energy average value in a vector - potential space.

Average value of the system n photons energy can be calculated using the following formula similar to [19]:

$$\overline{\varepsilon} = \frac{\left|\Psi_1\right|^2 \varepsilon_1 + \left|\Psi_2\right|^2 \varepsilon_2 + \ldots + \left|\Psi_n\right|^2 \varepsilon_n}{\left|\Psi_1\right|^2 + \left|\Psi_2\right|^2 + \ldots + \left|\Psi_n\right|^2} \tag{4.55}$$

where $\varepsilon_i = \hbar\delta_i$ is energy i-th photon in system, $\left|\Psi_i\right|^2$ - probability that the photon has energy ε_i.

The amplitude of a photon wave function according to (4.17) is:

$$\left|\Psi_i\right| = \exp\left(\frac{c^2}{8\pi} - \hbar\delta_i + \frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q} - \mathbf{c}t\right)^2}{8\pi\hbar^2}\right] = B\exp\left(-\hbar\delta_i\right) \tag{4.56}$$

where $B = \exp\left(\frac{c^2}{8\pi} + \frac{1}{2}\right)\exp\left[-\frac{\left(\mathbf{q} - \mathbf{c}t\right)^2}{8\pi\hbar^2}\right]$.

We substitute the formula (4.56) in (4.55). Using $\delta_i = i\delta_1$ where δ_1 is minimal frequency of the photon in system we shall find average value of the photon system energy on coordinate $\mathbf{q} = const$ at the moment of time t:

$$\begin{aligned}\bar{\varepsilon} &= \frac{B^2\sum_{i=1}^{n}\hbar\delta_i\exp\left(-2\hbar\delta_i\right)}{B^2\sum_{i=1}^{n}\exp\left(-2\hbar\delta_i\right)} = \frac{\hbar\delta_1\frac{d}{d\left(\hbar\delta_1\right)}\int\left(\sum_{i=1}^{n}i\exp\left(-2\hbar i\delta_1\right)\right)d\left(\hbar\delta_1\right)}{\sum_{i=1}^{n}\exp\left(-2\hbar i\delta_1\right)} = \\ &= \frac{\hbar\delta_1\frac{d}{d\left(\hbar\delta_1\right)}\left(-\frac{1}{2}\sum_{i=1}^{n}\exp\left(-2\hbar i\delta_1\right)\right)}{\sum_{i=1}^{n}\exp\left(-2\hbar i\delta_1\right)} = \hbar\delta_1\frac{d}{d\left(\hbar\delta_1\right)}\ln\left(\sum_{i=1}^{n}\exp\left(-2\hbar i\delta_1\right)\right)\end{aligned} \tag{4.57}$$

Using the formula of the geometrical progression sum with a denominator $\exp\left(-2\hbar\delta_1\right)$ we shall find:

$$\sum_{i=1}^{n}\exp\left(-2\hbar i\delta_1\right) = \exp\left(-2\hbar\delta_1\right)\frac{1 - \exp\left(-2\hbar n\delta_1\right)}{1 - \exp\left(-2\hbar\delta_1\right)} \tag{4.58}$$

Substituting (4.58) in (4.57) we shall find:

$$\begin{aligned}\bar{\varepsilon} &= \hbar\delta_1\left(1 + \frac{d}{d\left(-2\hbar\delta_i\right)}\ln\left(1 - \exp\left(-2\hbar n\delta_1\right)\right) - \frac{d}{d\left(-2\hbar\delta_i\right)}\ln\left(1 - \exp\left(-2\hbar\delta_1\right)\right)\right) = \\ &= \hbar\delta_1\left(1 - \frac{n\exp\left(-2\hbar n\delta_1\right)}{1 - \exp\left(-2\hbar n\delta_1\right)} + \frac{\exp\left(-2\hbar\delta_1\right)}{1 - \exp\left(-2\hbar\delta_1\right)}\right) = \frac{\hbar\delta_1}{1 - \exp\left(-2\hbar\delta_1\right)} - \frac{n\hbar\delta_1\exp\left(-2\hbar n\delta_1\right)}{1 - \exp\left(-2\hbar n\delta_1\right)}\end{aligned} \tag{4.59}$$

At $n \to \infty$ the formula (4.59) becomes simpler:

$$\bar{\varepsilon} = \frac{\hbar\delta_1}{1 - \exp\left(-2\hbar\delta_1\right)} = \hbar\delta_1 + \frac{\hbar\delta_1}{\exp\left(2\hbar\delta_1\right) - 1} \tag{4.60}$$

However in the found result there is also an essential difference in comparison with Euclidian space. In a vector - potential space we do not connect system of quantums with set of the quantum oscillators [20]. Therefore there is no zero energy of a photon in the basic condition and in the formula (4.60) is added composed $\hbar\delta_1$ - the minimal energy of a photon in system.

As shown in paragraph 3.5 the energy of a photon (including average) includes the energy of vacuum equal $\frac{1}{2}$. At small energies it is possible to accept $\exp\left(-2\hbar\delta_1\right) \approx 1 - 2\hbar\delta_1$. Hence $\bar{\varepsilon} = \frac{1}{2}$. The clean average energy of a photon is equal:

$$\bar{\varepsilon}_p = \frac{\hbar\delta_1}{1 - \exp\left(-2\hbar\delta_1\right)} - \frac{1}{2} \tag{4.61}$$

If photons are absent $\bar{\varepsilon}_p = 0$.

5 Conclusion

Now there is an essential incompleteness of theoretical physics, as sciences. This incompleteness is caused, first, by absence of the advanced theory of photon space, i.e. absence of the advanced theoretical research of the reference system moving with a light velocity. For overcoming this situation at the given stage it is necessary to solve rather particular task: to find the multi-soliton solution of the equation for multiphoton system - nonlinear Schrodinger's equation with logarithmic nonlinearity (NSELN). Second, it is necessary to connect physics of Euclidian space to physics of photon space, i.e. to create the uniform theory of gravitational and electromagnetic fields. Only after that it will be possible to understand completely that such the dark matter, the latent mass, dark energy, etc.

There is an opportunity of evident representation of an electromagnetic radiation quantum in space of the generalized coordinates.

The analysis shows that in a basis of the Schrodinger's equation for a light quantum the Euler − Lagrange's equation lays from which at the classical approach it is possible to receive the classical wave equation for vector - potential, and at quantization of an electromagnetic field the nonlinear Schrodinger's equation for a wave function of quantum in space of the generalized coordinates or photon space. In space of the generalized coordinates Schrodinger's equation has nonlinear character that is consequence of nonlinear dependence of the generalized coordinate from parameters.

In space of the generalized coordinates energy of vacuum is a constant not dependent on the changing parameter of photon - its frequencies, and the photon length exponential falls with increase in volumetric density of its energy.

The two-solitons solution of Schrodinger's equation for a photon, apparently, will allow solve a problem of a quantum entanglement (a quantum teleportation).

To investigate interaction of a photon and a material particle, for example, electron it is necessary to consider them in the uniform reference system moving with a light velocity. But the material particle cannot be investigated in Euclidian space in the reference system moving with a light velocity. This is opposed by the special relativistic theory. It is necessary to pass to other space − photon space, where existence of a reference system of the cooperating particles moving with a light velocity is possible. One of such spaces is the space of a vector - potential. In this space the volumetric density of photon energy, its velocity and the density of electron and atom ring currents are exist and preserved.

Consideration of process of a photon and electron interaction in space of a vector - potential shows:

- for an opportunity of an electron and photon interaction the electron should represent quantum oscillator i.e. to "jitter" (as Dirac) with a discrete set of energies.

- Dirac's "jitter" of an electron occurs with a light velocity in vacuum.

It is found the electron energy in vacuum in space of a vector − potential (photon space).

The electron magnetic moment (and hence its spin) is determined by electronic ring currents. On the basis of dependence of the electron magnetic moment energy from the generalized coordinate and density of electronic ring currents the Schrodinger's equation for wave function of the electron magnetic moment is received. The solution of this equation shows that this wave function is connected to Airy's function, and has essentially oscillatory character in a vector − potential space.

The principle of transition to model of a photon and atom interaction is shown. Values of energy which the atom can have are found. The condition of an atom currents quantization in a vector - potential space as Sommerfeld's condition is submitted. Also a principle of the Heisenberg's uncertainty in this space is submitted. To that Lamb's shift of frequency equal in a vector - potential space it is shown. Energy of multiphoton system in photon space is considered also.

References

1. M. Thomson. “Modern Particle Physics.” *University Printing House, Cambridge, United Kingdom*, 2013, 556 p.
2. A. N. Volobuev. “Quantum Electrodynamics through the Eyes of a Biophysicist.” *Nova Science Publishers, Inc. New York*, 2017, 252 p.
3. R. P. Feynman. “Quantum Electrodynamics, A Lecture Note.” *Book House “LIBROKOM”, Moscow*, 2009, 216 p.
4. V. B. Berestetskij, E. M. Lifshits, L. P. Pitaevskij. “Quantum Electrodynamics.” *Science, Moscow*, 1989. 728 p.
5. Chandrasekhar Roychoudhuri, Krasklauer A.F., Katherine Creath. “The Nature of Light. What is Photon?” *CRC Press. Taylor & Francis Group.* Boca Raton, London, New York, 2008. 456 p.
6. L.D. Landau, E.M. Lifshits “Theory of Field,” *Science*, Moscow, 1967, 460 p.

7. R.P. Feynman, A.R. Hibbs "Quantum Mechanics and Path Integrals," *McGraw-Hill Book Company*, New York, 1965, 382 p.
8. Landau L.D., Lifshits E.M. "Mechanics," *Science*, Moscow, 1988, 216 p.
9. Landau L. D., Lifshits E. M. "Quantum Mechanics," *FIZMATLIT*, Moscow, 2004, 800 p.
10. Physical Encyclopedic Dictionary. Edit. Prohorov A.M. Moscow, *Soviet Encyclopedia*, 1983, p. 731.
11. A.N. Volobuev "The Physical Processes are Submitting to Nonlinear Schrodinger's Equation," Moscow, 2005, *Mathematical Modelling*, V. 17, No. 2, pp. 103-108.
12. S. Ya. Kilin "Quantum Information," Moscow, 1999, *Uspekhi Fizicheskikh Nauk*, V. 169, No. 5, pp. 507-527.
13. Bogolubov N.N., Shirkov D.V., "Quantum Fields," *FIZMATLIT*, Moscow, 2005, 384 p.
14. A. N. Volobuev, A.P. Tolstonogov. On the Possibility of Visualization of an Electromagnetic – Radiation Quantum. *Journal of Surface Investigation: X-ray, Synchrotron and Neutron Techniques.* Vol. 11, No. 6, 2017, pp. 1289 –1295.
15. Mathematical physics. The encyclopedia. Under edit. Faddeev L.D. Scientific *publishing house "Big Russian encyclopedia"*, Moscow, 1998. P. 385.
16. Schrödinger, E. Über die kräftefreie Bewegung in der relativistischen Quantenmechanik / Schrödinger E. // *Sitzungsber. Peuss. Akad. Wiss. Phys. Math. Kl.* 1930, Vol. 24, pp. 418-428.
17. Vonsovskij S.V., Svirsky M.S. "Paradox Klein and jittering movement of an electron in a field with constant scalar potential," Moscow, 1993, *Uspekhi Fizicheskikh Nauk*, V. 163, No. 5, pp. 115-118.
18. Dirac P.A.M. "Recollections of an Exciting Era," *Science*, Moscow, 1990, p. 208.
19. Levich V.G., et al. "Theoretic Physics Course," V. 1, *FIZMATGIS,* Moscow, 1962, 696 p. V. 2, 820 p.
20. Feynman R., Leighton R., Sands M. "The Feynman Lectures on Physics" V. 3, 4. *World*, Moscow, 1976, 496 p.
21. Zeldovich J.B., Novikov I.D. "The Theory of Gravitation and Evolution of Stars," *Science*, Moscow (1971), 484 p.
22. Kris Pardo, Maya Fishbach, Daniel E. Holz, David N. Spergel. "Limits on the Number Spacetime Dimensions from GW170817," *ArXiv.org* 1801.08160v1, 24 Jan 2018, pp. 1-7.
23. Christian Corda "Interferometric Detection of Gravitational Waves: the Definitive Test for General Relativity," *Int. J. Mod. Phys.* D18, 2009, pp. 2275-2282.

