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New Methods for Solving the Problem of Radiation and Propagation of Electromagnetic Waves

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I. Concept of Emission in the Classical Electrodynamics

Any field is this field, which can be revealed with the aid of the meters. If there is a charged parallel-plate capacitor (Fig. 1), consisting of two flat plates, the electric field between them it is easy to reveal, introducing between these plates trial charge. By the force, which acts on this charge, and is revealed the electric field? By the characteristic property of this field is the fact that it presents the continuous homogeneous medium, which possesses specific energy, proportional to the square of electric field. Of this easily it will be convinced with the aid of the simple experiment. If we begin to separate the plates of capacitor, then in this case it will be necessarily spend the specific work.

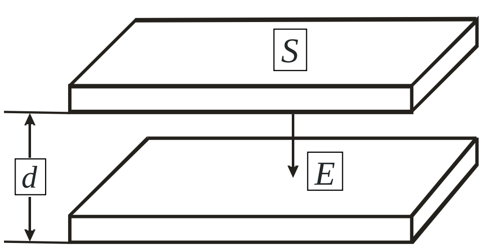

Fig. 1: Capacitor, which consists of the plane-parallel charged plates

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If the surface density of charges on its plates is equal σ, that the tension of the electric field between its plates is equal

$$E=\frac{\sigma}{2\varepsilon_0}.$$

Without taking into account edge effects the electric force, which acts on the plates of capacitor is determined by the relationship

$$F=\frac{1}{2}\varepsilon_0 E^2 S.$$

If in this case plates are moved apart up to the distance d, that in this case the mechanical work will be perfected

$$W=\frac{1}{2}\varepsilon_0 E^2 Sd.$$

But energy of electrical pour on also it will be equal to the same value. But if plates converge, then, on the contrary, electrical energy will be converted into the mechanical. These examples show, as mechanical energy it can be converted into the electrical and vice versa.

It is well known that near the wires, along which flows alternating electric current, are formed the electrical induction fields, which can be connected with the alternating magnetic field. Magnetic field was introduced by ampere by phenomenological way on the basis of the observation of power interaction between the conductors, along which flows the current.

The Ampere law, expressed in the vector form, determines magnetic field at the point [1]:

$$\vec{H}=\frac{1}{4\pi}\int\frac{I\left[d\vec{l}\ \vec{r}\right]}{r^3},$$

where I - current in the element $d\vec{l}$, $\vec{r}$ - vector, directed from $d\vec{l}$ to the viewpoint (Fig. 2).

It is possible to show that

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

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And, besides the fact that

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

Fig. 2: The formation of vector potential by the element of the conductor dl, along which flows the current I

But the rotor of $d\vec{l}$ 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

$$\vec{A}_H=\int I\left(\frac{d\vec{l}}{4\pi r}\right)\ . \qquad (1.1)$$

The remarkable property of this expression is the fact that the dependence of vector potential is inversely proportional to distance to the observation point, which is characteristic for the emission laws. 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 (1.1) we obtain:

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

If the size of element $d\vec{l}$, along which flows current, it is considerably less than distance to the observation point, then this relationship takes the form:

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

From this relationship follows interesting fact. Even on the direct current the dependence of vector potential on the distance corresponds to emission laws. And, it would seem, that, changing by jumps current in the short section of wire, and measuring the vector potential at the remote point, it is possible to transfer information into this point by the emission laws. But this interferes with the circumstance that the direct-current circuit is always locked to the local power source and therefore always there is both straight and return conductor. This special feature leads to the fact that in this situation the vector potential in the distant zone occurs inversely it is proportional to the square of distance to the observed point. This is easy to show based on the example of two parallel elements of conductor, located at a distance d (Fig. 3), in which flow the opposite currents.

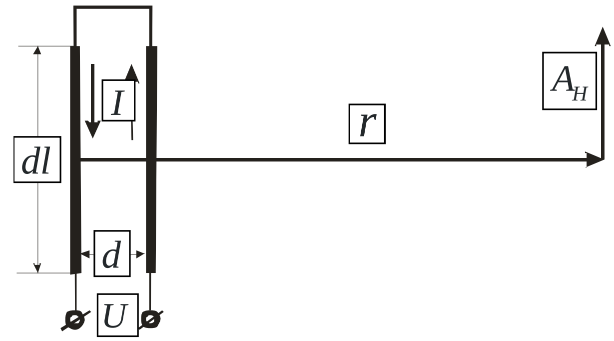

Fig. 3: Two conductors with the opposite currents

In this case vector potential in the remote zone is defined as the sum of the vector potentials, created in the distant zone individually by each current element. When considerably more than we obtain:

$$\vec{A}_H=\frac{gv\ d\vec{l}}{4\pi r}-\frac{gv\ d\vec{l}}{4\pi(r+d)}\cong\frac{gv\ d\vec{l}\ d}{4\pi r^2}\ .$$

To avoid these difficulties is possible by the way of using alternating currents. Since the electric field and vector potential in the free space are connected with the relationship

$$\vec{E}=-\mu_0\frac{\partial\vec{A}}{\partial t}\ ,$$

where μ_0 - magnetic permeability of vacuum, the electric field, created in the distant zone by current element $gvd\vec{l}$, will depend on the acceleration of charges in this element

$$\vec{E}=-\frac{\mu_0 ga\ d\vec{l}}{4\pi r}\ , \qquad (1.2)$$

where $a=\frac{dv}{dt}$ - acceleration of charge. It is known from Maxwell's equations that the electric fields are extended in the free space with the speed

$$c=\frac{1}{\sqrt{\varepsilon_0\mu_0}}\ , \qquad (1.3)$$

where ε_0 - the dielectric constant of vacuum.

Therefore, if the current elements are arranged at a distance equal to half the wavelength and create multidirectional currents in them, then in the far zone, due to the delay, the electric fields from the individual current elements will add up and the total electric field will be doubled:

$$\vec{E}_{\Sigma}=-\frac{\mu_0 ga\ d\vec{l}}{2\pi r}.$$

If we in the relationship (1.2) consider that the fields are extended with the final speed and to consider delay $\left(t-\frac{r}{c}\right)$, that we will obtain taking into account (1.3) relationship:

$$\vec{E}=-\int\frac{ga(t-\frac{r}{c})\ d\vec{l}}{4\pi\varepsilon_0 c^2 r} \quad .(1.4)$$

When the acceleration of charges changes according to the harmonic law $a=a_0\sin\omega\left(t-\frac{r}{c}\right)$ Relationship (1.4) takes the form

$$\vec{E}=-\int\frac{ga_0\sin\omega\left(t-\frac{r}{c}\right)\ d\vec{l}}{4\pi\varepsilon_0 c^2 r}. \quad (1.5)$$

In the case, when the size of current element is considerably lower than the distance to the observation point, we obtain:

$$\vec{E}=-\frac{ga_0\sin\omega\left(t-\frac{r}{c}\right)\ d\vec{l}}{4\pi\varepsilon_0 c^2 r}. \quad (1.6)$$

Relationships (1.4-1.6) it shows that the electric fields in the distant zone for the case examined depend on the acceleration of charges. Examining the electric fields of parallel-plate capacitor, we saw that such fields possess the specific energy, which they will transfer with their propagation.

But in this examination metal of the place for the magnetic field, which is located in the electromagnetic wave. This field can be introduced as purely mathematical concept from the second equation of Maxwell

$$rot\vec{H}=\varepsilon_0\frac{\partial\vec{E}}{\partial t}.$$

We have for the case of the smallness of current element in comparing with the distance to the observation point:

$$rot\vec{H}=-\frac{\omega ga_0\cos\omega\left(t-\frac{r}{c}\right)\ d\vec{l}}{4\pi c^2 r}. \quad (1.7)$$

From these relationships it follows that the magnetic field is the gradient of electric field.

If there is a single charge e, that relationship (1.6), (1.7) they will be rewritten as follows:

$$\vec{E}=-\frac{ea_0\sin\omega\left(t-\frac{r}{c}\right)\ \vec{k}}{4\pi\varepsilon_0 c^2 r}, \quad (1.8)$$

$$rot\vec{H}=-\frac{\omega ea_0\cos\omega\left(t-\frac{r}{c}\right)\ \vec{k}}{4\pi c^2 r}, \quad (1.9)$$

where $\vec{k}$ - unit vector in the direction of the motion of charge.

Let us write down these relationships in the Cartesian coordinate system, by considering that direction of propagation is the axis y, and vector $\vec{E}$ it is directed along the axis z (Fig. 4).

Fig. 4: Diagram of shaping of magnetic field

From relationship (18.2) we obtain

$$\frac{\partial H_x}{\partial y}=-\frac{\omega ea_0\cos\omega\left(t-\frac{y}{c}\right)}{4\pi c^2 y}, \quad (1.10)$$

One should consider with the integration of this relationship that with the wavelength considerably smaller than distance to the observation point, harmonic derivative on the coordinate is considerably more than derivative of the reverse value of coordinate. Therefore coordinate in the numerator of the right side of the relationship (1.10) can be considered constant. We obtain with this condition from (1.10) the relationship

$$H_x=-\frac{ea_0\sin\omega\left(t-\frac{y}{c}\right)}{4\pi cy}. \quad (1.11)$$

This value of magnetic field is obtained with the condition for existence Z of the component of the electric field

$$E_z = -\frac{ea_0 \sin\omega\left(t-\frac{r}{c}\right)}{4\pi\varepsilon_0 c^2 r}. \quad (1.12)$$

After dividing (1.12) on (1.11) we obtain

$$\frac{E_z}{H_x} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = Z_0,$$

where Z_0 - the wave drag of vacuum.

The carried out examination showed that in the free space can be extended the so-called electromagnetic wave, whose vectors of electrical and magnetic field are cophasal. Let us emphasize again that the introduction of the vector of magnetic field is the purely mathematical formality, which is not the necessary for the construction theory of emission.

Thus, relying on the phenomenological concept of magnetic field, are obtained the laws of the propagation of electromagnetic waves. These laws exclude the need of using Maxwell's equations, since all laws of propagation can be obtained from them, and Maxwell's equations with respect to these equations are the special case, when distance from the emitter to the observation point is great.

There remains only to ask, why electrodynamics is not banal along this way immediately after the introduction of the concept of magnetic field. Answer lies in the fact that then no one knew about existence of electromagnetic waves and only experiences of Hertz confirmed this.

Thus, the physical basis of this approach is not thus far clear, since it is not understandable that the vector potential represents from a physical point of view and why it is connected with the motion of charges. In connection with the incomprehension of these questions, but vector potential is critical not only for the emission, but also for the power of interaction of the current carrying systems, the classical electrodynamics and it is divided up to now into two those not connected with each other of part. Its one parts this of Maxwell's equation, the determining wave processes in the material media. Another part, which determines power interaction of the current carrying systems, is based on the experimental postulate about the Lorentz force.

From the relationships (8) and (11) it is evident that the electrical and magnetic fields of electromagnetic waves in this posing of the question depend only on the second the derivatives of coordinate on the time, and in this case as yet there is no answer apropos of that, can these fields depend on higher derivatives.

This question is examined from a formal phenomenological point of view by the way of the introduction of the concept of magnetic field and vector potential, and the obtained results well correspond with the experiment. However, basic problem today consists in the fact that physical nature of this potential until is known.

Further development of phenomenological approaches to questions of the propagation of electromagnetic waves.

a) Laws of the self-induction

To the laws of self-induction should be carried those laws, which describe the reaction of such elements of radio-technical chains as capacity, inductance and resistance with the galvanic connection to them of the sources of current or voltage [2-4]. These laws are the basis of the theory of electrical chains. The motion of charges in any chain, which force them to change their position, is connected with the energy consumption from the power sources. The processes of interaction of the power sources with such structures are regulated by the laws of self-induction.

To the self-induction let us carry also that case, when its parameters can change with the presence of the connected power source or the energy accumulated in the system. This self-induction we will call parametric. Subsequently we will use these concepts: as current generator and the voltage generator. By ideal voltage generator we will understand such source, which ensures on any load the lumped voltage, internal resistance in this generator equal to zero. By ideal current generator we will understand such source, which ensures in any load the assigned current, internal resistance in this generator equally to infinity. The ideal current generators and voltage in nature there does not exist, since both the current generators and the voltage generators have their internal resistance, which limits their possibilities.

If we to one or the other network element connect the current generator or voltage, then opposition to a change in its initial state is the response reaction of this element and this opposition is always equal to the applied action, which corresponds to third Newton's law.

If the capacity C is charged to a potential difference U, then the charge Q, accumulated in it, is determined by the relationship

$$Q_{C,U} = CU. \quad (2.1.1)$$

The charge $Q_{C,U}$, depending on the capacitance values of capacitor and from a voltage drop across it, we will call still the flow of electrical self-induction.

When speech goes about a change in the charge, determined by relationship (2.1.1), that this value it can change with the method of changing the potential difference with a constant capacity, either with a change in capacity itself with a constant potential difference, or and that and other parameter simultaneously.

If capacitance value or voltage drop across it depend on time, then the current strength is determined by the relationship:

$$I=\frac{dQ_{C,U}}{dt}=C\frac{dU}{dt}+U\frac{dC}{dt}.$$

This expression determines the law of electrical self-induction. Thus, current in the circuit, which contains capacitor, can be obtained by two methods, changing voltage across capacitor with its constant capacity either changing capacity itself with constant voltage across capacitor, or to produce change in both parameters simultaneously.

For the case, when the capacity C_1 is constant, we obtain known expression for the current, which flows through the capacity:

$$I=C_1\frac{dU}{dt}. \qquad (2.1.2)$$

When changes capacity, and at it is supported the constant voltage U_1, we have:

$$I=U_1\frac{dC}{dt}. \qquad (2.1.3)$$

This case to relate to the parametric electrical self-induction, since the presence of current is connected with a change in this parameter as capacity.

Let us examine the consequences, which escape from relationship (1.1.2).

If we to the capacity connect the direct-current generator I_0, then voltage on it will change according to the law:

$$U=\frac{I_0 t}{C_1}. \qquad (2.1.4)$$

Thus, the capacity, connected to the source of direct current, presents for it the effective resistance

$$R=\frac{t}{C_1} \qquad (2.1.5)$$

linearly depending on the time. The it should be noted that obtained result is completely obvious; however, such properties of capacity, which customary to assume by reactive element they were for the first time noted in the work [1].

This is understandable from a physical point of view, since in order to charge capacity, source must expend energy.

The power, output by current source, is determined in this case by the relationship:

$$P(t)=\frac{I_0^2 t}{C_1} \qquad (2.1.6)$$

The energy, accumulated by capacity in the time t we will obtain after integrating relationship (2.1.6) with respect to the time:

$$W_C=\frac{I_0^2 t^2}{2C_1}.$$

Substituting here the value of current from relationship (2.1.4), we obtain the dependence of the value of the accumulated in the capacity energy from the instantaneous value of voltage on it:

$$W_C=\frac{1}{2}C_1 U^2.$$

Using for the case examined a concept of the flow of electrical induction, which is the charge, we obtain

$$\Phi_U=C_1 U=Q(U) \qquad (2.1.7)$$

and using relationship (2.1.2), let us write down:

$$I_0=\frac{d\Phi_U}{dt}=\frac{dQ(U)}{dt}, \qquad (2.1.8)$$

i.e. if we to a constant capacity connect the source of direct current, then the current strength will be equal to the derivative of the flow of capacitive induction on the time.

Now we will support at the capacity constant voltage U_1, and change capacity itself, then

$$I=U_1\frac{dC}{dt}. \qquad (2.1.9)$$

It is evident that the value

$$R_C=\left(\frac{dC}{dt}\right)^{-1} \qquad (2.1.10)$$

plays the role of the effective resistance. This result is also physically intelligible, since with an increase in the capacitance increases the energy accumulated in it, and thus, capacity extracts in the voltage source energy, presenting for it resistive load. The power, expended in this case by source, is determined by the relationship:

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$$P(t)=\frac{dC}{dt}U_1^{\ 2}. \qquad (2.1.11)$$

From relationship (2.1.11) is evident that depending on the sign of derivative the expendable power can have different signs. When the derived positive, expendable power goes for the accomplishment of external work. If derived negative, then external source accomplishes work, charging capacity.

Again, introducing concept the flow of the capacitive induction

$$\Phi_C=CU_1=Q(C),$$

we obtain

$$I=\frac{\partial\Phi_C}{\partial t}. \qquad (2.1.12)$$

Relationships (2.1.8) and (2.1.12) indicate that regardless of the fact, how changes the flow of electrical self-induction (charge), its time derivative is always equal to current.

Let us examine one additional process, which earlier the laws of induction did not include; however, it falls under for our extended determination of this concept. From relationship (2.1.7) it is evident that if the charge, left constant (we will call this regime the regime of the frozen electric flux), and then voltage on the capacity can be changed by its change. In this case the relationship will be carried out:

$$CU=C_0U_0=const,$$

where C, U - instantaneous values, and C_0, U_0 - initial values of these parameters, which occur with turning off from the capacity of the power source.

The voltage on the capacity and the energy, accumulated in it, will be in this case determined by the relationships:

$$U=\frac{C_0U_0}{C}, \qquad (2.1.13)$$

$$W_C=\frac{1}{2}\frac{(C_0U_0)^2}{C}.$$

It is natural that this process of self-induction can be connected only with a change in capacity itself, and therefore it falls under for the determination of parametric self-induction.

Thus, are located three relationships (2.1.8), (2.1.12) and (2.1.13), which determine the processes of electrical self-induction. We will call their rules of capacitive flow. Relationship (2.1.8) determines the electrical self-induction, during which there are no changes in the capacity, and therefore this self-induction can be named simply electrical self-induction. Relationships (2.1.3) and (2.1.9-2.1.11) assume the presence of changes in the capacity; therefore the processes, which correspond by these relationships, we will call electrical parametric self-induction.

Let us now move on to the examination of the processes, proceeding in the inductance. Let us introduce the concept of the flow of the inductive self-induction

$$\Phi_{L,I}=LI.$$

If inductance is shortened outed, and made from the material, which does not have effective resistance, for example from the superconductor, then

$$\Phi_{L,I}=L_1I_1=const,$$

where L_1 and I_1 - initial values of these parameters, which are located at the moment of the short circuit of inductance with the presence in it of current.

This regime we will call the regime of the frozen flow. In this case the relationship is fulfilled:

$$I=\frac{I_1L_1}{L}, \qquad (2.1.14)$$

where I and L - the instantaneous values of the corresponding parameters.

In flow regime examined of current induction remains constant, however, in connection with the fact that current in the inductance it can change with its change, this process falls under for the determination of parametric self-induction. The energy, accumulated in the inductance, in this case will be determined by the relationship

$$W_L=\frac{1}{2}\frac{(L_1I_1)^2}{L}=\frac{1}{2}\frac{(const)^2}{L}.$$

Voltage on the inductance is equal to the derivative of the flow of current induction on the time:

$$U=\frac{d\Phi}{dt}=L\frac{dI}{dt}+I\frac{dL}{dt}.$$

Let us examine the case, when the inductance of is constant

$$U=L_1\frac{dI}{dt} \qquad (2.1.15)$$

designating $\Phi_I=L_1I$, we obtain

$$U=\frac{d\Phi_I}{dt}.$$

After integrating expression (2.1.15) on the time, we will obtain:

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$$I=\frac{Ut}{L_1} \quad (2.1.16)$$

Thus, the capacity, connected to the source of direct current, presents for it the effective resistance

$$R=\frac{L_1}{t}, \quad (2.1.17)$$

which decreases inversely proportional to time.

The power, expended in this case by source, is determined by the relationship:

$$P(t)=\frac{U^2t}{L_1} \quad (2.1.18)$$

This power linearly depends on time. After integrating relationship (2.1.18) on the time, we will obtain the energy, accumulated in the inductance

$$W_L=\frac{1}{2}\frac{U^2t^2}{L_1}. \quad (2.1.19)$$

After substituting into expression (2.1.19) the value of voltage from relationship (2.1.16), we obtain:

$$W_L=\frac{1}{2}L_1I^2.$$

This energy can be returned from the inductance into the external circuit, if we open inductance from the power source and to connect effective resistance to it.

Now let us examine the case, when the current I_1, which flows through the inductance, is constant, and inductance itself can change. In this case we obtain the relationship

$$U=I_1\frac{dL}{dt} \quad (2.1.20)$$

Thus, the value

$$R(t)=\frac{dL}{dt} \quad (2.1.21)$$

plays the role of the effective resistance.

As in the case the electric flux, effective resistance can be (depending on the sign of derivative) both positive and negative. This means that the inductance can how derive energy from without, so also return it into the external circuits.

Introducing the designation $\Phi_L=LI_1$ and, taking into account (2.1.20), we obtain:

$$U=\frac{d\Phi_L}{dt}. \quad (2.1.22)$$

The relationship (2.1.14), (2.1.19) and (2.1.22) we will call the rules of current self-induction, or the flow rules of current self-induction. From relationships (2.1.19) and (2.1.22) it is evident that, as in the case with the electric flux, the method of changing the flow does not influence eventual result, and its time derivative is always equal to the applied potential difference. Relationship (2.1.19) determines the current self-induction, during which there are no changes in the inductance, and therefore it can be named simply current self-induction. Relationships (2.1.20-2.1.21) assume the presence of changes in the inductance; therefore we will call such processes current parametric self-induction.

b) Work presents the new method of obtaining the wave equation for the long lines

The processes, examined in two previous paragraphs, concern chains with the lumped parameters, when the distribution of potential differences and currents in the elements examined can be considered uniform. However, there are chains, for example the long lines, into which potential differences and currents are not three-dimensional uniform. These processes are described by the wave equations, which can be obtained from Maxwell's equations or with the aid of the telegraphic equations, but physics of phenomenon itself in these processes to us is not clear.

We will use the results, obtained in the previous paragraph, for examining the processes, proceeding in the long lines, in which the capacity and inductance are the distributed parameters [5-7]. Let us assume that linear (falling per unit of length) capacity and inductance of this line are equal C_0 and L_0. If we to this line connect the dc power supply U_1, then its front will be extended in the line some by the speed v and the moving coordinate of this front will be determined by the relationship $z=vt$. In this case the total quantity of the charged capacity and the value of the summary inductance, along which it flows current, calculated from the beginning lines to the location of the front of voltage, will change according to the law:

$$C(t)=zC_0=vt\ C_0,$$

$$L(t)=zL_0=vt\ L_0.$$

The source of voltage U_1 will in this case charge the being increased capacity of line, for which from the source to the charged line in accordance with relationship (2.1.9) must leak the current:

$$I_1=U_1\frac{dC(t)}{dt}=vU_1C_0. \quad (2.2.1)$$

This current there will be the leak through the conductors of line that possess inductance. But, since the inductance of line in connection with the motion of the front of voltage, also increases, in accordance with relationship (2.1.20), on it will be observed a voltage drop:

$$U=I_1\frac{dL}{dt}=vI_1L_0=v^2U_1C_0L_0\,.$$

But a voltage drop across the conductors of line in the absolute value is equal to the voltage, applied to its entrance; therefore in the last expression should be placed $U=U_1$. We immediately find taking this into account that the rate of the motion of the front of voltage with the assigned linear parameters and when, on, the incoming line of constant voltage of U_1 is present, must compose

$$v=\frac{1}{\sqrt{L_0C_0}}\,. \qquad (2.2.2)$$

This expression corresponds to the signal velocity in line itself. Consequently if we to the infinitely long line connect the voltage source, then in it will occur the expansion of electrical pour on and the currents, which fill line with energy, and the speed of the front of constant voltage and current will be equal to the velocity of propagation of electromagnetic vibrations in this line. This wave we will call electric current wave. It is interesting to note that the obtained result does not depend on the form of the function U, i.e. to the line can be connected both the dc power supply and the source, whose voltage changes according to any law. In all these cases the value of the local value of voltage on incoming line will be extended along it with the speed, which follows from relationship (2.2.2). This result could be, until now, obtained only by the method of solution of wave equation, but in this case he indicates the physical cause for this propagation, and it gives the physical picture of process itself. Examination shows that very process of propagation is connected with the energy processes of the filling of line with electrical and current energy. This process occurs in such a way that the wave front, being extended with the speed v, leaves after itself the line, charged to a potential difference U_1, which corresponds to the filling of line with electrostatic electric field energy. However, in the section of line from the voltage source also to the wave front flows the current I_1, which corresponds to the filling of line in this section with energy, which is connected with the motion of the charges along the conductors of line, which possess inductance.

The current strength in the line can be obtained, after substituting the values of the velocity of propagation of the wave front, determined by relationship (2.2.2), into relationship (2.2.1). After making this substitution, we will obtain

$$I_1=U_1\sqrt{\frac{C_0}{L_0}}\,,$$

where $Z=\sqrt{\frac{L_0}{C_0}}$ - line characteristic.

In this case

$$U_1=I\frac{dL}{dt}=\frac{d\Phi_L}{dt}\,.$$

So accurately

$$I_1=U_1\frac{dC}{dt}=\frac{d\Phi_C}{dt}\,.$$

It is evident that the flow rules both for the electrical and for the current self-induction are observed also in this case.

Thus, the processes of the propagation of a potential difference along the conductors of long line and current in it are connected and mutually supplementing each other, and to exist without each other they do not can. This process can be called electric current spontaneous parametric self-induction. This name connected with the fact that flow expansion they occur arbitrarily and characterizes the rate of the process of the filling of line with energy. From the aforesaid the connection between the energy processes and the velocity of propagation of the wave fronts in the long lines becomes clear. Since with the emission of electromagnetic waves the free space is also transmission line, similar laws must characterize propagation in this space.

That will be, if we in the considered case as one of the conductors of long line take spiral, or to as is customary call, long solenoid. Obviously, in this case the velocity of propagation of the front of voltage in this line will decrease, since the linear inductance of line will increase. This propagation will accompany the process of the propagation not only of external with respect to the solenoid pour on and currents, but both the process of the propagation of magnetic flux inside the solenoid itself and the velocity of propagation of this flow will be equal to the velocity of propagation of electromagnetic wave in line itself.

Knowing current and voltage in the line, it is possible to calculate the specific energy, concluded in the linear capacity and the inductance of line. These energies will be determined by the relationships:

$$W_C=\frac{1}{2}C_0U_1^2\,, \qquad (2.2.3)$$

$$W_L = \frac{1}{2} L_0 I_1^2 . \qquad (2.2.4)$$

It is not difficult to see that $W_C = W_L$.

Now let us discuss a question about the duration of the front of electric current wave and about which space will occupy this front in line itself. Answer to the first question is determined by the properties of the very voltage source, since local derivative $\frac{\partial U}{\partial t}$ at incoming line depends on transient processes in the source itself and in that device, with the aid of which this source is connected to the line. If the process of establishing the voltage on incoming line will last some time Δt , then in the line it will engage section with the length $v\Delta t$. If we to the line exert the voltage, which is changed with the time according to the law $U(t)$, then the same value of function will be observed at any point of the line at a distance Z relaunch. Of beginning with the delay $t = \frac{z}{v}$. Thus, the function

$$U(t,z) = U\left(t - \frac{z}{v}\right). \qquad (2.2.5)$$

Can be named propagation function, since it establishes the connection between the local temporary and three-dimensional values of function in the line. Long line is the device, which converts local derivative voltage on the time on incoming line into the gradients in line itself. On the basis propagation function (2.2.5) it is possible to establish the connection between the local and gradients in the long line. It is obvious that

$$\frac{\partial U(z)}{\partial z} = \frac{1}{v} \frac{\partial U(t)}{\partial t} .$$

Is important to note that very process of propagation in this case is obliged to the natural expansion of electric field and current in the line and it is subordinated to the rules of parametric self-induction. In the second place, for solving the wave equations of the long lines

$$\frac{\partial^2 U}{\partial z^2} = \frac{1}{v^2} \frac{\partial^2 U}{\partial t^2}$$

$$\frac{\partial^2 I}{\partial z^2} = \frac{1}{v^2} \frac{\partial^2 I}{\partial t^2} \qquad (2.2.6)$$

Obtained from the telegraphic equations

$$\frac{\partial U}{\partial z} = -L \frac{\partial I}{\partial t}$$

$$\frac{\partial I}{\partial z} = -C \frac{\partial U}{\partial t}$$

the knowledge second derivative voltages and currents are required.

But what is to be done, if to incoming line is supplied voltage, whose second derivative is equal to zero (case, when the voltage of source it does change according to the linear law)? Answer to this question equation (2.2.6) they do not give. The utilized method gives answer also to this question.

With the examination of processes in the long line figured such concepts as linear capacity and inductance, and also currents and voltage in the line. However, in the electrodynamics, based on Maxwell's equations, there are no such concepts as capacity and inductance, and there are concepts of the electrical and magnetic permeability of medium. In the carried out examination such concepts as electrical and magnetic fields also was absent. Let us show how to pass from such categories as linear inductance and capacity, current and voltage in the line to such concepts as dielectric and magnetic constant, and also electrical and magnetic field. For this let us take the simplest construction of line, located in the vacuum, as shown in Fig. 5.

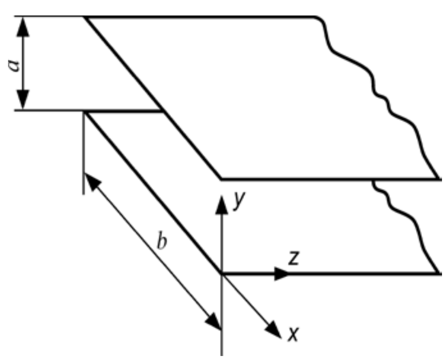

Fig. 5: The two-wire circuit, which consists of two ideally conducting planes

We will consider that $b >> a$ and edge effects it is possible not to consider. Then the following connection will exist between the linear parameters of line and the magnetic and dielectric constants:

$$L_0 = \mu_0 \frac{a}{b} , \qquad (2.2.7)$$

$$C_0 = \varepsilon_0 \frac{b}{a} \qquad (2.2.8)$$

where μ_0 , ε_0 - dielectric and magnetic constant of vacuum.

The phase speed in this line will be determined by the relationship:

$$v=\frac{1}{\sqrt{L_0C_0}}=\frac{1}{\sqrt{\mu_0\varepsilon_0}}=c\,,$$

where c - velocity of propagation of light in the vacuum. The wave drag of the line examined will be equal

$$Z=\frac{a}{b}\sqrt{\frac{\mu_0}{\varepsilon_0}}=\frac{a}{b}Z_0\,,$$

where $Z_0=\sqrt{\frac{\mu_0}{\varepsilon_0}}$ - wave drag of free space.

Moreover with the observance of the condition $a=b$ we obtain the equality $L_0=\mu_0$.

This means that magnetic permeability μ_0 plays the role of the longitudinal specific inductance of vacuum. In this case is observed also the equality $C_0 = \varepsilon_0$. This means that the dielectric constant ε_0 plays the role of the transverse specific capacity of vacuum. In this interpretation both μ_0 and ε_0 acquire clear physical sense and, just as in the long line, ensure the process of the propagation of electromagnetic wave in the free space.

The examination of electromagnetic wave in the long line can be considered as filling of space, which is been located between its conductors, special form of material, which present the electrical and magnetic fields. Mathematically it is possible to consider that these fields themselves possess specific energy and with their aid it is possible to transfer energy by the transmission lines. But if we examine the processes, which take place with the emission of electromagnetic waves with the aid of any antenna, then it is possible to examine also as the filling of free space with this form of material. However, pour on geometric form and currents in this case it will be more complexly, since they will always be present both transverse and longitudinal component pour on. This approach excludes the need for application, for describing the propagation of electromagnetic waves, this substance as ether.

If we to the examined line of infinite length, or of line of that loaded with wave drag, connect the dc power supply U, and then the field strength in the line will comprise:

$$E_y=\frac{U}{a}\,,$$

and the current, which flows into the line from the power source, will be determined by the relationship:

$$I=\frac{U}{Z}=\frac{aE_y}{Z} \qquad (2.2.9)$$

Magnetic field in the line will be equal to the specific current, flowing in the line

$$H_x=\frac{I}{b}=\frac{aE_y}{bZ}\,.$$

Substituting here the value Z, we obtain

$$H_x=\frac{E_y}{Z_0}\,. \qquad (2.2.10)$$

The same connection between the electrical and magnetic field exists also for the case of the transverse electromagnetic waves, which are extended in the free space.

Comparing expressions for the energies, it is easy to see that the specific energy can be expressed through the electrical and magnetic fields

$$\frac{1}{2}\mu_0 H_x{}^2=\frac{1}{2}\varepsilon_0 E_y{}^2. \qquad (2.2.11)$$

This means that the specific energy, accumulated in the magnetic and electric field in this line is identical. If the values of these energies are multiplied by the volumes, occupied by fields, then the obtained values coincide with expressions (2.2.3-2.2.4).

Thus, it is possible to make the conclusion that in the line examined are propagated the same transverse plane waves, as in the free space. Moreover this conclusion is obtained not by the method of solution of Maxwell's equations, but by the way of examining the dynamic processes, which are related to the discharge of parametric self-induction. The special feature of this line will be the fact that in it, in contrast to the free space, the stationary magnetic and electric fields can be extended, but this case cannot be examined by the method of solution of Maxwell's equations.

Cconsequently, conditionally it is possible to consider that the long line is the device, which with the connection to it of dc power supply is filled up with two forms of the energy: electrical and magnetic. The specific densities of these energies are equal, and since and electrical and magnetic energy fill identical volumes, the general energy, accumulated in these fields is identical. The special feature of this line is the fact that with the flow in the line of direct current the distribution of electrical and magnetic pour on in it is uniform. It is not difficult to show that the force, which acts on the conductors of this line, is equal to zero. This follows from relationship (2.2.11), in which its right and leftist of part present the force gradients, applied to the planes of line. But electrical and magnetic forces have different signs; therefore they compensate each other. This conclusion concerns the transmission lines of any other configuration.

If we to the line exert the voltage, which is changed in the course of time according to any law $U(t)=aE_y(t)$, the like of analogy (2.2.5) it is possible to write down

$$E_y(z)=E_y\left(t-\frac{z}{c}\right). \quad (2.2.12)$$

Analogous relationship will be also pouring on for the magnetic.

Is obvious that the work $I(t)U(t)$ represents the power P, transferred through the cross section of line in the direction z. If in this relationship current and voltage was replaced through the tensions of magnetic and electrical pour on, then we will obtain $P=abE_yH_x$. The work E_yH_x represents the absolute value of Pointing's vector, which represents the specific power, transferred through the cross section of the line of single area. Certainly, all these relationships can be written down also in the vector form.

Thas all conclusions, obtained on the basis of the examination of processes in the long line by two methods, coincide. Therefore subsequently, without risking committing the errors of fundamental nature, it is possible for describing the processes in the long lines successfully to use such parameters as the distributed inductance and capacity. Certainly, in this case one should understand that C_0 and this L_0 some integral characteristics, which do not consider structure, pour on. It should be noted that from a practical point of view, the application of the parameters C_0 and L_0 has important significance, since can be approximately solved the tasks, which with the aid of Maxwell's equations cannot be solved. This, for example, the case, when spirals are the conductors of transmission line.

II. New Approaches to Questions of Emission and Propagation of the Electromagnetic Waves

a) Dynamic potentials and the field of the moving charges

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 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 inflated 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 voltage 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.

Being located in assigned inertial frame of reference [IFR], we 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 [7-10]. The fields, which are created in this IFR 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 conversions of Lorenz. With the entire mathematical validity of this approach the physical essence of such conversions up to now remains unexplained.

In this division will made attempt find the precisely physically substantiated ways of obtaining the conversions pour on upon transfer of one IFR to another, and to also explain what dynamic potentials and fields can generate the moving charges. Next step, demonstrated in the works [11-15], was made in this direction a way of the introduction of the symmetrical laws of magneto electric and electromagnetic induction. These laws are written as follows:

$$\begin{aligned}\oint \vec{E}'dl' &= -\int \frac{\partial \vec{B}}{\partial t}d\vec{s} + \oint \left[\vec{v}\times\vec{B}\right]dl' \\ \oint \vec{H}'dl' &= \int \frac{\partial \vec{D}}{\partial t}d\vec{s} - \oint \left[\vec{v}\times\vec{D}\right]dl'\end{aligned}, \quad (3.1.1)$$

or

$$\begin{aligned}rot\vec{E}' &= -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v}\times\vec{B}\right] \\ rot\vec{H}' &= \frac{\partial \vec{D}}{dt} - rot\left[\vec{v}\times\vec{D}\right]\end{aligned}. \quad (3.1.2)$$

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

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$$\vec{E}' = \left[\vec{v}\times\vec{B}\right]$$
$$\vec{H}' = -\left[\vec{v}\times\vec{D}\right] \quad (3.1.3)$$

In relationships (3.1.1-3.1.3), which assume the validity of the conversions of Galilei prime and not prime values present fields and elements in moving and fixed IFR respectively. It must be noted, that conversions (3.1.3) earlier could be obtained only from the conversions of Lorenz.

Of relationships (3.1.1-3.1.3), which present the laws of induction, do not give information about how arose fields in initial fixed IFR. They describe only laws governing the propagation and conversion pour on in the case of motion with respect to the already existing fields.

Of relationship (3.1.3) attest to the fact that in the case of relative motion of frame of references, between the fields of $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e., motion in the fields of $\vec{H}$ 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 [16]. The electric field $E=\dfrac{g}{2\pi\varepsilon r}$ outside the charged long rod, per unit length of which there is a charge g, decreases according to the law $\dfrac{1}{r}$, where r is the distance from the central axis of the rod to the observation point.

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

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

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 $v_\perp$ - 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 [1-4]:

$$\varphi'(r,v_\perp)=\frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r}=\varphi(r)ch\frac{v_\perp}{c} \quad (3.1.4)$$

where $\varphi(r)$ - scalar potential of fixed charge.

The potential of 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 IFR as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then conversions pour on they will be written down:

$$\vec{E}'_\uparrow=\vec{E}_\uparrow,$$

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

$$\vec{H}'_\uparrow=\vec{H}_\uparrow,$$

$$\vec{H}'_\perp=\vec{H}_\perp ch\frac{v}{c}-\frac{1}{vZ_0}\left[\vec{v}\times\vec{E}_\perp\right]sh\frac{v}{c}, \quad (3.1.5)$$

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

Conversions pour on (3.1.5) they were for the first time obtained in the work [16-18] they are called Mende conversions.

b) Phase aberration and the transverse Doppler effect

Of the aid of relationships (3.1.5) 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 prime coordinate system in accordance with relationships (3.1.5) they will be written down:

$$E'_x = E_x,$$

$$E'_y = H_z sh\frac{v_x}{c},$$

$$H'_z = H_z ch\frac{v_x}{c}.$$

Thas 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 IFR:

$$E' = \left[\left(E'_x\right)^2 + \left(E'_y\right)^2 \right]^{\frac{1}{2}} = E_x ch\frac{v_x}{c}. \qquad (3.2.1)$$

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:

$$\alpha \cong sh\frac{v}{c} \cong \frac{v}{c} \qquad (3.2.2)$$

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 of Pointing 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 (3.2.2). 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 very vector of Pointing 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 (3.2.1).

Is not difficult to show that, if we the polarization of electromagnetic wave change ourselves, then result will remain before. Conversions with respect to the vectors $\vec{E}$ and $\vec{H}$ are completely symmetrical, only difference will be the fact that to now come out the wave, which has to appear addition in the direction of propagation in the component H'_y.

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 vector of Pointing to the angle, determined by relationship (3.2.2). 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 IFR it is necessary to incline telescope on the motion of motion to the angle, determined by relationship (3.2.2). 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 (3.2.2). But this means that this star with respect to the observer has a radial velocity component, determined by the relationship

$$v_r = v \sin\alpha,$$

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

$$\omega_{d\perp} = \omega_0 \frac{v^2}{c^2}. \qquad (3.2.3)$$

This result numerically coincides with results special theory of relativity (STR), but it is principally characterized by relaunch. Of results fact that it is considered into STR that the transverse Doppler effect, determined by relationship (3.2.3), there is in actuality, while in this case this only apparent effect. If we compare the results of conversions pour on (3.1.5) with conversions STR, then it is not difficult to see that they coincide with accuracy to the quadratic members of the ratio of the velocity of the motion of charge to the speed of light.

Of conversion STR, 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 (3.1.4) and (3.1.5) 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 (3.1.5) 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.

c) Laws of the electro-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 [19-20]:

$$\varphi(r,t)=\frac{g\ \ ch\dfrac{v_{\perp}\left(t-\dfrac{r}{c}\right)}{c}}{4\pi\ \varepsilon_0 r}, \qquad (3.3.1)$$

where $v_{\perp}\left(t-\dfrac{r}{c}\right)$ - component of the charge rate g, normal to the vector $\vec{r}$ at the moment of the time $t'=t-\dfrac{r}{c}$, r-the distance between the charge and the point at which the field is determined at the time t.

But does appear a question, on what bases, if we do not use Maxwell's 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 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 are late to the period $\dfrac{r}{c}$. The same delay we introduce in this case and for the scalar-vector potential, which is the carrier of electrical field.

Using relationship $\vec{E}=-grad\ \varphi(r,t)$, let us find field at point 1 (Fig. 6)

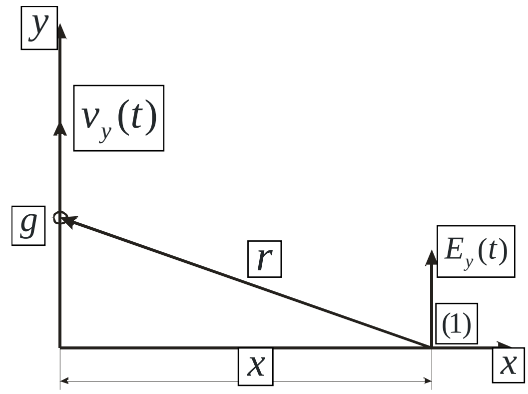

Fig. 6: Diagram of shaping of the induced electric field

The gradient of the numerical value of a radius of the vector of 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 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 is considered as the function of the position of observation point.
2) Observation point is fixed and $\vec{r}$ is considered as the function of the position of the point of source.

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:

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

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:

$$E_y(x,t)=-\frac{e}{4\pi\varepsilon_0 cx}\frac{\partial v_y\left(t-\dfrac{x}{c}\right)}{\partial y}sh\frac{v_y\left(t-\dfrac{x}{c}\right)}{c}, \qquad (3.3.2)$$

where x - some fixed point on the axis x.

Taking into account that

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

we obtain from (3.3.2):

$$E_y(x,t)=\frac{e}{4\pi\varepsilon_0 cx}\frac{1}{v_y\left(t-\frac{x}{c}\right)}\frac{\partial v_y\left(t-\frac{x}{c}\right)}{\partial t}sh\frac{v_y\left(t-\frac{x}{c}\right)}{c} \cdot \quad (3.3.3)$$

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 (3.3.3):

$$E_y(x,t)=-\frac{ea_y\left(t-\frac{x}{c}\right)}{4\pi\varepsilon_0 c^2 x} , \quad (3.3.4)$$

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 y the angle α, then relationship (3.3.4) takes the form:

$$E_y(x,t,\alpha)=-\frac{ea_y\left(t-\frac{x}{c}\right)\sin\alpha}{4\pi\varepsilon_0 c^2 x} . \quad (3.3.5)$$

Relationship (3.3.5) 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

$$\frac{ev_z\left(t-\frac{x}{c}\right)}{4\pi x}=A_H\left(t-\frac{x}{c}\right)$$

there is the being late vector potential, the relationship (3.3.5) can be rewritten

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

or

$$E_y(x,t,\alpha)=-\mu_0\frac{\partial A_H\left(t-\frac{x}{c}\right)}{\partial t} .$$

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 Maxwell's 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 (3.3.5). 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:

$$\vec{p}=e\vec{d} , \quad (3.3.6)$$

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

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

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 (3.3.5), we obtain the emission law of the being varied dipole.

$$\vec{E}=-\frac{1}{4\pi r\varepsilon_0 c^2}\frac{\partial^2 p(t-\frac{r}{c})}{\partial t^2} . \quad (3.3.7)$$

This is also very well-known relationship [21].

In the process of fluctuating the electric dipole are created the electric fields of two forms. Firs, these are the electrical induction fields of emission, represented by equations (3.3.4), (3.3.5) and (3.3.6), 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. However, the summary value of field, around this dipole defines as the superposition of those obtained pour on.

Laws (3.3.4), (3.3.5), (3.3.7) neither 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 (3.3.5) 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 (3.3.5). The superposition of electrical pour on, radiated by all charges, it is electrical wave.

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

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

Taking into account this relationship (18.5) assumes the form

$$E_y(x,t,\alpha) = \frac{e^2 \ \sin\alpha}{4\pi\varepsilon_0 c^2 mx} E'_{y0} \sin\omega(t - \frac{x}{c}) \,, \quad (3.3.8)$$

where the coefficient

$$K = \frac{e^2 \ \sin\alpha}{4\pi\varepsilon_0 c^2 m} \,,$$

where the coefficient of 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:

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

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

$$j_y(x,t) = -\frac{e^2 \omega}{4\pi c^2 mx} E'_{y0} \cos\omega\left(t - \frac{x}{c}\right) . \quad (3.3.9)$$

The sum wave, which presents the propagation of electrical pour on (3.3.8) and bias currents (3.3.9), can be named 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 firth time this term and definition of this wave was used in the works [2,3].

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

$$\vec{j} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = rot\vec{H} \,, \quad (3.3.10)$$

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

Introduced thus magnetic field is vortex. Comparing (3.3.9) and (3.3.10) 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

$$H_z(x,t) = \frac{e^2 \ \sin\alpha}{4\pi cmx} E'_{y0} \sin\omega\left(t - \frac{x}{c}\right) . \quad (3.3.11)$$

Thus, relationship (3.3.8), (3.3.9) and (3.3.11) 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 in the role of the transformer, which ensures this reradiation.

The magnetic field, which can be calculated with the aid of relationship (3.3.11), 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 o

$$Z = \frac{E_y}{H_z} = \frac{1}{\varepsilon_0 c} = \left(\frac{\mu_0}{\varepsilon_0}\right)^{\frac{1}{2}} ,$$

where Z - wave drag of free space.

Wave drag 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 current wave, crossing this area, transfers through it the power, determined by the data by relationship, which is located in accordance with by Pointing's theorem about the power flux of electromagnetic wave. Therefore, for finding all parameters, which characterize wave process, it is sufficient examination only of electric current 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

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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 vectorial field $\vec{F}$, which turns into zero at infinity, can be represented uniquely as the sum of the gradient of a certain scalar function φ and rotor of a certain vector function $\vec{C}$, whose divergence is equal to zero:

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

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

C 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 - vortex.

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 (3.3.1), which assumes the dependence of the scalar potential of charge on the speed, 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 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.

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