To the Model of the Light Particles

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Abstract

The present research offers a scalar generalization of Maxwell's electrodynamics for moving media, allowing to describe the relativistic effects without using Einstein's relativity theory in the model of Newton's macroscopic space. These results allow to start theoretical research on the structure of the light particles in our own rest system.

Keywords: generalization of Maxwell's electrodynamics, superlight velocities, dynamics of the relativistic effects

Introduction

It is known that an uniform description of experimental data in the classical Maxwell's electrodynamics with relative movements taken into consideration was worked out on the basis on the special relativity theory, developed by Einstein [1]. It is based upon three principles: a) relativity, b) consistency of the light velocity in the vacuum, c) an implicit postulate of the absence of ether. This model of Einstein does not include ideology or some theoretical suppositions on the physical structure of the light.

Later corpuscular properties of the light were found out by means of experiment. They manifested themselves in particular in the photoeffect and Compton's effect [2]. This data along with other facts initiated the setting and resolution of the light structure problem.

These attempts were not successful within the quantum theory of light, thus a photon is looked upon by theorists as an unstructured quasi-particle. The results of experimental works carried out on a systematical basis from 1960 till the present time support the opportunity to look upon photons as structured objects like adrons [3].

In order to raise the theory to the level of modern experiments the following questions should be answered:

a) is the model of relativistic description of electrodynamical phenomena proposed by Einstein unique or another model is possible?

b) is it possible to make a theoretically consistent description of the whole set of relativistic experiments without using the special relativity theory and without the limitations following from it?

c) what is the possible basis for creating a new model of relativist effects in electrodynamics, how to do it and what will the new consequences be like?

This work gives *a dynamical* description of relativist effects. It is based upon the scalar generalization of electrodynamics in the *Newton's* space-time model. The key role in generalization is played by a new scalar unit w, denominated as an index of relation. It allowed to complete the index of refraction n controlling the alteration of the field velocity by the index of relation which controls the alteration of the field frequency.

The offered variant of analysis is in accordance with *the standard approach* to physical phenomena. The issue under consideration is the model of a phenomenon, as well as its generalization opportunities. We find the solutions of the equations, which can be independent from the symmetrical properties of the investigeted problem. Then the calculation is accorded with the experiment.

1. Maxwell's electrodynamic equations in the Newton's space-time

We shall start from the assumption that there is a single observer. He has a system of measurement devices, necessary and sufficient to research electromagnetic phenomena. The observer uses the "absolute" models of length and time in accordance with Newton's physical model of space $R^3 \times T^1$. Physical laws of electrodynamics are also given in $R^3 \times T^1$ on the basis of the three-dimensional *rot* and *div* in the vectorial form:

$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t},\ \nabla \cdot \vec{B} = 0,$$

$$\nabla \cdot \vec{D} = 4\pi\rho,\ \nabla \times \vec{H} = \frac{1}{c}\frac{\partial \vec{D}}{\partial t} + 4\pi\frac{\vec{J}}{c}.$$

On the base of Maxwell's equations, taking into consideration the properties of real physical media with no ether model used, let's describe in a uniform way the experiments by Bradley, Doppler, Fizeau, Michelson. Let's consider as well the problem of "consistency" of light velocity in the vacuum, formulated by Einstein.

2. Generalized connections of fields and induction

It is known that the connection of fields and induction for the resting isotropic media looks like

$$\vec{D} = \varepsilon\,\vec{E},\ \vec{B} = \mu\,\vec{E},$$

where ε and μ are the dielectric and magnetic penetrabilities. With electrodynamics considered in the tensor aspect, the fields $F_{\mu\nu}$ and inductions H^{ik} will be connected by the tensor

$$\varepsilon^{ij} = \frac{1}{\sqrt{\mu}} diag\,(1,1,1,\varepsilon\mu)\,.$$

The variant considered by Minkowsky, wenn the medium is a secondary source of radiation assumes that its velocity $\vec{U}_m$ connects fields and inductions. Then

$$\vec{D} + \left[\frac{\vec{U}_m}{c} \times \vec{H}\right] = \varepsilon\,\left(\vec{E} + \left[\frac{\vec{U}_m}{c} \times \vec{B}\right]\right),$$

$$\vec{B} + \left[\vec{E} \times \frac{\vec{U}_m}{c}\right] = \mu\,\left(\vec{H} + \left[\vec{D} \times \frac{\vec{U}_m}{c}\right]\right).$$

His model does not contain the velocity of the primary source of radiation or any suppositions about the structure of radiation.

Let's find more general connections between the fields F_{mn} and inductions H^{ik} in the form [4]:

$$H^{ik} = \Omega^{im}\Omega^{kn}F_{mn}.$$

They will contain the standart model as particular case. Let's choose:

$$\Omega^{im} = \alpha\left(\Theta^{im} + \beta\,U^iU^m\right).$$

Here α and β are scalar functions, Θ^{im} is a tensor, $U^i = dx^i/d\Theta$ are four-velocities constructed on its basis. The expression Ω^{im} was found in [5] as a solution for the system of non-linear algebraic equations:

$$\Omega^{im} = \frac{1}{\sqrt{\mu}}\left[\Theta^{im} + \left(\frac{\varepsilon\mu}{\chi} - 1\right)\,U^iU^m\right].$$

Here $\Theta^{im} = diag\ (1,\ 1,\ 1,\ \chi)$, and $\chi = \det\,\Theta^{im}$. The tensor Ω^{im} has no singularity with $\chi = 0$, as

$$d\Theta = \frac{icdt}{\sqrt{\chi}}\left(1 - \chi\frac{U^2}{c^2}\right)^{1/2},$$

$$U^k = \frac{dx^k}{d\Theta} = \frac{\sqrt{\chi}}{ic}\frac{dx^k}{dt}\left(1 - \chi\frac{U^2}{c^2}\right)^{-1/2}.$$

For the velocities $U_n = \Theta_{nk}U^k$ the correlation $U^kU_k = 1$ is realized. With the anti-symmetry of F_{mn} and H^{ik} the following expression can be used:

$$H^{ik} = \Omega^{ikmn}F_{mn}, \Omega^{ikmn} = 0,5\left(\Omega^{im}\Omega^{kn} - \Omega^{in}\Omega^{km}\right)$$

with the conditions

$$\Omega^{ikmn} = -\Omega^{iknm} = -\Omega^{kimn}.$$

Thus Maxwell's equations

$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}, \nabla \cdot \vec{B} = 0,$$

$$\nabla \cdot \vec{D} = 4\pi\rho, \nabla \times \vec{H} = \frac{1}{c}\frac{\partial \vec{D}}{\partial t} + \frac{4\pi}{c}\vec{j}$$

are supplemented by generalized connections [6]:

$$\vec{D} + \chi\left[\frac{\vec{U}}{c} \times \vec{H}\right] = \varepsilon\left(\vec{E} + \left[\frac{\vec{U}}{c} \times \vec{B}\right]\right),$$

$$\vec{B} + \chi\left[\vec{E} \times \frac{\vec{U}}{c}\right] = \mu\left(\vec{H} + \left[\vec{D} \times \frac{\vec{U}}{c}\right]\right).$$

3. Model problem

Let the primary radiation source move around the Earth in the vacuum with the velocity of $\vec{U}_{fs}$, which is the velocity of the primary source of the radiation $\vec{U}\Big|_{\rho=0} = \vec{U}_{fs}$. Let the radiation spread from the vacuum in the atmosphere of the Earth with the density ρ. Let the velocity radiation source velocity with $\rho = \rho_0$ become equal to the velocity of physical medium

$$\vec{U}\Big|_{\rho=\rho_0} = \vec{U}_m \ .$$

Let's introduce the new velocity

$$\vec{U} = \vec{U}\left(\vec{U}_{fs},\, \vec{U}_m,\, w(\rho)\right),$$

supposing that it depends on the functional $w(\rho)$. Let's call it the index of relation. Let's subordinate the velocity $\vec{U}$ to the relaxation equation

$$\frac{d\vec{U}}{d\xi} = -P_0\left(\vec{U} - \vec{U}_m\right), \vec{U}\Big|_{\xi=0} = \vec{U}_{fs} \ , \xi = \rho/\rho_0.$$

This demand is in accordance with the physical conditions [7]. We shall get the solution:

$$\vec{U} = (1-w)\vec{U}_{fs} + w\vec{U}_m, w = 1 - \exp\left(-P_0\frac{\rho}{\rho_0}\right).$$

Then

$$\vec{U}\Big|_{\rho=\rho_0} = \vec{U}_{fs} \ , \quad w\,|_{\rho=0} = 0 \ ,$$
$$\vec{U}\Big|_{\rho=\rho_0} = \vec{U}_m \ , \quad w\,|_{\rho=\rho_0} = 1 \ .$$

Let's accept an additional condition that $\chi = w$.

4. Solution for Maxwell's generalized equations with $w = const$

The equations for the field potentials A_m with $w = \text{const}$ [8] are:

$$\hat{M}A_m = -\mu U^i \Theta_{im}.$$

Here

$$\hat{M} = \left[\Theta^{kn}\frac{\partial}{\partial x^k}\frac{\partial}{\partial x^n} - (\varepsilon\mu - w)\left(V^k\frac{\partial}{\partial x^k}\right)^2\right],$$
$$V^k = \frac{U^k}{\chi}.$$

The calibration condition is

$$\Theta^{kn}\frac{\partial A_n}{\partial x^k} + (\varepsilon\mu - w)\frac{\partial A_l}{\partial x^k}U^l U^k = 0.$$

For the vectorial $\vec{A}$ and scalar φ potentials according to the standard definition

$$\vec{E} = -\frac{1}{c}\frac{\partial\vec{A}}{\partial t} - \nabla\varphi,\ \vec{B} = \nabla\times\vec{A}$$

we get

$$\widehat{L}\vec{A} = -\frac{4\pi\mu}{c}\left\{\vec{J} + \frac{\sigma\,\Gamma^2}{\sigma + w}\frac{\vec{U}}{c}\left(w\vec{U}\cdot\vec{J} - c^2\rho\right)\right\},$$

$$\widehat{L}\varphi = -4\pi\mu\frac{\Gamma^2}{w+\sigma}\left\{\rho\left(1 - \varepsilon\mu\frac{U^2}{c^2}\right) + \sigma\frac{\vec{U}\cdot\vec{J}}{c^2}\right\}$$

and the condition of calibration

$$\left(\nabla\cdot\vec{A} + \frac{w}{c}\frac{\partial^2}{\partial t^2}\right) - \frac{\sigma\,\Gamma^2}{c^2}\left(\frac{\partial}{\partial t} + \vec{U}\cdot\nabla\right)\left(\vec{U}\cdot\vec{A} - c\varphi\right) = 0.$$

Here

$$\widehat{L} = \left(\Delta - \frac{w}{c^2}\frac{\partial^2}{\partial t^2}\right) - \sigma\frac{\Gamma^2}{c^2}\left(\frac{\partial}{\partial t} + \vec{U}\cdot\nabla\right)^2,$$

$$\sigma = \varepsilon\mu - w, \Gamma^2 = \left(1 - w\beta^2\right)^{-1}, \beta = \frac{U}{c}.$$

Green's function for vectorial equations

$$G_0\left(\vec{r},\ t\right) = 16\pi^4\mu\left(r^2 + \xi^2\right)^{-1/2}\delta \times\left(t - \frac{1}{c}\frac{\varepsilon\mu - \beta^2 w^2}{\left(1 - w\beta^2\right)\sqrt{\varepsilon\mu}}\left(r^2 + \xi^2\right)^{1/2}\right)$$

is given in [7]. In the cylindrical coordinate system whose radius vector is $R = \left(\rho^2 + z^2\right)^{1/2}$ there are the following values

$$r^2 = \rho^2\frac{\varepsilon\mu\left(1 - w\beta^2\right)}{\varepsilon\mu - \beta^2 w^2}, \xi = z - \frac{\varepsilon\mu - w}{\varepsilon\mu - \beta^2 w^2}Ut.$$

With $\beta = 0$ we shall get the Green's function for the resting source of the radiation in the dispersion-free medium.

$$G_0\left(\vec{r},\ t\right)\,|_{\vec{U}=0} = 16\pi^4\mu\frac{1}{R}\delta\left(t - \frac{R\sqrt{\varepsilon\mu}}{c}\right).$$

It is different from zero on the surface

$$t = \frac{1}{c}\frac{\varepsilon\mu - \beta^2 w^2}{\left(1 - w\beta^2\right)\sqrt{\varepsilon\mu}}\left(r^2 + \xi^2\right)^{1/2}.$$

This is an ellipsoid of rotation whose axis of symmetry coincides with $\vec{U}$ and the position of the centre is given by the formula

$$z_0 = Ut\frac{\varepsilon\mu - w}{\varepsilon\mu - \beta^2 w^2}.$$

The centre of the surface on which Green's function is different from zero moves with the velocity

$$U_0 = U\frac{\varepsilon\mu - w}{\varepsilon\mu - \beta^2 w^2}$$

Ellipse semi-axes are

$$a = ct\left(\frac{1 - w\beta^2}{\varepsilon\mu - \beta^2 w^2}\right)^{1/2}, b = ct\frac{\sqrt{\varepsilon\mu}\left(1 - w\beta^2\right)}{\varepsilon\mu - \beta^2 w^2}.$$

There is a generalized dispersion equation

$$c^2K^2 = w\omega^2 + \Gamma^2\left(\varepsilon\mu - w\right)\left(\omega - \vec{K}\cdot\vec{U}\right)^2$$

for the electromagnetic field. The expression resulting from it for the group velocity is

$$\vec{V}_g = \frac{\partial\omega}{\partial\vec{K}} = c\frac{K + \sigma\,\Gamma^2 c^{-2}\vec{U}\left(\omega - \vec{K}\cdot\vec{U}\right)}{\omega c^{-1}w + \sigma\,\Gamma^2 c^{-1}\left(\omega - \vec{K}\cdot\vec{U}\right)}.$$

In the non-relativist limit

$$\vec{V}_g = \frac{c}{n}\frac{\vec{K}}{K} + \left(1 - \frac{w}{n^2}\right)\left[\left(1 - w\right)\vec{U}_{fs} + w\vec{U}_m\right].$$

The expression obtained illustrates the dependence of electromagnetic field group velocity not only from the index of refraction, but also from the index of relation, not only from the velocity of the medium, but also from the velocity of primary source of radiation.

5. Analysis of the expressions obtained

1. If $w = 0$ we shall get

$$\vec{V}_g = c\frac{\vec{K}}{K} + \vec{U}_{fs}.$$

In the electromagnetic phenomena generalized model the field in the vacuum will move so that the centre of the surface on which the Green's function differs from zero moves with the velocity $\vec{U}_{fs}$.

The semi-axes of the ellipse in this case are equal setting the sphere of a variable radius.

2. This model is in accordance with the experiments of Michelson. In his experiment the velocity of the medium and the velocity of radiation source were equal to zero: $\vec{U}_m = 0$, $\vec{U}_{fs} = 0$. Thus,

$$\vec{V}_g = \frac{c}{n}\frac{\vec{K}}{K}.$$

3. New model is in accordance with the Fizeau's experiment. According to the conditions of the experiment, $\vec{U}_{fs} = 0$, $\omega = 1$, thus

$$\vec{V}_g = \frac{c}{n}\frac{\vec{K}}{K} + \left(1 - \frac{1}{n^2}\right)\vec{U}_m.$$

6. The new conditions for the wave phase

Let us study the field frequency dynamics. According to the solutions obtained, electromagnetic field group velocity does not depend on the velocity $\vec{U}_{fs}$ in case $w \to 1$. This alteration, from the physical point of view, could manifest itself in the alteration of frequency. In order to understand whether it is theoretically possible, let us complete the dispersion equation with a generalised phase condition, according to [9]:

$$(\omega - \vec{K}\cdot\vec{U}_\xi)\left(1 - w_\xi\frac{U_\xi^2}{c^2}\right)^{-1/2} = \text{const}.$$

We shall assume that the velocity $\vec{U}_\xi$ is not identical to the generalized velocity $\vec{U}$. Let us introduce

$$\vec{U}_\xi\left(\vec{U}_{fs},\ \vec{U}_m,\ w_\xi\left(\rho\right)\right) \neq \vec{U}.$$

Let us set for it an equation

$$\frac{d\vec{U}_\xi}{d\xi} = -P_\xi\left(\vec{U}_\xi - \vec{U}_*\right),\ \vec{U}_\xi\,|_{\rho=0} = \vec{U}_{fs}$$

of relaxation type [7]. We shall use $\vec{U}_* = \vec{U}_{fs} + \vec{U}_m$ as the velocity relaxation value. This variant is possible in the Newton's model of space. We shall get the solution

$$\vec{U}_\xi = \vec{U}_{fs} + w_\xi\vec{U}_m,\quad w_\xi = 1 - \exp\left(-P_\xi\frac{\rho}{\rho_0}\right).$$

"From the kinematical point of view", the velocity $\vec{U}_{fs}$ disappears due to the interaction with the medium if $w = 1$ and does not manifest itself in the group velocity. "From the energetical point of view" it turns into the frequency ω. It is possible because dispersion and phase conditions play different roles in the offered model and possess the conditions supplementing each other.

7. Dynamics of aberration and Doppler effect

We shall consider the radiation with the initial frequency value ω_0 and the wave vector $\vec{K}_0$. Let it spread from the source moving in the vacuum at the velocity of $\vec{U}_{fs}$, towards the surface of the Earth. Let $\vec{U}_m = 0$. We shall calculate the change of the frequency ω and the wave vector $\vec{K}$ during the radiation interaction with the atmosphere. Let $w = w_\xi$.We shall get an equation system [5]:

$$c^2K^2 - w\omega^2 = \Gamma^2 \left(\varepsilon\mu - w\right) \left(\omega - \vec{K} \cdot \vec{U}\right)^2,$$

$$\omega = \omega_0 \left(1 - wU_\xi^2/c^2\right)^{1/2} + \vec{K} \cdot \vec{U}_\xi.$$

Let us accept the assumptions that $K_{y_0} = 0$, $K_z = K_{z_0}$. We will find the dependence of ω, K_x from the initial values ω_0, K_{z_0}. We can transform the dispersion equation, with the precision up to $\left(U_{fs}/c\right)^2$, into the form

$$AK_x^2 + BK_x + P = 0.$$

Its coefficients are:

$$A = 1 - a\frac{U_{fs}^2}{c^2}, a = 2w + (\varepsilon\mu - 2)w^2 - w^3,$$

$$B = -2w\frac{w_0}{c}\frac{U_{fs}}{c}b, b = 1 + \varepsilon\mu - w,$$

$$P = \frac{w_0^2}{c^2}\frac{U_{fs}^2}{c^2}q, q = (1 + 2\varepsilon\mu)\, w^2 - (\varepsilon\mu + 2)w^3 + w^4.$$

Let us calculate *a, b, q,* with the value $\varepsilon\mu = 1$. We can introduce the function:

$$\Phi = w\,[(2 - w) - (1 - w)^{1/2}].$$

We shall get K_x in the form of a non-linear formula to w:

$$K_x = \Phi\frac{\omega_0}{c}\frac{U_{fs}}{c}.$$

The aberration angle is defined by the expression:

$$tg\alpha = \frac{K_x}{K_z} = \frac{U_{fs}}{c}\Phi.$$

The connection of the initial and intermediate frequency

$$\omega = \omega_0 \left[\left(1 - w\frac{U_{fs}^2}{c^2}\right)^{1/2} + \Phi\frac{U_{fs}^2}{c^2}\right].$$

depends on w. Far from the Earth surface it is

$$K_x = 0, K_z = -\frac{\omega_0}{c}, \omega = \omega_0.$$

When a light is approaching to the Earth its parameters change dynamically. At the final stage we shall get:

$$K_x = \frac{\omega_0}{c}\frac{U_{fs}}{c}, \omega = \omega_0\left(1 - \frac{U_{fs}^2}{c^2}\right)^{-1/2}.$$

These laws are similar to those obtained within the special relativity theory. Two new phenomena are in the generalized electromagnetic model: the ultimate values of the dynamic process parameters and the law of transformation of the velocity into frequency.

8. New effects in generalized electrodynamics

1. In the vacuum $\rho = 0$, thus $w = 0$. Group velocity of the field

$$\vec{V}_g = c\frac{\vec{K}}{K} + \vec{U}_{fs}$$

depends on the velocity of the primary source of radiation. The wave front surface is a sphere as $a = b = c_0t$, and the centre of this sphere moves at the velocity of $\vec{U}_* = \vec{U}_{fs}$. The view of radiation proliferation in the new model is in accordance with the "ballistic" idea of Ritz. Due to the interaction with the medium, in particular with the measurement system, the velocity $\vec{U}_{fs}$ can "disappear". It happens in all the cases of the direct measuring of the light velocity in the vacuum [10].

2. Let the source of radiation rest relative to the observer $\vec{U}_{fs} = 0$, and the medium move at the velocity $\vec{U}_m$. For the group velocity of the field we shall receive

$$\vec{V}_g = \frac{c}{n}\frac{\vec{K}}{K} + \left(1 - \frac{w}{n^2}\right) w\vec{U}_m$$

The maximum value corresponds $w = 0.5$. Wenn the index of refraction close to 1, the velocity corresponding to it is

$$\vec{V}_g^{\max} = c\frac{\vec{K}}{K} + 0.25\,\vec{U}_m$$

3. The analysis of transverse Doppler effect dynamics for the case of small relative velocities will

lead us to the conclusion that for $w = 1$ the frequency ω is set by the expression

$$\omega = \omega_0 \left(1 - \frac{U_{fs}^2}{c^2}\right)^{-1/2}$$

Let us multiply it by the value $\hbar/c^2$, where $\hbar$ is the Plank's constant. We shall get the formula for the masse, used in relativist dynamics.

Our model of electromagnetic field dynamic gives another expression for the connection of frequencies. We shall show it. We shall considere the spreading of radiation from the vacuum into the atmosphere of the earth. We can formally suppose that the velocity $\vec{U}_{fs}$ is additionally to the velocity of light in the vacuum. Let $w = 1$ to simplify the calculation. Then $\vec{U} = 0$, $cK_z = n\omega_0$. As U_{fs}/c is close to 1, it is necessary to use the real index of refraction, for example $n = 1 + Q$, where $Q << 1$. We shall get the system of equations in the form

$$c^2 K_x^2 = n^2 \left(\omega^2 - \omega_0^2\right),$$
$$\omega = \omega_0 \left(1 - \frac{U_{fs}^2}{c^2}\right)^{1/2} + \frac{n}{c} U_{fs} \left(\omega^2 - \omega_0^2\right)^{1/2}.$$

The square equation for the frequency

$$\omega^2 - 2\omega\,\omega_0\sigma \left(1 - \frac{U_{fs}^2}{c^2}\right)^{1/2} + \omega_0^2\sigma \left(1 + \frac{U_{fs}^2}{c^2}\Psi\right) = 0$$

contains the multiplier

$$\sigma = \left[1 - U_{fs}^2(1+\Psi)/c^2\right]^{-1},$$

where $\Psi = 2Q + Q^2,\ n = 1 + Q$. The value of the limit frequency is set by the law:

$$\omega = \omega_0\sigma \left[\left(1 - \frac{U_{fs}^2}{c^2}\right)^{1/2} - \frac{U_{fs}^2}{c^2}\Psi^{1/2}\left(1+\Psi\right)^{1/2}\right].$$

Then $\omega^* = \lim \omega \left|_{U_{fs}\to c}\right. = \omega_0 \left(1 + \Psi^{-1}\right)^{1/2}$. Supposing that the mass m is proportional to frequency, we shall get a new law:

$$m = m_0 \frac{\left(1 - \frac{U^2}{c^2}\right)^{1/2} - \frac{U^2}{c^2}\Phi^{1/2}\left(1+\Phi\right)^{1/2}}{1 - \frac{U^2}{c^2}\left(1+\Phi\right)}.$$

9. Mechanical law of energy conservation for the photon

When the radiation propagates in the rarefied gas from the primary source moving in the vacuum at the velocity of $\vec{U}_{fs}$ dynamic change of its group velocity $\vec{V}_g$ and its frequency ω occurs. At small relative velocities the frequency ω at the ultimate stage of the dynamic process differs from the initial frequency ω_0 by the value

$$\Delta\omega = \omega - \omega_0 = 0.5\omega_0 \frac{U_{fs}^2}{c^2}.$$

Let us multiply this expression by the Plank's constant and use the Einstein's definition by for the photon inertia mass:

$$m_{in} = \hbar \frac{\omega_0}{c^2}$$

We can introduce the following definitions:

a) kinetic energy of the photon caused by the primary radiation source velocity is

$$E_{kin} = 0.5\hbar \frac{\omega_0}{c^2} U_{fs}^2$$

b) difference of the potential energies of the photon is

$$\Delta U = \hbar\left(\omega - \omega_0\right).$$

Then $\Delta U = E_{kin}$.

From the physical point of view the situation looks this: at first the photon had the velocity $\vec{U}_{fs}$ additionally to the velocity of light in the vacuum c, and the frequency ω_0. While interacting with the medium it "transformed" the velocity $\vec{U}_{fs}$ into an addition to the frequency $\Delta\omega$.

Conclusion

Generalization of connections between fields and inductions in Maxwell's electrodynamics is possible. The model describes the familiar experimental facts, setting the dynamics of electromagnetic field inertial parameters.

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