Maxwell's Electrodynamics Without Special Relativity Theory (Part II)

Victor N. Barykin
Scientific Center 'Malinovka'
15-234 Str. Slobodskaya, Minsk 220098, BELARUS

This work finds a previously unknown dynamic mechanism for the transformation of the velocity that specifies the external inertia of an electromagnetic field into a proper frequency of the field. It is shown that a particle of non-zero rest mass can be limited to a speed equal to light speed in vacuum.

Introduction

Part I of this series suggests a generalization of Maxwell's electrodynamics in which the dynamic equations are used without involving any new elements, while the connections between fields and inductions are extended. The generalized connections contain the velocity of a primary radiation source $\mathbf{U}_{fs}$, the medium velocity $\mathbf{U}_m$, and also a new quantity called the phase of the external inertia of the electromagnetic field, $w(\rho) = 1 - \exp(-P_0\rho / \rho_0)$, where ρ is the density of the atmosphere.

The calculation of the field parameters and analysis of experimental data are carried out in Newton's model of space. The absolute character of length and time are the foundation of the proposed algorithm for the dynamic change in the inertial parameters of the field.

The equations for field potentials that follow from Maxwell's generalized equations are obtained. The Green's function is found, and its physical consequences are analyzed. A generalized expression for the field group velocity is obtained. The dependence of the field velocity in vacuum on the primary radiation source velocity is shown.

Now, we will study the dynamics of the field frequency.

New Requirement on the Wave Phase

The group velocity of an electromagnetic field for $w \to 1$ does not depend on $\mathbf{U}_{fs}$. Physically this change of the speed can and must be exhibited as a change in frequency. Since a dynamic change in the speed is considered, there will consequently also be dynamic change in the frequency ω. To understand the manner in which this occurs, we supplement the dispersion equation with the generalized phase requirement [1]:

$$\omega - \vec{K} \cdot \vec{U}_\xi \Big/ \sqrt{1 - w_\xi {U_\xi}^2 / c^2} = \text{const}$$

This requirement does not follow directly from Maxwell's equations and, consequently, we will assume that the velocity $\mathbf{U}_\xi$ can be different from the radiation carrier velocity $\mathbf{U}$. By analogy with the algorithm and model already adopted for the analysis, we will consider the new velocity $\mathbf{U}_\xi$ in the form:

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

We assign for it an equation of the relaxation type [2]:

$$d\mathbf{U}_\xi / d\xi = -P_\xi\left(\mathbf{U}_\xi - \mathbf{U}_*\right), \quad \mathbf{U}_\xi\big|_{\xi=0} = \mathbf{U}_{fs}$$

In order to preserve $\mathbf{U}_{fs}$ as a function on of $\mathbf{U}_\xi$, we use as the relaxation value

$$\mathbf{U}_* = \mathbf{U}_{fs} + \mathbf{U}_m$$

which is permissible in Newton's model. We have the solution

$$\mathbf{U}_\xi = \mathbf{U}_{fs} + w_\xi \mathbf{U}_m, \quad w_\xi = 1 - \exp(-P_\xi \rho / \rho_0)$$

The situation appears thus: from the kinematic viewpoint, the interaction with the medium causes the velocity $\mathbf{U}_{fs}$ to disappear, so it is not exhibited in the group velocity; from the energy viewpoint, $\mathbf{U}_{fs}$ is transformed into the frequency ω. This is achieved because the roles and functions of the dispersion and phase requirements are complementary.

Dynamics of Doppler Effect and Aberrations in Maxwell's Electrodynamics

We will adopt the point of view that the change of the parameters of an electromagnetic field happens only because of its interaction with the medium or with external fields. Let us consider how these processes occur in the generalized electromagnetic model. Let us analyze the model problem:

The radiation with an initial frequency ω_0 and wave vector $\mathbf{K}_0$ from a radiation source moving in vacuum with the velocity $\mathbf{U}_{fs}$ is spread to the Earth surface, on which there is an observer. The atmosphere is at rest, $\mathbf{U}_m = 0$. It is required to calculate the manner in which the frequency ω and wave vector $\mathbf{K}$ change because of the interaction of the radiation with the medium.

Let $w = w_\xi$. Using the equations obtained, we can unite into a uniform system the dispersion and phase requirements [3]:

$$c^2 K^2 - w\omega^2 = \Gamma^2(\varepsilon\mu - w)(\omega - \mathbf{K} \cdot \mathbf{U})$$

$$\omega = \omega_0 \sqrt{1 - w U_\xi^2 / c^2} + \mathbf{K} \cdot \mathbf{U}_\xi$$

$$\Gamma^2 = 1 / (1 - w U^2 / c^2)$$

We assume that $K_{y_0} = 0$, $K_z = K_{z_0}$. We find the dependence of ω, K_x on the initial values of ω_0, K_{z_0}. We transform the dispersion equation, accurate to $(U_{fs}/c)^2$, to the form

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

The coefficients are $A = 1 - aU_{fs}^2 / c^2$ with $a = w + \varepsilon\mu w^2 - w^3$, $B = w(w_0 / c)(U_{fs} / c)b$ with $b = 1 + \varepsilon\mu - w$, and $P = (w_0^2 / c^2)(U_{fs}^2 / c^2)q$ with $q = w^2 - 2w^3 + w^4 + 2\varepsilon\mu w^2 - w^3\varepsilon\mu$ The a, b, q are calculated for $\varepsilon\mu = 1$. Analysis has shown that the solution can be expressed by the function

$$\hat{\Phi} = w\left[(2 - w) + \sqrt{1 - w}\right]$$

We have for K_x a nonlinear dependence on w

$$K_x = \hat{\Phi}(\omega_0 / c)U_{fs} / c$$

The aberration angle is defined by the expression

$$\tan\alpha = K_x / K_z = \hat{\Phi}U_{fs} / c$$

The connection of initial and intermediate frequencies is given by dependence

$$\omega = \omega_0\left[\sqrt{1 - wU_{fs}^2 / c^2} + \hat{\Phi}U_{fs}^2 / c^2\right]$$

According to the calculations, far from Earth's surface we have $K_x = 0$, $K_z = -\omega_0 / c$, $\omega = \omega_0$. As the Earth is approached, ω and K_x vary continuously because of the change in w. For $w = 1$ we obtain

$$K_x = (\omega_0 / c)(U_{fs} / c), \quad \omega = \omega_0 / \sqrt{1 - U_{fs}^2 / c^2}$$

These values agree with Bradly's experiment and with the formula for the Doppler cross effect. The same results are obtained by the methods of the special relativity theory.

The special relativity theory, as is typical of a kinematic theory, connects initial and final parameters of the field. It is possible to consider the special theory of relativity as corresponding to a 'black box'; given the input parameters, the values at the output of the box are prescribed, but the process itself is not analyzed. The generalized model indicates the laws of the dynamics of the processes. We have

$$\omega = \omega_0 + \left(\hat{\Phi} - \tfrac{1}{2}w\right)(U_{fs} / c)\omega_B, \quad \mathbf{V}_g = \frac{c}{n}\frac{\mathbf{K}}{K} + \left(1 - \frac{w}{n^2}\right)(1 - w)\mathbf{U}_{fs}$$

where $\omega_B = \omega_0 U_{fs} / c$.

New Effects in Generalized Maxwell's Electrodynamics

1) Unlimited velocities of an electromagnetic field in vacuum

In vacuum we have $\rho = 0$ and, consequently, $w = 0$. The field group velocity

$$\mathbf{V}_g = c\mathbf{K} / K + \mathbf{U}_{fs}$$

depends on the velocity of the initial radiation source. The wave front surface represents a sphere, because $a = b = c_0 t$ and its center moves with the velocity $\mathbf{U}_* = \mathbf{U}_{fs}$.. This is the pattern in which the radiation propagates in the new model. It corresponds to the idea suggested by Ritz [4]. Because of the interaction with the medium, in particular with the frame of reference, the velocity $\mathbf{U}_{fs}$ can vanish. Precisely this happens in all of the schemes for direct measurement of light speed in vacuum [5]. Therefore it is possible to consider that the generalized model of electromagnetic phenomena agrees with the 'constancy' of light speed in vacuum, demonstrating that for finding the dependence, the only suitable experiments are indirect, where measurement without the influence on the quantity $\mathbf{U}_{fs}$, is possible.

If the radiation moves in a gravitational field, its influence on the inertia of the radiation carrier is possible. This note can turn out to be important for the analysis of radiation transfer in outer space.

2) Superluminal speeds in a moving rarefied gas

Let the radiation source be at rest with respect to the observer $\mathbf{U}_{fs} = 0$, and let the medium - a gas stream - move with the velocity $\mathbf{U}_m$. Then the group velocity of the field is

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

For index of refraction close to unity, the value $w = 0.5$ maximizes the correction term. The velocity is then

$$\mathbf{V}_g^{\max} = c_0\mathbf{K} / K + \tfrac{1}{4}\mathbf{U}_m$$

In special relativity theory, we have different results. The group field velocity depends on the classical Fresnel coefficient according to

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

Since $n = 1 + Q_\lambda$, where $Q_\lambda \cong 10^{-4}$, we have $\mathbf{V}_g \cong c_0\mathbf{K} / K$.

The discrepancy between the predictions of the generalized electromagnetic model and the algorithm based on relativistic kinematics is clearly expressed. The requirements indicated correspond to Fizeau's experiment, if a moving rarefied gas is used as the fluid in the experimental setup. According to the dynamical model of the electromagnetic field inertia, we can change the moving gas density so that fringes in a Fizeau interferometer will begin to move. Such an experiment can be carried out any time.

3) The possibility for superluminal speeds in vacuum

At $w = 1$, the analysis of the dynamics of the transverse Doppler effect for the case of small relative velocities gives

$$\omega = \omega_0 \Big/ \sqrt{1 - U_{fs}^2 / c^2}$$

Let us multiply this expression be the quantity $\hbar / c^2$, where $\hbar$ is Planck's constant. Then we will obtain the dependence for masses which is used in relativistic dynamics:

$$m = m_0 \Big/ \sqrt{1 - U_{fs}^2 / c^2}$$

It will be shown below that the generalized theory of electromagnetic phenomena gives another frequency formula when the velocities approach light speed in vacuum. Maintaining the relationship between frequency and mass valid, we will offer a new dependence of the mass on the velocity. For this purpose we maintain the above model of the radiation propagation from empty space into the Earth's atmosphere, assuming that the velocity $\mathbf{U}_{fs}$ tends to light velocity in vacuum. The problem can be easily solved entirely, but it is sufficient for our purposes to be restricted to a version when the value $w = 1$ is reached. Then $\mathbf{U} = 0$, $cK_z = n\omega_0$. Since U_{fs} / c is close to unity, the index of refraction corresponding to the actual situation is to be taken. Let $n = 1 + Q$, where $Q << 1$.

With allowance for the above remark, we obtain the following system of equations

$$c^2 K_x^2 = n^2(\omega^2 - \omega_0^2), \ \omega = \omega^0 \sqrt{1 - U_{fs}^2 / c^2} + \frac{n}{c} U_{fs} \sqrt{\omega^2 - \omega_0^2}$$

The quadratic equation for the frequency

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

$$\Psi = 2Q + Q^2, \ n = 1 + Q$$

now contains the factor

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

The value of the field-limited frequency is given by the law [3]

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

This expression has no singularity for $U_{fs} \to c$. We obtain $\omega^* = \lim \omega\big|_{U_{fs} \to c} = \omega_0 \sqrt{1 + 1 / \Psi}$. Assuming that mass is proportional to frequency, we have the new formula

$$m = m_0 \frac{\sqrt{1 - U^2 / c^2} - \Psi^{1/2}\sqrt{1 + \Psi} U^2 / c^2}{1 - (1 + \Psi) U^2 / c^2}$$

where the value of Ψ should be found from experiment.

4) The mechanical law of energy conservation for a photon

When radiation propagates in a rarefied gas from a primary source, moving in vacuum with the velocity $\mathbf{U}_{fs}$, a dynamical change in its group velocity $\mathbf{V}_g$ and frequency ω occurs. At small relative velocities the frequency at the final stage of the dynamical process changes by the value

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

Let us multiply this expression by the Plank constant $\hbar$ and use the Einstein formula for the photon inertia mass:

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

This will yield the relation

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

where the following designations are introduced:

a) the kinetic energy of the photon E_{kin}, which depends on the primary radiation source velocity as

$$E_{kin} = \frac{1}{2} \hbar\omega_0 U_{fs}^2 / c^2$$

b) the potential energy of the photon, which depends on the frequency differences

$$\Delta U = \hbar(\omega - \omega_0)$$

The situation appears thus: the photon had the velocity $\mathbf{U}_{fs}$, additional to the light speed in vacuum c_0, and the frequency ω_0; in its interaction with the medium the velocity $\mathbf{U}_{fs}$ was 'transformed' to the frequency ω.

Therefore the photon is similar to a physical body with its tangential $L_{||}$ and transverse L_* lengths in the Newtonian space-time and it has an interior motion. Let $L_* = a\lambda$, and $L_{||} = b\lambda$, where a and b are constants. Then the change of the frequency gives some changes in the L_* and $L_{||}$.

Conclusions

1) Maxwell's electrodynamics admits a generalization that takes into account all the forms of inertial motion, and which, 1) does not use the special relativity theory; 2) is based on the Newtonian space; 3) gives superluminal velocities and indicates the conditions under which they can be discovered; 4) describes the known experimental facts, additionally assigning parameters for the dynamics of the external inertia of the electromagnetic field.

2) The Bradly, Michelson, Fizeau, and Doppler effects all have a dynamic nature.

3) Special relativity theory correctly relates initial and final magnitudes of dynamical processes, fulfilling the function of a peculiar kind of a black box.

4) Primary radiation source velocity transforms into electromagnetic field frequency by a dynamic mechanism of field interaction with the medium, wherein the 'mechanical' law of energy conservation is fulfilled.

5) Light speed in a moving rarefied gas can exceed light speed in vacuum.

6) The velocity of an electromagnetic field in vacuum is not restricted to a limiting value, but any velocity measurement is limited by interaction between the field and the experimental devices or those conditions in which the field is spread.

7) Particles with $m_0 \neq 0$ can move at light speed in vacuum.