Dynamic potentials and the field of the moving charges

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Abstract

Is developed the concept of scalar-vector potential, in which within the framework Galiley conversions the scalar potential of charge depends on speed. This made it possible to obtain conversions pour on upon transfer of one inertial system to another and to explain such phenomena as phase aberration and transverse Doppler effect.

1. Dynamic potentials and the field

The method, which is demonstrated in the second chapter, that is concerned the introduction of total derivatives pour on, it is passed in the substantial part still by Hertz [1]. Hertz did not introduce the concept of vector potentials, but he operated only with fields, but this does not diminish its merits. It made mistakes only in the fact that the electrical and magnetic fields were considered the invariants of speed. But already simple example of long lines is evidence of the inaccuracy of this approach. With the propagation of wave in the long line it is filled up with two forms of energy, which can be determined through the currents and the voltages or through the electrical and magnetic fields in the line. And only after wave will fill with electromagnetic energy all space between the generator and the load on it it will begin to be separated energy. I.e. the time, by which stays this process, generator expended its power to the filling with energy of the section of line between the generator and the load. But if we begin to move away load from incoming line, then a quantity of energy being isolated on it will decrease, since. the part of the energy, expended by source, will leave to the filling with energy of the additional length of line, connected with the motion of load. If load will approach a source, then it will obtain an additional quantity of energy due to the decrease of its length. But if effective resistance is the load of line, then an increase or the decrease of the power expendable in it can be connected only with a change in the stress on this resistance. Therefore we come to the conclusion that during the motion of the observer of those of relatively already existing in the line pour on must lead to their change. The productivity of this approach with the application of conversions of Galileo will be demonstrated in this chapter.

Being located in assigned IMS, us interest those fields, which are created in it by the fixed and moving charges, and also by the electromagnetic waves, which are generated by the fixed and moving sources of such waves. The fields, which are created in this IMS by moving charges and moving sources of electromagnetic waves, we will call dynamic. Can serve as an example of dynamic field the magnetic field, which appears around the moving charges.

As already mentioned, in the classical electrodynamics be absent the rule of the conversion of electrical and magnetic pour on upon transfer of one inertial system to another. This deficiency removes STR, basis of which are the covariant of the Lorenz conversions. With the entire mathematical validity of this approach the physical essence of such conversions up to now remains unexplained [2].

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions pour on upon transfer of one IMS to another, and to also explain what dynamic potentials and fields can generate the moving charges. The first step, demonstrated in the works [3-5], was made in this direction a way of the introduction of the symmetrical laws of magnetoelectric and electromagnetic induction. These laws are written as follows:

$$\begin{gathered}\oint \vec{E}'dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v} \times \vec{B}\right] dl' \\ \oint \vec{H}'dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v} \times \vec{D}\right] dl'\end{gathered}, \tag{1.1}$$

or

$$\begin{gathered}rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B}\right] \\ rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D}\right]\end{gathered}. \tag{1.2}$$

For the constants pour on these relationships they take the form:

$$\begin{gathered}\vec{E}' = \left[\vec{v} \times \vec{B}\right] \\ \vec{H}' = -\left[\vec{v} \times \vec{D}\right]\end{gathered}. \tag{1.3}$$

In relationships (1.1-1.3), which assume the validity of the Galilean transformations the primed system and not primed system values present fields and elements in moving and fixed IMS respectively. It must be noted, that conversions (1.3) earlier could be obtained only from the covariant Lorentz transformations.

The relationships (1.1-1.3), which present the laws of induction, do not give information about how arose fields in initial fixed IMS. They describe only laws governing the propagation and conversion pour on in the case of motion with respect to the already existing fields.

The relationship (1.3) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e., motion in the fields $\vec{H}$ leads to the appearance pour on $\vec{E}$

and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [3].

Electric field beyond the limits of the long charged rod is determined from the relationship $E = \dfrac{g}{2\pi\varepsilon r}$, where g - charge of the unit length of rod.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IMS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IMS begin to move third frame of reference with the speed Δv, then already due to the motion in the field ΔH will appear additive to the electric field $\Delta E = \mu\varepsilon E \left(\Delta v\right)^2$. This process can be continued and further, as a result of which can be obtained the number, which gives the value of the electric field $E_v'\left(r\right)$ in moving IMS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IMS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship:

$$E'\left(r, v_\perp\right) = \frac{g ch \frac{v_\perp}{c}}{2\pi\varepsilon r} = E ch \frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship:

$$E'\left(r, v_\perp\right) = \frac{e ch \frac{v_\perp}{c}}{4\pi\varepsilon r^2},$$

where $v_\perp$ - normal component of charge rate to the vector, which connects the moving charge and observation point.

Expression for the scalar potential, created by the moving charge, for this case will be written down as follows [3,4]:

$$\varphi'(r,v_\perp) = \frac{ech\dfrac{v_\perp}{c}}{4\pi\varepsilon r} = \varphi(r)ch\frac{v_\perp}{c}, \qquad (1.4)$$

where $\varphi(r)$ - scalar potential of fixed charge. The potential $\varphi'(r,v_\perp)$ can be named scalar- vector since it depends not only on the absolute value of charge, but also on speed and direction of its motion with respect to the observation point. Maximum value this potential has in the direction normal to the motion of charge itself. Moreover, if charge rate changes, which is connected with its acceleration, then can be calculated the electric fields, induced by the accelerated charge.

During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp) = Hch\frac{v_\perp}{c}.$$

where $v_\perp$ - speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components pour on parallel speeds [ISO] as $E_\uparrow$ and $H_\uparrow$, and $E_\perp$ and $H_\perp$ as components normal to it, then conversions pour on they will be written down:

$$\vec{E}'_{\uparrow} = \vec{E}_{\uparrow},$$
$$\vec{E}'_{\perp} = \vec{E}_{\perp} ch\frac{v}{c} + \frac{Z_0}{v}\left[\vec{v} \times \vec{H}_{\perp}\right] sh\frac{v}{c},$$
$$\vec{H}'_{\uparrow} = \vec{H}_{\uparrow}, \tag{1.5}$$
$$\vec{H}'_{\perp} = \vec{H}_{\perp} ch\frac{v}{c} - \frac{1}{vZ_0}\left[\vec{v} \times \vec{E}_{\perp}\right] sh\frac{v}{c},$$

where $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ - impedance of free space, $c = \sqrt{\frac{1}{\mu_0 \varepsilon_0}}$ - speed of light.

Conversions pour on (1.5) they were for the first time obtained in the work [3].

2. Phase aberration and the Doppler transverse effect

Of the assistance of relationships (1.5) it is possible to explain the phenomenon of phase aberration, which did not have within the framework existing classical electrodynamics of explanations. We will consider that there are components of the plane wave H_z and E_x, which is extended in the direction y, and primed system moves in the direction of the axis x with the speed v_x. Then components pour on in the primed system in accordance with relationships (16.5) they will be written down:

$$E'_x = E_x,$$
$$E'_y = H_z sh\frac{v_x}{c},$$
$$H'_z = H_z ch\frac{v_x}{c}.$$

Thus, is a heterogeneous wave, which has in the direction of propagation the component E'_y.

Let us write down the summary field E' in moving IMS:

$$E' = \left[\left(E'_x \right)^2 + \left(E'_y \right)^2 \right]^{\frac{1}{2}} = E_x ch \frac{v_x}{c}. \qquad (2.1)$$

If the vector $\vec{H}'$ is as before orthogonal the axis y, then the vector $\vec{E}'$ is now inclined toward it to the angle α, determined by the relationship:

$$\alpha \cong sh \frac{v}{c} \cong \frac{v}{c}. \qquad (2.2)$$

This is phase aberration. Specifically, to this angle to be necessary to incline telescope in the direction of the motion of the Earth around the sun in order to observe stars, which are located in the zenith.

The vector Poynting vector is now also directed no longer along the axis y, but being located in the plane xy, it is inclined toward the axis y to the angle, determined by relationships (2.2). However, the relation of the absolute values of the vectors $\vec{E}'$ and $\vec{H}'$ in both systems they remained identical. However, the absolute value of the Poynting vector increased. Thus, even transverse motion of inertial system with respect to the direction of propagation of wave increases its energy in the moving system. This phenomenon is understandable from a physical point of view. It is possible to give an example with the rain drops. When they fall vertically, then is energy in them one. But in the inertial system, which is moved normal to the vector of their of speed, to this speed the velocity vector of inertial system is added. In this case the absolute value of the speed of drops in the inertial system will be equal to square root of the sum of the squares of the speeds indicated. The same result gives to us relationship (2.1). The transformations with respect to the vectors $\vec{E}$ and $\vec{H}$ is completely symmetrical.

Such waves have in the direction of its propagation additional of the vector of electrical or magnetic field, and in this they are similar to E and H of the waves, which are extended in the waveguides. In this case appears the uncommon wave, whose phase front is inclined toward the Poyntnng vector to the angle, determined by relationship (2.2). In fact obtained wave is the superposition of plane wave with the phase speed $c = \sqrt{\frac{1}{\mu\varepsilon}}$ and additional wave of plane wave with the infinite phase speed orthogonal to the direction of propagation.

The transverse Doppler effect, who long ago is discussed sufficiently, until now, did not find its confident experimental confirmation. For observing the star from moving ISM it is necessary to incline telescope on the motion of motion to the angle, determined by relationship (2.2). But in this case the star, observed with the aid of the telescope in the zenith, will be in actuality located several behind the visible position with respect to the direction of motion. Its angular displacement from the visible position in this case will be determined by relationship (2.2). but this means that this star with respect to the observer has radial spid, determined by the relationship

$$v_r = v \sin\alpha .$$

Since for the low values of the angles $\sin\alpha \cong \alpha$, and $\alpha = \frac{v}{c}$, the Doppler frequency shift will compose

$$\omega_{d\perp} = \omega_0 \frac{v^2}{c^2} . \qquad (2.3)$$

This result numerically coincides with results STR, but it is principally characterized by rel.un. of results. It is considered in STR that the transverse Doppler effect, determined by relationship (2.3), there is in reality, while in this case this only apparent effect. If we compare the results of conversions pour on (2.5) with conversions STR, then it is not difficult to see that they coincide with an accuracy to the quadratic members of the ratio of the velocity of the motion of charge to the speed of light.

The STR conversion although they were based on the postulates, could correctly explain sufficiently accurately many physical phenomena, which before this explanation did not have. With this circumstance is connected this great success of this theory. Conversions (2.4) and (2.5) are obtained on the physical basis without the use of postulates and they with the high accuracy coincided with STR. Difference is the fact that in conversions (2.5) there are no limitations on the speed for the material particles, and also the fact that the charge is not the invariant of speed. The experimental confirmation of the fact indicated can serve as the confirmation of correctness of the proposed conversions.

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