Chapter 1. The theory axiomatics

The axiomatic basis of the present theory includes 6 postulates, the first 4 of which are the postulates of the modern field theory. The postulates 5 and 6 express the specificity of the present theory and do not contradict to modern physics.

1. A postulate of fundamentality of an electromagnetic field: ***the self-consistent Maxwell-Lorentz microscopic equations are the independent fundamental field equations***.

The Maxwell-Lorentz equations are following four differential (or equivalent integral) equations for any electromagnetic medium (Jackson, 1999; Tonnelat, 1959):

$$rot\vec{H} = \frac{4\pi}{c}\left(\vec{j} + \vec{j}_{ext}\right) + \frac{1}{c}\frac{\partial \vec{E}}{\partial t}, \tag{1.1}$$

$$rot\vec{E} = -\frac{1}{c}\frac{\partial \vec{H}}{\partial t}, \tag{1.2}$$

$$div\vec{E} = 4\pi\left(\rho + \rho_{ext}\right), \tag{1.3}$$

$$div\vec{H} = 0, \tag{1.4}$$

where $\vec{F} = \left\{\vec{E}, \vec{H}\right\}$ is the electromagnetic field vectors, ρ is the charge density; $\vec{j}$ is the current density; c is the speed of light. Values $\vec{j}$ and ρ (or in 4-vector form $j_\mu = \left\{\vec{j}, i\rho\right\}$, where $\mu = 1,2,3,4$) in these equations should be considered as functions (more precisely, functionals) of strength $\vec{E}$ and $\vec{H}$ of the same fields, which these charges and currents substantially define: $j_\mu = j_\mu(\vec{E}, \vec{H})$. The part of charges and currents can be caused by external in relation to the given system reasons. Such charges and currents, which do not dependent on $\vec{E}$ and $\vec{H}$ of an initial source, sometimes are referred to as external and are designated as $\vec{j}_{ext}$ and ρ_{ext}. (We shall remind, that generally the fields and currents of these equations are interdependent, and the equations are thereof non-linear).

As is known, the Maxwell-Lorentz theory predict the existence of electromagnetic waves. In relation to these the following postulate has place.

2. Plank's-Einstein's postulate of quantization of electromagnetic waves: ***the electromagnetic waves are the superposition of the elementary wave fields named photons, having the certain energy, momentum and zero rest mass.***

In this postulate are simultaneously taken into account both quantization of electromagnetic waves and the belonging of photons to bosons.

3. A postulate of dualism of photons: ***photons exist as real independent objects, which have***

a) <u>the wave properties</u>, described by Maxwell-Lorentz equations **(1.1) - (1.4)** ***and by the wave equation following from them:***

$$\left(\frac{\partial^2}{\partial t^2} - c^2\vec{\nabla}^2\right)\vec{F} = 0, \tag{1.5}$$

b) <u>quantum properties</u>, which are not deduced from Maxwell-Lorentz theory, but also not contradicted to it.

The numerical characteristics of photons are determined by a below postulate of Planck.

4. Planck postulate: ***Connection between energy, frequency and wavelength of a photon is set by the following formulas*****:**

$$\varepsilon = h\nu = \hbar\omega\,, \tag{1.6}$$

$$\lambda = \frac{h}{p} = \frac{hc}{\varepsilon}, \tag{1.7}$$

where $\varepsilon,\ \nu,\ \omega,\ \lambda,\ p,\ c$ are the energy, linear frequency, circular frequency, wavelength, momentum and speed of a photon, and $h,\ \hbar$ are the usual and bar Planck's constants accordingly.

The following postulate is neither proved nor disproved by experiments, but it doesn't contradict to the theoretical description of photons:

5. The postulate of EM string.

Since this postulate is central in our theory, it demands a serious substantiation of its consistency to modern results.

As it is known, in framework of QED (Ahiezer and Berestetski, 1969), to obtain the photon wave function the second order wave equations for EM field vectors E and H (1.5) are used.

Factorizing the wave equation to the equations for retarded and advanced waves, we receive two equations of the first degree regarding the function f_k, which adequate to a wave vector k and is some generalization of the EM field vectors. The equation for this function is equivalent to the Maxwell-Lorentz equations.

But the function f_k can be interpreted as wave function of a photon only in the *momentum space*. It does not allow to describe an interaction of a photon in the local point of *coordinate space*, since for this aim the wave function in the coordinate representation is required.

Unfortunately the attempt to enter the photon function in the coordinate representation has strike on an insuperable difficulty. According to analysis of Landau, L.D. and Peierls, R. (Landau and Peierls, 1930) and later of Cook, R.J. (Cook, 1982a;1982b) and Inagaki, T. (Inagaki, 1994) the photon wave function is nonlocal.

Actually, having made the inverse Fourie transformation of above f_k function $\frac{1}{(2\pi)^3}\int f_k e^{i\vec{k}\vec{r}} d^3k = f(\vec{r},t)$, it is possible to define $f(\vec{r},t)$ as the photon wave function in coordinate representation. But the $f(\vec{r},t)$ function is not defined by the value of the field $\vec{E}(\vec{r},t)$ in the same point; it depends on the field distribution in some area, which sizes are of the order of the photon wavelength. This means, that the localization of a photon in a smaller area is impossible and, hence, the value $\left| f(\vec{r},t)\right|^2$ will not have the sense of probability density to find a photon in the given point of coordinate space.

The linear object, which, on the one hand, obeys the wave equation, and on the other hand has some size, is referred to as a *string*. Thus, within the framework of CWED it is admissible to describe a photon as an element of electromagnetic wave - an electromagnetic string (not forgetting of course that this supposition cannot have any relationship to the real structure of a photon). This allows us to formulate the following postulate**:**

Within the framework of the present theory the fundamental particle of an EM field - the photon - can be described as a relativistic EM string of one wavelength size, which corresponds to its energy according to Planck's formula.

The main proof of validity of this postulate is the opportunity to construct on its basis the theory, which coincides completely with the existing quantum field theory.

6. A postulate of formation of massive particles: ***Within the framework of the present theory under the certain external conditions the EM-string can start to move along the closed curvilinear trajectory, forming the elementary particles.***

As is known, the bending of a trajectory of an EM wave in the strong EM field follows already from the Maxwell-Lorentz theory. Thus, strictly speaking, the opportunity of an EM wave propagation along a curvilinear trajectory does not demand a special postulate.

At the same time, it is obvious, that due to the quantum nature of a photon (EM-string) the formed particles should possess, at least, a rest mass and the angular momentum (spin). Moreover, the detail analysis shows that such elementary particles can have electric charge, helicity and all other characteristics and parameters of real elementary particles.

It would be very difficult to find simultaneously the adequate description of all EM elementary particles. The most logical way of construction of the general theory - to begin with the most simple and good studied - theoretically and experimentally – particle: the electron. Chapters 2-4 of the book are devoted to this. Then we shall try to generalize the received results for the description of more exotic and complex particles.

Further for brevity this theory is referred to as **CWED** - Curvilinear Waves' Electrodynamics.