Laws of the electric-electrical induction

F. F. Mende

http://fmnauka.narod.ru/works.html mende_fedor@mail.ru

Abstract

In the article is shown that the emission laws can find their physical explanation within the framework the concept of scalar- vector potential. Within the framework this concept of find also their explanation the laws of induction.

1. Laws of the electric-electrical induction

Since pour on any process of the propagation of electrical and potentials it is always connected with the delay, let us introduce the being late scalar-vector potential, by considering that the field of this potential is extended in this medium with a speed of light [1]:

$$\varphi(r,t) = \frac{g\ ch\dfrac{v_\perp\left(t-\frac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r}, \tag{1}$$

where $v_\perp\left(t-\frac{r}{c}\right)$ - component of the charge rate g, normal to

to the vector $\vec{r}$ at the moment of the time $t' = t - \frac{r}{c}$, r - distance between the charge and the point, at which is determined the field, at the moment of the time t.

But does appear a question, on what bases, if we do not use the Maksvell equation, from whom does follow wave equation, is introduced the being late scalar- vector potential? This question was examined in the thirteenth paragraph, when the velocity of propagation of the front of the wave of the tension of magnetic and electric field in the long line was determined. There, without resorting to the Maxwell's equations, it was shown that electrical and magnetic field they are extended with the final speed, which in the vacuum line is equal to the speed of light. Consequently, such fields be late to the period $\frac{r}{c}$. The same delay we introduce in this case and for the scalar- vector potential, which is the carrier of electrical pour on.

Using relationship $\vec{E} = -grad\ \varphi(r,t)$, let us find field at point 1 (Fig. 1) . The gradient of the numerical value of a radius of the vector $\vec{r}$ is a scalar function of two points: the initial point of a radius of vector and its end point (in this case this point 1 on the axis of x and point 0 at the origin of coordinates). Point 1 is the point of source, while point 0 - by observation point. With the determination of gradient from the function, which contains a radius depending on the conditions of task it is necessary to distinguish two cases: 1) the point of source is fixed and $\vec{r}$ is considered as the function of the position of observation point; and 2) observation point is fixed and $\vec{r}$ is considered as the function of the position of the point of source.

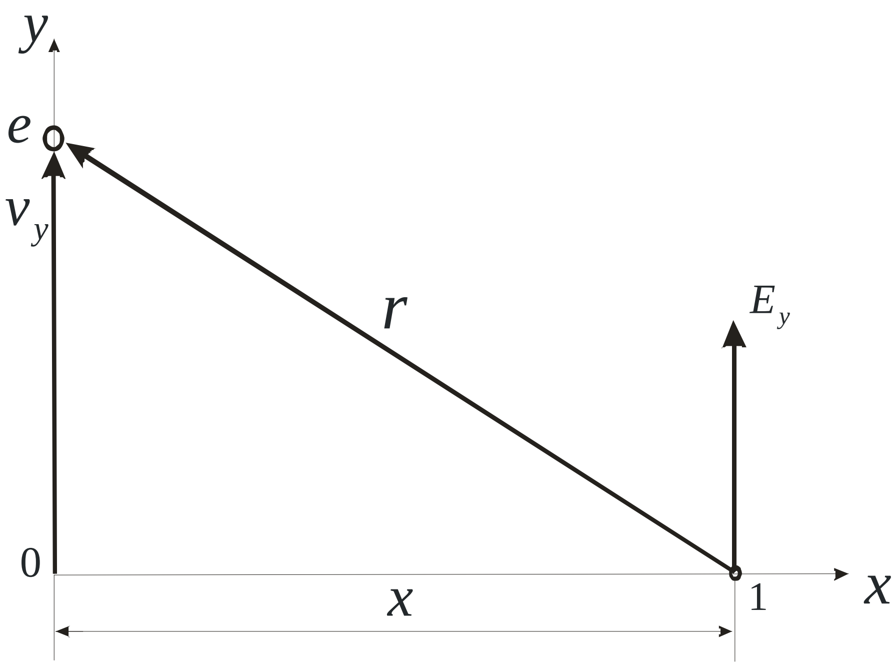

Fig. 1. Diagram of shaping of the induced electric field.

We will consider that the charge e accomplishes fluctuating motion along the axis y, in the environment of point 0, which is observation point, and fixed point 1 is the point of source and $\vec{r}$ is considered as the function of the position of charge. Then we write down the value of electric field at point 1:

$$E_y(1) = -\frac{\partial \varphi_\perp(r,t)}{\partial y} = -\frac{\partial}{\partial y}\frac{e}{4\pi\varepsilon_0 r(y,t)}\ ch\frac{v_y\left(t - \frac{r(y,t)}{c}\right)}{c}$$

When the amplitude of the fluctuations of charge is considerably less than distance to the observation point, it is possible to consider a radius vector constant. We obtain with this condition:

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 cx} \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} sh \frac{v_y\left(t-\frac{x}{c}\right)}{c} \qquad (2)$$

where x - some fixed point on the axis x.

Taking into account that

$$\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{\partial t}{\partial y} = \frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}\frac{1}{v_y\left(t-\frac{x}{c}\right)}$$

we obtain from (2):

$$E_y(x,t) = \frac{e}{4\pi\varepsilon_0 cx}\frac{1}{v_y\left(t-\frac{x}{c}\right)}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} sh \frac{v_y\left(t-\frac{x}{c}\right)}{c}. \qquad (3)$$

This is a complete emission law of the moving charge.

If we take only first term of the expansion $sh\frac{v_y\left(t-\frac{x}{c}\right)}{c}$, then we will obtain from (3):

$$E_y(x,t) = -\frac{e}{4\pi\varepsilon_0 c^2 x}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t} = -\frac{ea_y\left(t-\frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x}, \qquad (4)$$

where $a_y\left(t-\frac{x}{c}\right)$ - being late acceleration of charge. This relationship is wave equation and defines both the amplitude and phase responses of the wave of the electric field, radiated by the moving charge.

If we as the direction of emission take the vector, which lies at the plane xy, and which constitutes with the axis of y the angle α, then relationship (4) takes the form:

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x}. \qquad (5)$$

Relationship (5) determines the radiation pattern. Since in this case there is axial symmetry relative to the axis y, it is possible to calculate the complete radiation pattern of this emission. This diagram corresponds to the radiation pattern of dipole emission.

since $\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x} = A_H\left(t-\frac{x}{c}\right)$ - being late vector potential, relationship (5) it is possible to rewrite

$$E_y(x,t,\alpha) = -\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} =$$

$$= -\frac{1}{\varepsilon_0 c^2}\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t} = -\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t}$$

Is again obtained complete agreement with the equations of the being late vector potential, but vector potential is introduced here not by phenomenological method, but with the use of a concept of the being late scalar- vector potential. It is necessary to note one important circumstance: in the Maxwell equations the electric fields, which present wave, vortex. In this case the electric fields bear gradient nature.

Let us demonstrate the still one possibility, which opens relationship (5). Is known that in the electrodynamics there is this concept, as the electric dipole and the dipole emission, when the charges, which are varied in the electric dipole, emit electromagnetic waves. Two charges with the opposite signs have the dipole moment:

$$\vec{p} = e\vec{d}\ , \tag{6}$$

where the vector $\vec{d}$ is directed from the negative charge toward the positive charge. Therefore current can be expressed through the derivative of dipole moment on the time of

$$e\vec{v} = e\frac{\partial \vec{d}}{\partial t} = \frac{\partial \vec{p}}{\partial t}\ .$$

Consequently

$$\vec{v} = \frac{1}{e}\frac{\partial \vec{p}}{\partial t},$$

and

$$\vec{a} = \frac{\partial \vec{v}}{\partial t} = \frac{1}{e}\frac{\partial^2 \vec{p}}{\partial t^2}\ .$$

Substituting this relationship into expression (5), we obtain the emission law of the being varied dipole

$$\vec{E} = -\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2}. \tag{7}$$

This is also very well known relationship [2].

In the process of fluctuating the electric dipole are created the electric fields of two forms. First, these are the electrical induction fields of emission, represented by equations (4), (5) and (6), connected with the acceleration of charge. In addition to this, around the being varied dipole are formed the electric fields of static dipole, which change in the time in connection with the fact that the distance between the charges it depends on time. Specifically, energy of these pour on the freely being varied dipole and it is expended on the emission. However, the summary value of field around this dipole at any moment of time defines as superposition pour on static dipole pour on emissions.

Laws (4), (5), (7) are the laws of the direct action, in which already there is neither magnetic pour on nor vector potentials. I.e. those structures, by which there were the magnetic field and magnetic vector potential, are already taken and they no longer were necessary to us.

Using relationship (5) it is possible to obtain the laws of reflection and scattering both for the single charges and, for any quantity of them. If any charge or group of charges undergo the action of external (strange) electric field, then such charges begin to accomplish a forced motion, and each of them emits electric fields in accordance with relationship (5). The superposition of electrical pour on, radiated by all charges, it is electrical wave.

If on the charge acts the electric field , then the acceleration of charge is determined by the equation $E'_y = E'_{y0}\sin\omega t$

$$a = -\frac{e}{m}E'_{y0}\sin\omega t .$$

Taking into account this relationship (5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2\ \sin\alpha}{4\pi\varepsilon_0 c^2 mx}E'_{y0}\sin\omega(t-\frac{x}{c}) = \frac{K}{x}E'_{y0}\sin\omega(t-\frac{x}{c}), \quad (8)$$

where the coefficient $K = \dfrac{e^2\ \sin\alpha}{4\pi\varepsilon_0 c^2 m}$ can be named the coefficient of scattering (re-emission) single charge in the assigned direction, since it determines the ability of charge to re-emit the acting on it external electric field.

The current wave of the displacement accompanies the wave of electric field:

$$j_y(x,t) = \varepsilon_0 \frac{\partial E_y}{\partial t} = -\frac{e\sin\alpha}{4\pi c^2 x} \frac{\partial^2 v_y\left(t - \frac{x}{c}\right)}{\partial t^2}.$$

If charge accomplishes its motion under the action of the electric field, then bias current in the distant zone will be written down as $E' = E'_0 \sin \omega t$

$$j_y(x,t) = -\frac{e^2\omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right). \qquad (9)$$

The sum wave, which presents the propagation of electrical pour on (8) and bias currents (9), can be named the electric-current wave. In this current wave of displacement lags behind the wave of electric field to the angle equal $\frac{\pi}{2}$.

For the first time this term and definition of this wave was used in the works [3, 4].

In parallel with the electrical waves it is possible to introduce magnetic waves, if we assume that

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H}, \qquad (10)$$

$$div\vec{H} = 0$$

Introduced thus magnetic field is vortex. Comparing (9) and (10) we obtain:

$$\frac{\partial H_z(x,t)}{\partial x} = \frac{e^2\omega\, \sin\alpha}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right).$$

Integrating this relationship on the coordinate, we find the value of the magnetic field

$$H_z(x,t) = \frac{e^2\, \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t - \frac{x}{c}\right). \qquad (11)$$

Thus, relationship (8), (9) and (11) can be named the laws of electrical induction, since they give the direct coupling between the electric fields, applied to the charge, and by fields and by currents induced by this charge in its environment. Charge itself comes out [v] in the role of the transformer, which ensures this reradiation. The magnetic field, which can be calculated with the aid of relationship (11), is directed normally both toward the electric field and toward the direction of propagation, and their relation at each point of the space is equal

$$\frac{E_y(x,t)}{H_z(x,t)} = \frac{1}{\varepsilon_0 c} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z \,,$$

where Z - wave impedance of free space.

The wave impedance determines the active power of losses on the single area, located normal to the direction of propagation of the wave:

$$P = \frac{1}{2} Z E^2{}_{y0} \,.$$

Therefore electric-curent wave, crossing this area, transfers through it the power, determined by the data by relationship, which is located in accordance with by the Poynting theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electric-curent wave and knowledge of the wave drag of space. In this case it is in no way compulsory to introduce this concept as magnetic field and its vector potential, although there is nothing illegal in this. In this setting of the relationships, obtained for the electrical and magnetic field, they completely satisfy Helmholtz's theorem. This theorem says, that any single-valued and continuous vector field, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function and rotor of a certain vector function, whose divergence is equal to zero:

$$\vec{F} = grad\varphi + rot\vec{C},$$

$$div\vec{C} = 0.$$

Consequently, must exist clear separation pour on to the gradient and the vortex. It is evident that in the expressions, obtained for those induced pour on, this separation is located. Electric fields bear gradient nature, and magnetic bear vortex nature.

Thus, the construction of electrodynamics should have been begun from the acknowledgement of the dependence of scalar potential on the speed. But nature very deeply hides its secrets, and in order to come to this simple conclusion, it was necessary to pass way by length almost into two centuries. The grit, which so harmoniously were erected around the magnet poles, in a straight manner indicated the presence of some power pour on potential nature, but to this they did not turn attention; therefore it turned out that all examined only tip of the iceberg, whose substantial part remained invisible of almost two hundred years.

Taking into account entire aforesaid one should assume that at the basis of the overwhelming majority of static and dynamic phenomena at the electrodynamics only one formula

$$E'(r, v_\perp) = Ech\frac{v_\perp}{c},$$

which assumes the dependence of the scalar potential of charge on the speed [1], lies. From this formula it follows and static interaction of charges, and laws of power interaction in the case of their mutual motion, and emission laws and scattering. This approach made it possible to explain from the positions of classical electrodynamics such phenomena as phase aberration and the transverse the Doppler effect, which within the framework the classical electrodynamics of explanation did not find. After entire aforesaid it is possible to remove construction forests, such as magnetic field and magnetic vector potential, which do not allow here already almost two hundred years to see the building of electrodynamics in entire its sublimity and beauty.

Let us point out that one of the fundamental equations of induction (4) could be obtained directly from the Ampere law, still long before appeared the Maksvell equations. The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z

$$\vec{H} = \frac{1}{4\pi}\int \frac{I d\vec{l} \times \vec{r}}{r^3}$$

where I - current in the element $d\vec{l}$, $\vec{r}$ - vector, directed from $d\vec{l}$ to the point x, y, z.

It is possible to show that

$$\frac{[d\vec{l}\vec{r}]}{r^3} = grad\left(\frac{1}{r}\right) \times d\vec{l}$$

and, besides the fact that

$$grad\left(\frac{1}{r}\right) \times d\vec{l} = rot\left(\frac{d\vec{l}}{r}\right) - \frac{1}{r} rot\ d\vec{l}\ .$$

But the rotor $d\vec{l}$ is equal to zero and therefore is final

$$\vec{H} = rot \int I\left(\frac{d\vec{l}}{4\pi r}\right) = rot\ \vec{A}_H\ ,$$

where

$$\vec{A}_H = \int I\left(\frac{d\vec{l}}{4\pi r}\right). \qquad (12)$$

Remarkable property of this expression is that that the vector potential depends from the distance to the observation point as $\frac{1}{r}$. Specifically, this property makes it possible to obtain emission laws.

Since $I = gv$, where g the quantity of charges, which falls per unit of the length of conductor, from (12) we obtain:

$$\vec{A}_H = \int \frac{gv\, d\vec{l}}{4\pi r}.$$

For the single charge e this relationship takes the form:

$$\vec{A}_H = \frac{e\vec{v}}{4\pi r},$$

and since

$$\vec{E} = -\mu \frac{\partial \vec{A}}{\partial t},$$

that

$$\vec{E} = -\mu \int \frac{g \frac{\partial v}{\partial t}\ d\vec{l}}{4\pi r} = -\mu \int \frac{ga\ d\vec{l}}{4\pi r}, \qquad (13)$$

where a - acceleration of charge.

This relationship appears as follows for the single charge:

$$\vec{E} = -\frac{\mu e\vec{a}}{4\pi r}. \qquad (14)$$

If we in relationships (13) and (14) consider that the potentials are extended with the final speed and to consider the delay $\left(t - \frac{r}{c}\right)$, and assuming $\mu = \frac{1}{\varepsilon_0 c^2}$, these relationships will take the form:

$$\vec{E} = -\mu \int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi r} = -\int \frac{ga(t - \frac{r}{c})\ d\vec{l}}{4\pi\varepsilon_0 c^2 r}, \qquad (15)$$

$$\vec{E} = -\frac{e\vec{a}(t - \frac{r}{c})}{4\pi\varepsilon_0 c^2 r}. \qquad (16)$$

Of relationship (15) and (16) represent, it is as shown higher (see (4)), wave equations. Let us note that these equations - this solution of the Maxwell equations, but in this case they are obtained directly from the Ampere law, not at all coming running to the Maxwell equations. To there remains only present the question, why electrodynamics in its time is not banal by this method?

Given examples show, as electrodynamics in the time of its existence little moved. The phenomenon of electromagnetic induction Faraday opened into 1831 years and already almost 200 years its study underwent practically no changes, and the physical causes for the most elementary electrodynamic phenomena, until now, were misunderstood. Certainly, for his time Faraday was genius, but that they did make physics after it? There were still such brilliant figures as Maxwell and Hertz, but even they did not understand that the dependence of the scalar potential of charge on its relative speed is the basis of entire classical electrodynamics, and that this is that basic law, from which follow the fundamental laws of electrodynamics.

Earlier has already been indicated that solution of problems interactions of the moving charges in the classical electrodynamics are solved by the introduction of the magnetic field or vector potential, which are fields by mediators. To the moving or fixed charge action of force can render only electric field. Therefore natural question arises, and it is not possible whether to establish the laws of direct action, passing fields the mediators, who would give answer about the direct interaction of the moving and fixed charges. This approach would immediately give answer, also, about sources and places of the application of force of action and reaction. Let us show that application of scalar- vector potential gives the possibility to establish the straight laws of the induction, when directly the properties of the moving charge without the participation of any auxiliary pour on they give the possibility to calculate the electrical induction fields, generated by the moving charge [1].

Let us examine the diagram of the propagation of current and voltage in the section of the long line, represented in Fig. 2 . In this figure the wave front occupies the section of the line of the long z_2, therefore, the time of this transient process equally $t = \frac{z_2}{c}$. This are thing time, for which the voltage on incoming line grows from zero to its nominal value. The duration of this transient process is adjustable, and it depends on that, in which law we increase voltage on incoming line, now we will attempt to understand, from where is taken that field strength, which forces charges in the conductors, located near the current carrying elements of line, to move in the direction opposite to the direction of the motion of charges in the primary line. This exactly are that question, to which, until now, there is no physical answer. Let us assume that voltage on incoming line grows according to the linear law also during the time Δt it reaches its maximum value U, after which its increase ceases. Then in line itself transient process engages the section $z_1 = c\Delta t$. Let us depict this section separately, as shown in Fig. 2. In the section z_1 proceeds the acceleration of charges from their zero speed (more to the right the section z_1) to the value of speed, determined by the relationship

$$v = \sqrt{\frac{2eU}{m}} \ ,$$

where e and m - charge and the mass of current carriers, and U - voltage drop across the section z_1. Then the dependence of the speed of current carriers on the coordinate will take the form:

$$v^2(z) = \frac{2e}{m}\,\frac{\partial U}{\partial z}\,z\,. \qquad (17)$$

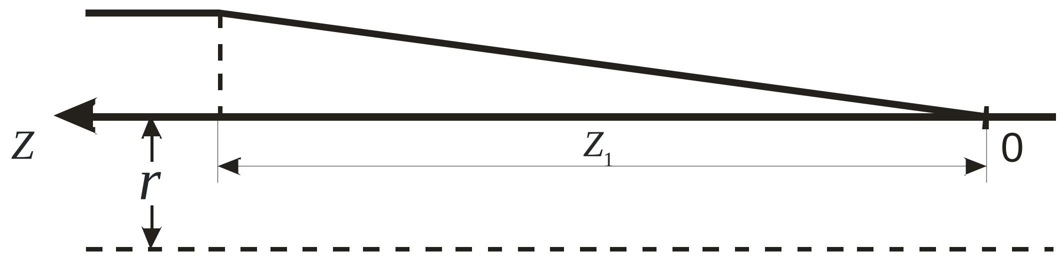

Fig. 2. Current wavefront, which is extended in the long line.

Since we accepted the linear dependence of stress from the time on incoming line, the equality occurs

$$\frac{\partial U}{\partial z} = \frac{U}{z_2} = E_z\,,$$

where E_z - field strength, which accelerates charges in the section z_1. Consequently, relationship (17) it is possible to rewrite

$$v^2(z) = \frac{2e}{m}E_z z\,.$$

Using for the value of scalar-vector potential relationship

$$\varphi(r,t) = \frac{g\;ch\frac{v_\perp}{c}}{4\pi\,\varepsilon_0 r}\,,$$

let us calculate it as the function z on a certain distance r from the line of

$$\varphi(z)=\frac{e}{4\pi\ \varepsilon_0 r}\left(1+\frac{1}{2}\ \frac{v^2(z)}{c^2}\right)=\frac{e}{4\pi\ \varepsilon_0 r}\left(1+\frac{eE_z z}{mc^2}\right). \qquad (18)$$

For the record of relationship (18) are used only first two members of the expansion of hyperbolic cosine in series.

Using the formula $E=-grad\ \varphi$, and differentiating relationship (18) on z, we obtain

$$E_z{}'=-\frac{e^2E_z}{4\pi\ \varepsilon_0 rmc^2}, \qquad (19)$$

where $E_z{}'$ - the electric field, induced at a distance r from the conductor of line. Near E we placed prime in connection with the fact that calculated field it moves along the conductor of line with the speed of light, inducing in the conductors surrounding line the induction currents, opposite to those, which flow in the basic line. The acceleration of charge is determined by the relationship $a_z=\frac{eE_z}{m}$. Taking this into account from (19) we obtain

$$E_z{}'=-\frac{ea_z}{4\pi\ \varepsilon_0 rc^2}\ . \qquad (20)$$

Thus, the charges, accelerated in the section of the line z_1, induce at a distance r from this section the electric field, determined by relationship (20). Direction of this field conversely to field, applied to the accelerated charges. Thus, is obtained the law of direct action, which indicates what electric fields generate around themselves the charges, accelerated in the conductor. This law can be called the law of electro-electrical induction, since it, passing fields mediators (magnetic field or vector potential), gives straight answer to what electric fields the moving electric charge generates around itself. This law gives also answer about the place of the application of force of interaction between the charges. Specifically, this relationship, but not the Faraday law, we must consider as the fundamental law of induction, since specifically, it establishes the reason for the appearance of induction electrical pour on around the moving charge. In what the difference between the proposed approach and that previously existing consists. Earlier we said that the moving charge generates vector potential, and the already changing vector potential generates electric field. Relationship (20) gives the possibility to exclude this intermediate operation and to pass directly from the properties of the moving charge to the induction fields. Let us show that relationship it follows from this and the introduced earlier phenomenologically vector potential, and, therefore, also magnetic field. Since the connection between the vector potential and the electric field is determined by relationship (19), equality (20) it is possible to rewrite

$$E_z{}' = -\frac{e}{4\pi\,\varepsilon_0 r c^2}\frac{\partial v_z}{\partial t} = -\mu\frac{\partial A_H}{\partial t},$$

and further, integrating by the time, we obtain

$$A_H = \frac{e v_z}{4\pi r}.$$

This relationship corresponds to the determination of vector potential. It is now evident that the vector potential is the direct consequence of the dependence of the scalar potential of charge on the speed. The introduction also of vector potential and of magnetic field this is the useful mathematical device, which makes it possible to simplify the solution of number of electrodynamic problems, however, one should remember that by fundamentals the introduction of these pour on it appears scalar- vector potential.

REFERENCE

1. Менде Ф. Ф. Великие заблуждения и ошибки физиков XIX-XX столетий. Революция в современной физике. Харьков, НТМТ, 2010, - 176 с.

2. Фейнман Р., Лейтон Р., Сэндс М. Фейнмановские лекции по физике. М: Мир, 1977.

3.Тамм И. Е. Основы теории электричества М.: Наука, 1989 - 504 с.

4. Менде Ф. Ф. Существуют ли ошибки в современной физике. Харьков, Константа, 2003.- 72 с.