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Problem of Lorentz Force and its Solution

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Problem of Lorentz Force and its Solution

F. F. Mende [α] & A. S. Dubrovin [σ]

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I. Introduction

All past century is marked by the most great when for the change to the materialist understanding of physical processes is alien scholastic mathematics, which itself began to develop its own physical laws. The introduction was a typical example of such approaches the concept the frequency dispersion of such the material parameters as the dielectric and magnetic constant of material media. These approaches have given rise to the whole direction in electrodynamics physical environments. These approaches gave birth to entire direction in the electrodynamics of material media. General with the theorists, for me it repeatedly was necessary to observe, that them usually little interests physics of processes, mathematics is god for them and if with mathematics all in the order, then theory is accurate. But this approach has its underwater stones. Thus it occurred also with the dielectric constant of dielectrics when, after entangling concepts, they began to consider that this permeability depends on frequency. Even in Large Soviet Encyclopedia it is written, that this dependence is located.

The special feature of contemporary physics is its politicization and creation of the transnational clans, which took into their hands and authority in the science, and the financial flows, and they uncontrolled by them manage. These negative phenomena gave birth to the personality cult of individual scientists, when they canonize, in contrast to the church, not only corpses, but also living. A typical example of this cult are Einstein and Hoking.

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Still one whip of science is its bureaucratization, when to the foreground in the science leave not true scientists, but bureaucrats from the science. Are especially well visible the results of this scientific activity based on the example to the USSR. That command-administrative system, which ruled in the national economy of the country, was extended also to the science, when the director of any large scientific establishment in the required order became academician.

The science, chained into the shackles of the yellow press, when on the covers of popular periodicals were depicted brilliant cripples, causes surprise. All this gave birth to the most severe crisis in the science. But this state of affairs cannot continue eternally. Now situation in physics greatly resembles that, which preceded the fall of the system of Ptolemy. But if we speak about the wreck of the old become obsolete ideas, then this cannot occur without the appearance of new progressive ideas and directions, which will arrive for the change to decrepit dogmas.

The special theory of relativity (SR) in its time arose for that reason, that in the classical electrodynamics there were no conversions fields on upon transfer of one inertial reference system into another. This theory, by the way of introduction into physics of known postulates, explained several important experimental results and in connection with this was obtained the acknowledgement.

Being based on the ideas of Maxwell about the calculation of total derivatives during the writing of the laws of induction, it is possible to obtain such laws of electrodynamics, which explain the existing electrodynamic phenomena and give the possibility within the framework of Galileo conversions to write down the rules of conversion fields on upon transfer of one inertial system (IS) to another. It follows from such laws that the main basic law of electrodynamics, from which follow its all the remaining dynamic laws, is the dependence of the scalar potential of charge on its relative speed. And this is the radical step, which gives the possibility to obtain a number of the important systematic and practical results, which earlier in the classical electrodynamics are obtained be they could not. This approach made possible not only to create on the united basis one-piece electrodynamics, but also to explain power interaction of the current carrying systems without the use of a postulate about the Lorentz force, or to describe the phenomenon of phase aberration and the transverse Doppler effect.

This article depicts an example of that how the problem of Lorentz force can be solved on the basis of new ideas. Still from the times of Lorenz and Poincare this force was introduced as experimental postulate and there was no that physical basis, which appears it would explain this phenomenon.

II. Maxwell Equations and Lorentz Force

The laws classical electrodynamics they reflect experimental facts they are phenomenological. Unfortunately, contemporary classical electrodynamics is not deprived of the contradictions, which did not up to now obtain their explanation. In order to understand these contradictions, and to also understand those purposes and tasks, which are placed in this work, let us briefly describe the existing situation.

The fundamental equations of contemporary classical electrodynamics are Maxwell equation [1]. They are written as follows for the vacuum:

$$rot\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}, \tag{2.1}$$

$$rot\ \vec{H} = \frac{\partial \vec{D}}{\partial t}, \tag{2.2}$$

$$div\ \vec{D} = 0, \tag{2.3}$$

$$div\ \vec{B} = 0, \tag{2.4}$$

where $\vec{E}$, $\vec{H}$ are tension of electrical and magnetic field, $\vec{D} = \varepsilon_0 \vec{E}$, $\vec{B} = \mu_0 \vec{H}$ are electrical and magnetic induction, μ_0, ε_0 are magnetic and dielectric constant of vacuum. From these equations follow wave equations for the electrical and magnetic fields

$$\nabla^2 \vec{E} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial t^2}, \tag{2.5}$$

$$\nabla^2 \vec{H} = \mu_0 \varepsilon_0 \frac{\partial^2 \vec{H}}{\partial t^2}, \tag{2.6}$$

these equations show that in the vacuum can be extended the plane electromagnetic waves, the velocity of propagation of which is equal to the speed of light

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \tag{2.7}$$

For the material media of Maxwell's equation they take the following form:

$$rot\ \vec{E} = -\tilde{\mu}\mu_0 \frac{\partial \vec{H}}{\partial t} = -\frac{\partial \vec{B}}{\partial t}, \tag{2.8}$$

$$rot\ \vec{H} = ne\vec{v} + \tilde{\varepsilon}\varepsilon_0 \frac{\partial \vec{E}}{\partial t} = ne\vec{v} + \frac{\partial \vec{D}}{\partial t}, \tag{2.9}$$

$$div\ \vec{D} = ne, \tag{2.10}$$

$$div\ \vec{B} = 0, \tag{2.11}$$

where $\tilde{\mu}$, $\tilde{\varepsilon}$ are the relative magnetic and dielectric constants of the medium and n, e, $\vec{v}$ are density, value and charge rate.

The equation (2.1 - 2.11) are written in the assigned IS, and in them there are no rules of passage of one IS to another. The given equations also assume that the properties of charge do not depend on their speed, since in first term of the right side of equation (2.9) as the charge its static value is taken. The given equations also assume that the current can flow as in the electrically neutral medium, where there is an equal quantity of charges of both signs, so also to represent the self-contained flow of the charged particles, moreover both situations are considered equivalent.

In Maxwell equations are not contained indication that is the reason for power interaction of the current carrying systems; therefore to be introduced the experimental postulate about the force, which acts on the moving charge in the magnetic field. This the so-called magnetic part of the Lorentz force

$$\vec{F}_L = e\left[\vec{v} \times \mu_0 \vec{H}\right] \tag{2.12}$$

However in this axiomatics is an essential deficiency. If force acts on the moving charge, then in accordance with Newton third law the reacting force, which balances the force, which acts on the charge, must occur and to us must be known the place of the application of this force. In this case the magnetic field comes out as a certain independent substance and comes out in the role of the mediator between the moving charges, and if we want to find the force of their interaction, then we must come running to the services of this mediator. In other words, we do not have law of direct action, which would give immediately answer to the presented question, passing the procedure examined, i.e., we cannot give answer to the question, where are located the forces, the compensating action of magnetic field to the charge.

The relationship (2.12) from the physical point sight causes bewilderment. The forces, which act on the body in the absence of losses, must be connected either with its acceleration, if it accomplishes forward motion, or with the centrifugal forces, if body accomplishes rotary motion. Finally, static forces appear when there is the gradient of the scalar potential of potential field, in which is located the body. But in relationship (2.12) there is nothing of this. Usual rectilinear motion causes the force, which is normal to the direction motion. What some new law of nature? To this question there is no answer also.

The magnetic field is one of the important concepts of contemporary electrodynamics. Its concept consists in the fact that around any moving charge appears the magnetic field. This field determines Ampere law.

The Ampere law, expressed in the vector form, determines magnetic field at the point x, y, z [2]

$$\vec{H} = \frac{1}{4\pi} \int \frac{I d\vec{l} \times \vec{r}}{r^3} \tag{2.13}$$

where I is current in the element $d\vec{l}$, $\vec{r}$ is vector, directed from $d\vec{l}$ to the point x, y, z. This law is introduced by phenomenological means and there is no physical basis under it. Consequently there is no physical basis, also, under the relationship (2.12), determining Lorentz force.

But, unfortunately, there is a number of the physical questions, during solution of which within the framework the concepts of magnetic field, are obtained paradoxical results. Here one of them.

Using relationships (2.12) and (2.13) not difficult to show that with the unidirectional parallel motion of two like charges, or flows of charges, between them must appear the additional attraction. However, if we pass into the inertial system, which moves together with the charges, then there magnetic field is absent, and there is no additional attraction. This paradox does not have an explanation.

The force with power interaction of material structures, along which flows the current, are applied not only to the moving charges, but to the lattice, but in the concept of magnetic field to this question there is no answer also, since. in equations (2.1-2.13) the presence of lattice is not considered. At the same time, with the flow of the current through the plasma its compression (the so-called pinch effect), occurs, in this case forces of compression act not only on the moving electrons, but also on the positively charged ions. And, again, the concept of magnetic field cannot explain this fact, since in this concept there are no forces, which can act on the ions of plasma.

The solution of the problems indicated and the physical explanation of Lorentz force can be obtained within the framework the concept of scalar-vector potential, which assumes the dependence of the scalar potential of charge and fields on it from the speed.

III. Concept of Scalar-Vector Potential

The Maxwell equations do not give the possibility to write down fields in the moving coordinate systems, if fields in the fixed system are known [1]. This problem is solved with the aid of the Lorenz conversions, however, these conversions from the classical electrodynamics they do not follow. Question does arise, is it possible with the aid of the classical electrodynamics to obtain conversions fields on upon transfer of one inertial system to another, and if yes, then, as must appear the equations of such conversions. Indications of this are located already in the law of the Faraday induction. Let us write down Faraday:

$$\oint \vec{E}' d\vec{l}' = -\frac{d\Phi_B}{dt}. \tag{3.1}$$

As is evident in contrast to Maxwell equations in it not particular and substantive (complete) time derivative is used.

The substantional derivative in relationship (3.1) indicates the independence of the eventual result of appearance emf in the outline from the method of changing the flow, i.e. flow can change both due to the local time derivative of the induction of and because the system, in which is measured , it moves in the three-dimensional changing field . The value of magnetic flux in relationship (3.1) is determined from the relationship

$$\Phi_B = \int \vec{B}\, d\vec{S}', \tag{3.2}$$

where the magnetic induction $\vec{B} = \mu \vec{H}$ is determined in the fixed coordinate system, and the element $d\vec{S}'$ is determined in the moving system. Taking into account (3.2), we obtain from (3.1)

$$\oint \vec{E}' d\vec{l}' = -\frac{d}{dt} \int \vec{B}\, d\vec{S}', \tag{3.3}$$

and further, since $\frac{d}{dt} = \frac{\partial}{\partial t} + \vec{v}\, grad$, let us write down [4-7]

$$\oint \vec{E}' d\vec{l}' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{S} - \int \left[\vec{B} \times \vec{v}\right] d\vec{l}' - \int \vec{v}\, d\dot{v}\, \vec{B}\, d\vec{S}' \tag{3.4}$$

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In this case contour integral is taken on the outline $d\vec{l}'$, which covers the area $d\vec{S}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the Galileo conversions, i.e., $d\vec{l}' = d\vec{l}$ and $d\vec{S}' = d\vec{S}$. From relationship (3.6) follows

$$\vec{E}' = \vec{E} + \left[\vec{v} \times \vec{B}\right]. \tag{3.5}$$

If both parts of equation (3.6) are multiplied by the charge, then we will obtain relationship for the Lorentz force

$$\vec{F}_L' = e\,\vec{E} + e\left[\vec{v} \times \vec{B}\right]. \tag{3.6}$$

Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

For explaining physical nature of the appearance of last term in relationship (3.5) let us write down $\vec{B}$ and $\vec{E}$ through the magnetic vector potential $\vec{A}_B$:

$$\vec{B} = rot\ \vec{A}_B, \qquad \vec{E} = -\frac{\partial \vec{A}_B}{\partial t}. \tag{3.7}$$

Then relationship (3.5) can be rewritten

$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} + \left[\vec{v} \times rot\ \vec{A}_B\right] \tag{3.8}$$

and further

$$\vec{E}' = -\frac{\partial \vec{A}_B}{\partial t} - \left(\vec{v}\ \nabla\right)\vec{A}_B + grad\ \left(\vec{v}\ \vec{A}_B\right). \tag{3.9}$$

The first two members of the right side of equality (3.9) can be gathered into the total derivative of vector potential on the time, namely:

$$\vec{E}' = -\frac{d\,\vec{A}_B}{d\,t} + grad\ \left(\vec{v}\ \vec{A}_B\right). \tag{3.10}$$

From relationship (3.9) it is evident that the field strength, and consequently also the force, which acts on the charge, consists of three parts.

First term is obliged by local time derivative. The sense of second term of the right side of relationship (3.9) is also intelligible. It is connected with a change in the vector potential, but already because charge moves in the three-dimensional changing field of this potential. Other nature of last term of the right side of relationship (3.9). It is connected with the presence of potential forces, since. potential energy of the charge, which moves in the potential field $\vec{A}_B$ with the speed $\vec{v}$, is equal $e\left(\vec{v}\ \vec{A}_B\right)$. The value $e\ grad\ \left(\vec{V}\ \vec{A}_B\right)$ gives force, exactly as gives force the gradient of scalar potential.

Taking rotor from both parts of equality (3.10) and taking into account that $rot\ \ grad \equiv 0$, we obtain

$$rot\ \vec{E}' = -\frac{d\,\vec{B}}{d\,t}. \tag{3.11}$$

If there is no motion, then relationship (3.11) is converted into the Maxwell first equation. Relationship (3.11) is more informative than Maxwell equation

$$rot\ \vec{E} = -\frac{\partial\,\vec{B}}{\partial\,t}.$$

Since in connection with the fact that $rot\ grad\ \equiv 0$, in Maxwell equation there is no information about the potential forces, designated through $e\ grad\ \left(\vec{v}\ \vec{A}_B\right)$.

Let us write down the amount of Lorentz force in the terms of the magnetic vector potential:

$$\vec{F}_L{}' = e\,\vec{E} + e\,[\vec{v} \times rot\,\vec{A}_B] = e\,\vec{E} - e(\vec{v}\,\nabla)\vec{A}_B + e grad\,(\vec{v}\,\vec{A}_B). \tag{3.12}$$

Is more preferable, since the possibility to understand the complete structure of this force gives.

Faraday law (3.2) is called the law of electromagnetic induction, however this is terminological error. This law should be called the law of magnetoelectric induction, since the appearance of electrical fields on by a change in the magnetic caused fields on.

However, in the classical electrodynamics there is no law of magnetoelectric induction, which would show, how a change in the electrical fields on, or motion in them, it leads to the appearance of magnetic fields on. The development of classical electrodynamics followed along another way. Ampere law was first introduced:

$$\oint \vec{H}\,d\,\vec{l} = I, \tag{3.13}$$

where I is current, which crosses the area, included by the outline of integration. In the differential form relationship (3.13) takes the form:

$$rot\ \vec{H} = \vec{j}_\sigma, \tag{3.14}$$

where $\vec{j}_\sigma$ is current density of conductivity.

Maxwell supplemented relationship (3.14) with bias current

$$rot\ \vec{H} = \vec{j}_\sigma + \frac{\partial\,\vec{D}}{\partial\,t}. \tag{3.15}$$

If we from relationship (3.15) exclude conduction current, then the integral law follows from it

$$\oint \vec{H} d\,\vec{l} = \frac{\partial\, \Phi_D}{\partial\, t}, \qquad (3.16)$$

where $\Phi_D = \int \vec{D}\, d\vec{S}$ the flow of electrical induction.

If we in relationship (3.16) use the substantional derivative, as we made during the writing of the Faraday law, then we will obtain [4-6]:

$$\oint \vec{H}' d\,\vec{l}' = \int \frac{\partial\,\vec{D}}{\partial\, t} d\,\vec{S} + \oint [\vec{D}\times\vec{v}] d\,\vec{l}' + \int \vec{v}\, d\,\dot{v}\, \vec{D}\, d\,\vec{S}' \qquad (3.17)$$

In contrast to the magnetic fields, when $div\vec{B}=0$, for the electrical fields on $div\vec{D}=\rho$ and last term in the right side of relationship (2.8) it gives the conduction current of and from relationship (2.7) the Ampere law immediately follows. In the case of the absence of conduction current from relationship (3.17) the equality follows:

$$\vec{H}' = \vec{H} - [\vec{v}\times\vec{D}]. \qquad (3.18)$$

As shown in the work [3], from relationship (2.18) follows and Bio-Savara law, if for enumerating the magnetic fields on to take the electric fields of the moving charges. In this case the last member of the right side of relationship (3.17) can be simply omitted, and the laws of induction acquire the completely symmetrical form [7]

$$\oint \vec{E}' dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v}\times\vec{B}\right] dl'\vec{H},$$
$$\oint \vec{H}' dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v}\times\vec{D}\right] dl'\vec{H}' \qquad (3.19)$$

or

$$rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v}\times\vec{B}\right]$$
$$rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v}\times\vec{D}\right]. \qquad (3.20)$$

For dc fields on these relationships they take the form:

$$\vec{E}' = \left[\vec{v}\times\vec{B}\right]$$
$$\vec{H}' = -\left[\vec{v}\times\vec{D}\right]. \qquad (3.21)$$

In relationships (3.19-3.21), which assume the validity of the Galileo conversions, prime and not prime values present fields and elements in moving and fixed inertial reference system (IS) respectively. It must be noted, that conversions (3.21) earlier could be obtained only from the Lorenz conversions.

The relationships (3.19-3.21), which present the laws of induction, do not give information about how arose fields in initial fixed IS. They describe only laws governing the propagation and conversion fields on in the case of motion with respect to the already existing fields.

The relationship (3.21) 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 fields on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work.

The electric field $E=\frac{g}{2\pi\varepsilon r}$ outsidethe chargedlong rodwith alinear density g decreases as $\frac{1}{r}$, where r isdistance from the centralaxis of the rodto the observation point.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IS 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 $\Delta E = \mu\varepsilon E(\Delta v)^2$. 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 $E'_v(r)$ in moving IS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n\to\infty$. In the final analysis in moving IS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship [8]:

$$E'(r,v_\perp) = \frac{gch\frac{v_\perp}{c}}{2\pi\varepsilon r} = Ech\frac{v_\perp}{c}.$$

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

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

where $v_\perp$ is 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:

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c}, \qquad (3.22)$$

here $\varphi(r)$ is 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 $v_\perp$ is speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components fields on parallel speeds IS as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then with the conversion fields on components, parallel to speed will not change, but components, normal to the direction of speed are converted according to the rule

$$\vec{E}'_\perp = \vec{E}_\perp ch\frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},$$
$$\vec{B}'_\perp = \vec{B}_\perp ch\frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c}, \qquad (3.23)$$

where c is speed of light.

Conversions fields (3.23) they were for the first time obtained in the work [9].

However, the iteration technique, utilized for obtaining the given relationships, it is not possible to consider strict, since its convergence is not explained

Let us give a stricter conclusion in the matrix form [8]. Let us examine the totality IS of such, that IS K_1 moves with the speed Δv relative to IS K, IS K_2 moves with the same speed Δv relative to K_1, etc. If the module of the speed Δv is small (in comparison with the speed of light c), then for the transverse components fields on in IS K_1, K_2,…. we have:

$$\vec{E}_{1\perp} = \vec{E}_\perp + \Delta\vec{v}\times\vec{B}_\perp \qquad \vec{B}_{1\perp} = \vec{B}_\perp - \Delta\vec{v}\times\vec{E}_\perp / c^2. \qquad (3.24)$$
$$\vec{E}_{2\perp} = \vec{E}_{1\perp} + \Delta\vec{v}\times\vec{B}_{1\perp} \qquad \vec{B}_{2\perp} = \vec{B}_{1\perp} - \Delta\vec{v}\times\vec{E}_{1\perp} / c^2$$

Upon transfer to each following IS of field are obtained increases in $\Delta\vec{E}$ and $\Delta\vec{B}$

$$\Delta\vec{E}=\Delta\vec{v}\times\vec{B}_\perp, \qquad \Delta\vec{B}=-\Delta\vec{v}\times\vec{E}_\perp/c^2, \qquad (3.25)$$

where of the field $\vec{E}_\perp$ and $\vec{B}_\perp$ relate to current IS. Directing Cartesian axis x along $\Delta\vec{v}$, let us rewrite (3.24) in the components of the vector

$$\Delta E_y=-B_z\Delta v, \qquad \Delta E=B_y\Delta v, \qquad \Delta B_y=E_z\Delta v/c^2. \qquad (3.26)$$

Relationship (3.26) can be represented in the matrix form

$$\Delta U = A U \Delta v \qquad \begin{pmatrix} 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \\ 0 & 1/c^2 & 0 & 0 \\ -1/c^2 & 0 & 0 & 0 \end{pmatrix} \qquad U = \begin{pmatrix} E_y \\ E_z \\ B_y \\ B_z \end{pmatrix}.$$

If one assumes that the speed of system is summarized for the classical law of addition of velocities, i.e. the speed of final IS $K'=K_N$ relative to the initial system K is $v=N\Delta v$, then we will obtain the matrix system of the differential equations of

$$\frac{dU(v)}{dv}=AU(v) \qquad (3.27)$$

with the matrix of the system v independent of the speed A. The solution of system is expressed as the matrix exponential curve $\exp(vA)$:

$$U'\equiv U(v)=\exp(vA)U, \qquad U=U(0) \qquad (3.28)$$

here U is matrix column fields on in the system K, and U' is matrix column fields on in the system K'. Substituting (3.28) into system (3.27), we are convinced, that U' is actually the solution of system (3.27):

$$\frac{dU(v)}{dv}=\frac{d[\exp(vA)]}{dv}U=A\exp(vA)U=AU(v).$$

It remains to find this exponential curve by its expansion in the series:

$$\exp(va)=E+vA+\frac{1}{2!}v^2A^2+\frac{1}{3!}v^3A^3+\frac{1}{4!}v^4A^4+...$$

where E is unit matrix with the size 4×4. For this it is convenient to write down the matrix A in the unit type form

$$A=\begin{pmatrix} 0 & -\alpha \\ \alpha/c^2 & 0 \end{pmatrix}, \qquad \alpha=\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}, \qquad 0=\begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}.$$

then

$$A^2=\begin{pmatrix} -\alpha^2/c^2 & 0 \\ 0 & -\alpha/c^2 \end{pmatrix}, \qquad A^3=\begin{pmatrix} 0 & \alpha^3/c^2 \\ -\alpha^3/c^4 & 0 \end{pmatrix},$$

$$A^4=\begin{pmatrix} \alpha^4/c^4 & 0 \\ 0 & \alpha^4/c^4 \end{pmatrix}, \qquad A^5=\begin{pmatrix} 0 & -\alpha^5/c^4 \\ \alpha^5/c^6 & 0 \end{pmatrix} .....$$

And the elements of matrix exponential curve take the form

$$[\exp(vA)]_{11}=[\exp(vA)]_{22}=I-\frac{v^2}{2!c^2}+\frac{v^4}{4!c^4}-....,$$

$$[\exp(vA)]_{21}=-c^2[\exp(vA)]_{12}=\frac{\alpha}{c}\left(\frac{v}{c}I-\frac{v^3}{3!c^3}+\frac{v^5}{5!c^5}-.....\right),$$

where I is the unit matrix 2×2. It is not difficult to see that $-\alpha^2=\alpha^4=-\alpha^6=\alpha^8=....=I$, therefore we finally obtain

$$\exp(vA)=\begin{pmatrix} Ich\ v/c & -c\alpha sh\ v/c \\ (\alpha sh\ v/c)/c & Ich\ v/c \end{pmatrix}=$$

$$\begin{pmatrix} ch\ v/c & 0 & 0 & -csh\ v/c \\ 0 & ch\ v/c & csh\ v/c & 0 \\ 0 & (ch\ v/c)/c & ch\ v/c & 0 \\ -(sh\ v/c)/c & 0 & 0 & ch\ v/c \end{pmatrix}.$$

Substituting there $\exp(vA)$, we find

$$E'_y = E_y ch\ \ v/c - cB_z sh\ \ v/c, \qquad E'_z = E_z ch\ \ v/c + cB_y sh\ \ v/c,$$

$$B'_y = B_y ch\ \ v/c + (E_z/c)\, sh\ \ v/c, \qquad B'_z = B_z ch\ \ v/c - (E_y/c)\, sh\ \ v/c\,,$$

or in the vector record

$$\vec{E}'_\perp = \vec{E}_\perp ch\ \frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},$$
$$\vec{B}'_\perp = \vec{B}_\perp ch\ \frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c}, \qquad (3.29)$$

This is conversions (3.23).

IV. Power Interaction of the Current Carrying systems

It was already said, that Maxwell equations do not include information about power interaction of the current carrying systems. In the classical electro-dynamics for calculating such an interaction it is necessary to calculate magnetic field in the assigned region of space, and then, using a Lorentz force, to find the forces, which act on the moving charges. Obscure a question about that remains with this approach, to what are applied the reacting forces with respect to those forces, which act on the moving charges.

The concept of magnetic field arose to a considerable degree because of the observations of power interaction of the current carrying and magnetized systems. Experience with the iron shavings, which are erected near the magnet poles or around the annular turn with the current into the clear geometric figures, is especially significant. These figures served as occasion for the introduction of this concept as the lines of force of magnetic field. In accordance with third Newton's law with any power interaction there is always a equality of effective forces and opposition, and also always there are those elements of the system, to which these forces are applied. A large drawback in the concept of magnetic field is the fact that it does not give answer to that, counteracting forces are concretely applied to what, since. magnetic field comes out as the independent substance, with which occurs interaction of the moving charges.

Is experimentally known that the forces of interaction in the current carrying systems are applied to those conductors, whose moving charges create magnetic field. However, in the existing concept of power interaction of the current carrying systems, based on the concepts of magnetic field and Lorentz force, the positively charged lattice, which is the frame of conductor and to which are applied the forces, it does not participate in the formation of the forces of interaction.

Let us examine this question on the basis of the concept of scalar- vector potential [11-12]. We will consider that the scalar- vector potential of single charge is determined by relationship (3.22), and that the electric fields, created by this potential, act on all surrounding charges, including to the charges positively charged lattices.

Let us examine from these positions power interaction between two parallel conductors (Fig. 1), over which flow the currents. We will consider that g_1^+, g_2^+ and g_1^-, g_2^- present the respectively fixed and moving charges, which fall per unit of the length of conductor.

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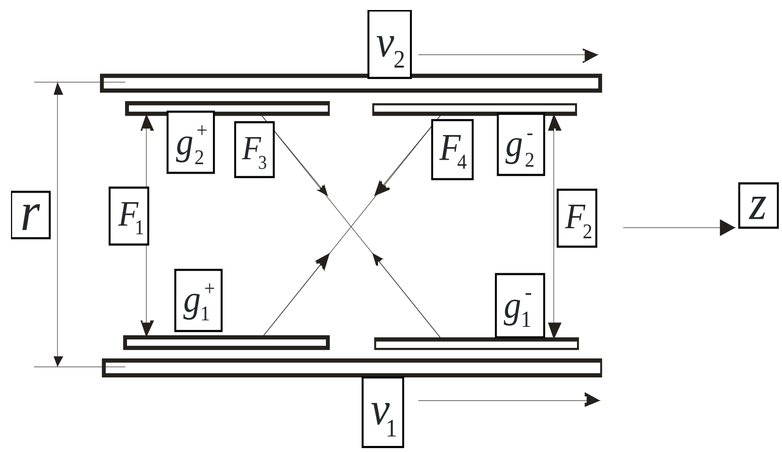

Fig. 1 : Schematic of power interaction of the current carrying wires of two-wire circuit taking into account the positively charged lattice.

The charges g_1^+, g_2^+ present the positively charged lattice in the lower and upper conductors. We will also consider that both conductors prior to the start of charges are electrically neutral, i.e., in the conductors there are two systems of the mutually inserted opposite charges with the specific density to g_1^+, g_1^- and g_2^+, g_2^-, which electrically neutralize each other. In Fig. 1 these systems for larger convenience in the examination of the forces of interaction are moved apart along the axis of z . Subsystems with the negative charge (electrons) can move with the speeds v_1, v_2. The force of interaction between the lower and upper conductors we will search for as the sum of four forces, whose designation is understandable from the figure.

The repulsive forces F_1, F_2 we will take with the minus sign, while the attracting force F_3, F_4 we will take with the plus sign.

For the single section of the two-wire circuit of force, acting between the separate subsystems, will be written down

$$F_1 = -\frac{g_1^+ g_2^+}{2\pi\varepsilon r},$$

$$F_2 = -\frac{g_1^- g_2^-}{2\pi\varepsilon r} ch\frac{v_1 - v_2}{c},$$

$$F_3 = +\frac{g_1^- g_2^+}{2\pi\varepsilon r} ch\frac{v_1}{c},$$

$$F_4 = +\frac{g_1^+ g_2^-}{2\pi\varepsilon r} ch\frac{v_2}{c}. \qquad (4.1)$$

Adding all force components, we will obtain the amount of the composite force, which falls per unit of the length of conductor,

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_1}{c} + ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} - 1 \right) \qquad (4.2)$$

In this expression as g_1, g_2 are undertaken the absolute values of charges, and the signs of forces are taken into account in the bracketed expression. For the case $v << c$, let us take only two first members of expansion in the series $ch\frac{v}{c}$, i.e., we will consider that $ch\frac{v}{c} \cong 1 + \frac{1}{2}\frac{v^2}{c^2}$. From relationship (4.2) we obtain

$$F_{\Sigma 1} = \frac{g_1 v_1 g_2 v_2}{2\pi\varepsilon c^2 r} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r}, \qquad (4.3)$$

where as g_1, g_2 are undertaken the absolute values of specific charges, and v_1, v_2 take with its signs.

Since the magnetic field of straight wire, along which flows the current of I, we determine by the relationship

$$H = \frac{I}{2\pi r},$$

From relationship (4.2) we obtain

$$F_{\Sigma 1} = \frac{I_1 I_2}{2\pi\varepsilon c^2 r} = \frac{H_1 I_2}{\varepsilon c^2} = I_2 \mu H_1,$$

where H_1 is the magnetic field, created by lower conductor in the location of upper conductor.

Itisanalogous

$$F_{\Sigma 1} = I_1 \mu H_2,$$

where H_2 is the magnetic field, created by upper conductor in the region of the arrangement of lower conductor.

These relationships completely coincide with the results, obtained on the basis of the concept of magnetic field.

The relationship (4.3) represents the known rule of power interaction of the current carrying systems, but is obtained it not by the phenomenological way on the basis of the introduction of phenomenological magnetic field, but on the basis of completely intelligible physical procedures, under the assumption that that the scalar potential of charge depends on speed. In the formation of the forces of interaction in this case the lattice takes direct part, which is not in the model of magnetic field. In the model examined are well visible the places of application of force. The obtained relationships coincide with the results, obtained on the basis of the concept of magnetic field and by the axiomatically introduced Lorentz force. In this case is undertaken only first member of expansion in the series $ch\frac{v}{c}$. For the speeds $v \sim c$ should be taken all terms of expansion. In terms of this the proposed method is differed from the method of calculation of power interactions by the basis of the concept of magnetic field. If we consider this circumstance, then the connection between the forces of interaction and the charge rates proves to be nonlinear. This, in particular it leads to the fact that the law of power interaction of the current carrying systems is asymmetric. With the identical values of currents, but with their different directions, the attracting forces and repulsion become unequal. Repulsive forces prove to be greater than attracting force. This difference is small and is determined by the expression

$$\Delta F = \frac{v^2}{2c^2} \frac{I_1 I_2}{2\pi\varepsilon c^2 \varepsilon},$$

but with the speeds of the charge carriers of close ones to the speed of light it can prove to be completely perceptible.

Let us remove the lattice of upper conductor (Fig. 1), after leaving only free electronic flux. In this case will disappear the forces F_1, F_3, and this will indicate interaction of lower conductor with the flow of the free electrons, which move with the speed v_2 on the spot of the arrangement of upper conductor. In this case the value of the force of interaction is defined as:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(ch\frac{v_2}{c} - ch\frac{v_1 - v_2}{c} \right) \qquad (4.4)$$

Lorentz force assumes linear dependence between the force, which acts on the charge, which moves in the magnetic field, and his speed. However, in the obtained relationship the dependence of the amount of force from the speed of electronic flux will be nonlinear. From relationship (4.4)it is not difficult to see that with an increase in v_2 the deviation from the linear law increases, and in the case, when $v_2 >> v_1$, the force of interaction are approached zero. This is very meaningful result. Specifically, this phenomenon observed in their known experiments Thompson and Kauffmann, when they noted that with an increase in the velocity of electron beam it is more badly slanted by magnetic field. They connected the results of their observations with an increase in the mass of electron. As we see reason here another.

Let us note still one interesting result. From relationship (4.3), with an accuracy to quadratic terms, the force of interaction of electronic flux with the rectilinear conductor to determine according to the following dependence:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\left(\frac{v_1 v_2}{c^2} - \frac{1}{2}\frac{v_1^2}{c^2} \right) \qquad (4.5)$$

from expression (4.5) follows that with the unidirectional electron motion in the conductor and in the electronic flux the force of interaction with the fulfillment of conditions $v_1 = \frac{1}{2} v_2$ is absent.

Since the speed of the electronic flux usually much higher than speed of current carriers in the conductor, the second term in the brackets in relationship (4.5) can be disregarded. Then, since

$$H_1 = \frac{g_1 v_1}{2\pi\varepsilon c^2 r}$$

will obtain the magnetic field, created by lower conductor in the place of the motion of electronic flux:

$$F_\Sigma = \frac{g_1 g_2}{2\pi\varepsilon r}\frac{v_1 v_2}{c^2} = g_2 \mu v_2 H.$$

In this case, the obtained value of force exactly coincides with the value of Lorentz force. Taking into account that

$$F_\Sigma = g_2 E = g_2 \mu v_2 H,$$

it is possible to consider that on the charge, which moves in the magnetic field, acts the electric field E, directed normal to the direction of the motion of charge. This result also with an accuracy to of the quadratic terms $\frac{v^2}{c^2}$ completely coincides with the results of the concept of magnetic field and is determined the Lorentz force, which acts from the side of magnetic field to the flow of the moving electrons.

As was already said, one of the important contradictions to the concept of magnetic field is the fact that two parallel beams of the like charges, which are moved with the identical speed in one direction, must be attracted. In this model there is no this contradiction already. If we consider that the charge rates in the upper and lower wire will be equal, and lattice is absent, i.e., to leave only electronic fluxes, then will remain only the repulsive force F_2.

Thus, the moving electronic flux interacts simultaneously both with the moving electrons in the lower wire and with its lattice, and the sum of these forces of interaction it is called Lorentz force. This force acts on the moving electron stream.

Regularly does appear a question, and does create magnetic field most moving electron stream of in the absence compensating charges of lattice or positive ions in the plasma. The diagram examined shows that the effect of power interaction between the current carrying systems requires in the required order of the presence of the positively charged lattice. Therefore most moving electronic flux cannot create that effect, which is created during its motion in the positively charged lattice.

Let us demonstrate still one approach to the problem of power interaction of the current carrying systems. The statement of facts of the presence of forces between the current carrying systems indicates that there is some field of the scalar potential, whose gradient ensures the force indicated. But that this for the field? Relationship (4.3) gives only the value of force, but he does not speak about that, the gradient of what scalar potential ensures these forces. We will support with constants the currents I_1, I_2, and let us begin to draw together or to move away conductors. The work, which in this case will be spent, and is that potential, whose gradient gives force. After integrating relationship (4.3) on r, we obtain the value of the energy:

$$W = \frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2}.$$

This energy, depending on that to move away conductors from each other, or to draw together, can be positive or negative. When conductors move away, then energy is positive, and this means that, supporting current in the conductors with constant, generator returns energy. This phenomenon is the basis the work of all electric motors. If conductors converge, then work accomplish external forces, on the source, which supports in them the constancy of currents. This phenomenon is the basis the work of the mechanical generators of emf.

Relationship for the energy can be rewritten and thus:

$$W = \frac{I_1 I_2 \ln r}{2\pi\varepsilon c^2} = I_2 A_{z1} = I_1 A_{z2},$$

where

$$A_{z1} = \frac{I_1 \ln r}{2\pi\varepsilon c^2}$$

is Z - component of vector potential, created by lower conductor in the location of upper conductor, and

$$A_{z2} = \frac{I_2 \ln r}{2\pi\varepsilon c^2}$$

is Z - component of vector potential, created by upper conductor in the location of lower conductor.

The approach examined demonstrates that large role, which the vector potential in questions of power interaction of the current carrying systems and conversion of electrical energy into the mechanical plays. This approach also clearly indicates that the Lorentz force is a consequence of interaction of the current carrying systems with the field of the vector potential, created by other current carrying systems. This is clear from a physical point of view. The moving charges, in connection with the presence of the dependence of their scalar potential on the speed, create the scalar field, whose gradient gives force. But the creation of any force field requires expenditures of energy. These expenditures accomplishes generator, creating currents in the conductors. In this case in the surrounding space is created the special field, which interacts with other moving charges according to the special vector rules, with which only scalar product of the charge rate and vector potential gives the potential, whose gradient gives the force, which acts on the moving charge. Thisis a Lorentz force.

In spite of simplicity and the obviousness of this approach, this simple mechanism up to now was not finally realized. For this reason the Lorentz force, until now, was introduced in the classical electro-dynamics by axiomatic way.

V. Conclusion

In the article is developed the concept of scalar- vector potential, based on the symmetrization of the equations of induction, during record of which is used the substantional derivative. The physical causes of molding of Lorentz force are examined. is shown that the dependence of the scalar potential of charge on the speed is the physical cause of Lorentz force. The examination of power interaction of the current carrying systems is carried out and it is shown that with the low speeds of charges the concept of scalar- vector potential gives the same results as the concept of magnetic field. It is shown that the Lorentz force is connected with the gradient of scalar potential.

This potential form the charges, which move in the field of the vector potential of magnetic field, which, is in turn the consequence of the dependence of the scalar potential of charge on the speed.

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