The material medium is differed from vacuum in terms of the fact that it consists of the connected or free charges. Pour on charges they begin to move during the imposition on this medium of electrical. But any charge has mechanical mass, and the presence of this mass affects the dynamics of its motion. From an electrodynamic point of view the calculation of the mass of charge in such processes can be taken into account by the way of the introduction of this concept as the kinetic inductance of charge. This parameter has the same important significance as the dielectric and magnetic constant of material media.

Fedor Mende

Kinetic inductance charges and its role in electrodynamics

Kinetic inductance charges has the same important significance as the dielectric and magnetic constant of material media

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978-3-659-58853-2

LAP LAMBERT Academic Publishing

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Impressum / Imprint
Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:
LAP LAMBERT Academic Publishing
ist ein Imprint der / is a trademark of
OmniScriptum GmbH & Co. KG
Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany
Email: info@lap-publishing.com

Herstellung: siehe letzte Seite /
Printed at: see last page
ISBN: 978-3-659-58853-2

Content

1. Introduction

By all is well known this phenomenon as rainbow. To any specialist in the electrodynamics it is clear that the appearance of rainbow is connected with the dependence on the frequency of the phase speed of the electromagnetic waves, passing through the drops of rain. Since water is dielectric, with the explanation of this phenomenon J. Heaviside and R. Vull assumed that this dispersion was connected with the frequency dispersion (dependence on the frequency) of the dielectric constant of water. Since then this point of view is ruling [1-6].

However very creator of the fundamental equations of the Maxwell electrodynamics considered that these parameters on frequency do not depend, but they are fundamental constants. As the idea of the dispersion of dielectric and magnetic constant was born, and what way it was past, sufficiently colorfully characterizes quotation from the monograph of well well-known specialists in the field of physics of plasma [1]: “Maxwell with the formulation of the equations of the electrodynamics of material media considered that the dielectric and magnetic constants are the constants (for this reason they long time they were considered as the constants). It is considerably later, already at the beginning of this century with the explanation of the optical dispersion phenomena (in particular the phenomenon of rainbow) J. Heaviside and R. Vull showed that the dielectric and magnetic constants are the functions of frequency. But very recently, in the middle of the 50's, physics they came to the conclusion that these values depend not only on frequency, but also on the wave vector. On the essence, this was the radical breaking of the existing ideas. It was how a serious, is characterized the case, which occurred at the seminar l. D. Landau into 1954 During the report A. I. Akhiezera on this theme of Landau suddenly exclaimed, after smashing the speaker: ” This is delirium, since the refractive index cannot be the function of refractive index”. Note that this said l. D. Landau - one of the outstanding physicists of our time”.

From the given quotation is incomprehensible, that precisely had in the form the author of these words. However, its subsequent publications speak, that it accepted this concept [2].

That rights there was Maxwell, who considered that the dielectric and magnetic constant of material media on frequency they do not depend. However, in a number of fundamental works on electrodynamics [2-6] are committed conceptual, systematic and physical errors, as a result of which in physics they penetrated and solidly in it were fastened such metaphysical concepts as the frequency dispersion of the dielectric constant of material media and, in particular, plasma. The propagation of this concept to the dielectrics led to the fact that all began to consider that also the dielectric constant of dielectrics also depends on frequency. These physical errors penetrated in all spheres of physics and technology. They so solidly took root in the consciousness of specialists, that many, until now, cannot believe in the fact that the dielectric constant of plasma is equal to the dielectric constant of vacuum, but the dispersion of the dielectric constant of dielectrics is absent. The difficulty of understanding these questions, first of all by physicists, is connected with those methods of teaching and those fundamental works, first of all l. D. Landau, which be the basis of these courses. Landau's itself, as can be seen from his works, was, first of all, mathematician. Its transactions are built in such a way that their basis is not physics, for describing laws of which is used mathematics, but mathematics, on basis of which are derived physical laws. Specifically, with this method was created the metaphysical concept of the dielectric constant of plasma depending on the frequency and this concept, without understanding of physics of processes, was disseminated by also purely mathematical means to the dielectrics. There is the publications of such well-known scholars as the Drudes, Vull, Heaviside, Landau, Ginsburg, Akhiezer, Tamm [1-6], where it is indicated that the dielectric constant of plasma and dielectrics depends on frequency. This is a systematic and physical error. This systematic and physical error became possible for that reason, that without the proper understanding of physics of the proceeding processes occurred the substitution of physical concepts by mathematical symbols, which appropriated physical, but are more accurate metaphysical, designations, which do not correspond to their physical sense.

2. **Kinetic inductance of conducting media**

By plasma media we will understand such, in which the charges can move without the losses. To such media in the first approximation, can be related the superconductors, free electrons or ions in the vacuum (subsequently conductors). In the absence magnetic field in the media indicated equation of motion for the electrons takes the form

$$m\frac{d\vec{v}}{dt} = e\vec{E}, \qquad (2.1)$$

where m - mass electron, e - electron charge, $\vec{E}$ - tension of electric field, $\vec{v}$ - speed of the motion of charge.

In this equation is considered that the electron charge is negative. In the work [6] it is shown that this equation can be used also for describing the electron motion in the hot plasma. Therefore it can be disseminated also to this case.

Using an expression for the current density

$$\vec{j} = ne\vec{v}, \qquad (2.2)$$

from (2.1) we obtain the current density of the conductivity

$$\vec{j}_L = \frac{ne^2}{m}\int \vec{E}\,dt\ . \qquad (2.3)$$

in relationship (2.1) and (2.3) the value n represents electron density. After introducing the designation

$$L_k = \frac{m}{ne^2} \qquad (2.4)$$

we find

$$\vec{j}_L = \frac{1}{L_k}\int \vec{E}\,dt\ . \qquad (2.5)$$

In this case the value L_k presents the specific kinetic inductance of charge carriers [7-10]. Its existence connected with the fact that charge, having a mass, possesses inertia properties. Pour on $\vec{E} = \vec{E}_0 \sin \omega t$ relationship (2.5) it will be written down for the case of harmonics

$$\vec{j}_L = -\frac{1}{\omega L_k} \vec{E}_0 \cos \omega t \ . \qquad (2.6)$$

For the mathematical description of electrodynamic processes the trigonometric functions will be here and throughout, instead of the complex quantities, used so that would be well visible the phase relationships between the vectors, which represent electric fields and current densities.

From relationship (2.5) and (2.6) is evident that $\vec{j}_L$ presents inductive current, since its phase is late with respect to the tension of electric field to the angle $\frac{\pi}{2}$.

If charges are located in the vacuum, then during the presence of summed current it is necessary to consider bias current

$$\vec{j}_\varepsilon = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} = \varepsilon_0 \vec{E}_0 \cos \omega t \, .$$

Is evident that this current bears capacitive nature, since its phase anticipates the phase of the tension of electrical to the angle $\frac{\pi}{2}$. Thus, summary current density will compose [8-10]

$$\vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E} \, dt \, ,$$

or

$$\vec{j}_\Sigma = \left(\omega \varepsilon_0 - \frac{1}{\omega L_k} \right) \vec{E}_0 \cos \omega t \, . \qquad (2.7)$$

If electrons are located in the material medium, then should be considered the presence of the positively charged ions. However, with the examination of the properties of such media in the rapidly changing fields, in connection with the fact that the mass of ions is considerably more than the mass of electrons, their presence usually is not considered.

In relationship (2.7) the value, which stands in the brackets, presents summary susceptance σ_Σ this medium and it consists it, in turn, of the capacitive σ_C and by the inductive σ_L the conductivity

$$\sigma_\Sigma = \sigma_C + \sigma_L = \omega\varepsilon_0 - \frac{1}{\omega L_k}.$$

Relationship (2.7) can be rewritten and differently

$$\vec{j}_\Sigma = \omega\varepsilon_0 \left(1 - \frac{\omega_0^2}{\omega^2}\right) \vec{E}_0 \cos\omega t ,$$

where $\omega_0 = \sqrt{\dfrac{1}{L_k \varepsilon_0}}$ - plasma frequency of Langmuir vibrations.

And large temptation here appears to name the value

$$\varepsilon^*(\omega) = \varepsilon_0 \left(1 - \frac{\omega_0^2}{\omega^2}\right) = \varepsilon_0 - \frac{1}{\omega^2 L_k},$$

by the depending on the frequency dielectric constant of plasma, that also is made in all existing works on physics of plasma. But this is incorrect, since this mathematical symbol is the composite parameter, into which simultaneously enters the dielectric constant of vacuum and the specific kinetic inductance of charges.

Let us introduce the determination of the concept of the dielectric constant of medium for the case of variables pour on for the purpose of further concrete definition of the study of the problems of dispersion.

If we examine any medium, including plasma, then current density (subsequently we will in abbreviated form speak simply current) it will be determined by three components, which depend on the electric field. The current of resistance losses there will be cophased to electric field. The permittance current, determined by first-order derivative of electric field from the time, will anticipate the tension of electric field on the phase $\frac{\pi}{2}$. This current is called bias current. The conduction current, determined by integral of the electric field from the time, will lag behind the electric field on the phase $\frac{\pi}{2}$. All three components of current indicated will enter into the second Maxwell equation and others components of currents be it cannot. Moreover all these three components of currents will be present in any nonmagnetic regions, in which there are losses. Therefore it is completely natural, the dielectric constant of any medium to define as the coefficient, confronting that term, which is determined by the derivative of electric field by the time in the second equation of Maxwell. In this case one should consider that the dielectric constant cannot be negative value. This connected with the fact that through this parameter is determined energy of electrical pour on, which can be only positive.

Without having introduced this clear determination of dielectric constant, [Landau] begins the examination of the behavior of plasma in the ac fields []. In this case it does not extract separately bias current and conduction current, one of which is determined by derivative, but by another integral, but is introduced the united coefficient, which unites these two currents, introducing the dielectric constant of plasma. It makes this error for that reason, that in the case of harmonic oscillations the form of the function, which determine and derivative and integral, is identical, and they are characterized by only sign. Performing this operation, Landau does not understand, that in the case of harmonic electrical pour on in the plasma there exist two different currents, one of which is bias current, and it is determined by the dielectric constant of vacuum and derivative of electric field. Another current is conduction current and is determined by integral of the electric field. these two currents are antiphase. But since both currents depend on frequency, moreover one of them depends on frequency linearly, and another it is inversely proportional to frequency, between them competition occurs. The conduction current predominates with the low frequencies, the bias current, on the contrary, predominates with the high. However, in the case of the equality of these currents, which occurs at the plasma frequency, occurs current resonance.

Let us emphasize that from a mathematical point of view to reach in the manner that it entered to Landau, it is possible, but in this case is lost the integration constant, which is necessary to account for initial conditions during the solution of the equation, which determines current density in the material medium.

is accurate another point of view. Relationship (2.7) can be rewritten and differently:

$$\vec{j}_{\Sigma} = -\frac{\left(\frac{\omega^2}{\omega_0^2} - 1\right)}{\omega L} \; \vec{E}_0 \cos \omega t$$

and to introduce another mathematical symbol

$$L^*(\omega) = \frac{L_k}{\left(\frac{\omega^2}{\omega_0^2} - 1\right)} = \frac{L_k}{\omega^2 L_k \varepsilon_0 - 1} \quad .$$

In this case also appears temptation to name this bending coefficient on the frequency kinetic inductance. But this value it is not possible to call inductance also, since this also the composite parameter, which includes those not depending on the frequency kinetic inductance and the dielectric constant of vacuum.

Thus, it is possible to write down

$$\vec{j}_{\Sigma} = \omega \varepsilon^*(\omega) \; \vec{E}_0 \cos \omega t ,$$

or

$$\vec{j}_{\Sigma} = -\frac{1}{\omega L^*(\omega)} \; \vec{E}_0 \cos \omega t \quad .$$

But this altogether only the symbolic mathematical record of one and the same relationship (2.7). Both equations are equivalent. But view neither $\varepsilon^*(\omega)$ nor

$L^*(\omega)$ by dielectric constant or inductance are from a physical point. The physical sense of their names consists of the following

$$\varepsilon^*(\omega) = \frac{\sigma_X}{\omega} \ ,$$

i.e. $\varepsilon^*(\omega)$ presents summary susceptance of medium, divided into the frequency, and

$$L_k^*(\omega) = \frac{1}{\omega\sigma_X}$$

it represents the reciprocal value of the work of frequency and susceptance of medium.

As it is necessary to enter, if at our disposal are values $\varepsilon^*(\omega)$ and $L^*(\omega)$, and we should calculate total specific energy. Natural to substitute these values in the formulas, which determine energy of electrical pour on

$$W_E = \frac{1}{2}\varepsilon_0 E_0^2$$

and kinetic energy of charge carriers

$$W_j = \frac{1}{2}L_k j_0^2 \qquad (2.8)$$

is cannot simply because these parameters are neither dielectric constant nor inductance. It is not difficult to show that in this case the total specific energy can be obtained from the relationship

$$W_\Sigma = \frac{1}{2}\cdot\frac{d\left(\omega\varepsilon^*(\omega)\right)}{d\omega}E_0^2 \qquad (2.9)$$

from where we obtain

$$W_\Sigma = \frac{1}{2}\varepsilon_0 E_0^2 + \frac{1}{2}\ \frac{1}{\omega^2 L_k}\ E_0^2 = \frac{1}{2}\varepsilon_0 E_0^2 + \frac{1}{2}L_k j_0^2 \ .$$

We will obtain the same result, after using the formula

$$W = \frac{1}{2}\,\frac{d\left[\dfrac{1}{\omega L_k{}^*(\omega)}\right]}{d\omega}\,E_0^2 .$$

The given relationships show that the specific energy consists of potential energy of electrical pour on and to kinetic energy of charge carriers.

With the examination of any media by our final task appears the presence of wave equation. In this case this problem is already practically solved.

Maxwell equations for this case take the form

$$\begin{gathered} rot\ \vec{E} = -\mu_0 \frac{\partial\,\vec{H}}{\partial\,t}, \\ rot\ \vec{H} = \varepsilon_0 \frac{\partial\,\vec{E}}{\partial\,t} + \frac{1}{L_k}\int \vec{E}\,dt, \end{gathered} \qquad (2.10)$$

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

The system of equations (2.10) completely describes all properties of nondissipative conductors. From it we obtain

$$rot\ rot\ \vec{H} + \mu_0\varepsilon_0 \frac{\partial^2\vec{H}}{\partial\,t^2} + \frac{\mu_0}{L_k}\vec{H} = 0 . \qquad (2.11)$$

For the case pour on, time-independent, equation (2.11) passes into London equation

$$rot\ rot\ \vec{H} + \frac{\mu_0}{L_k}\vec{H} = 0\ ,$$

where $\lambda_L{}^2 = \frac{L_k}{\mu_0}$ - London depth of penetration.

Thus, it is possible to conclude that London equations being a special case of equation (2.11), and do not consider bias currents on the medium. Therefore they do not give the possibility to obtain the wave equations, which describe the processes of the propagation of electromagnetic waves in the superconductors.

Pour on wave equation in this case it appears as follows for the electrical:

$$rot\ rot\ \vec{E} + \mu_0 \varepsilon_0 \frac{\partial^2 \vec{E}}{\partial\, t^2} + \frac{\mu_0}{L_k} \vec{E} = 0 .$$

For constant electrical pour on it is possible to write down

$$rot\ rot\ \vec{E} + \frac{\mu_0}{L_k} \vec{E} = 0 .$$

Consequently dc fields penetrate the superconductor in the same manner as for magnetic, diminishing exponentially. However, the density of current in this case grows according to the linear law

$$\vec{j}_L = \frac{1}{L_k} \int \vec{E}\, dt .$$

The carried out examination showed that the dielectric constant of this medium was equal to the dielectric constant of vacuum and this permeability on frequency does not depend. The accumulation of potential energy is obliged to this parameter. Furthermore, this medium is characterized still and the kinetic inductance of charge carriers and this parameter determines the kinetic energy.

Thus, are obtained all necessary given, which characterize the process of the propagation of electromagnetic waves in conducting media examined. However, in contrast to the conventional procedure [2-4] with this examination nowhere was introduced polarization vector, but as the basis of examination assumed equation of motion and in this case in the second Maxwell equation are extracted all components of current densities explicitly.

This examination showed not only that the fact that the frequency dispersion of dielectric constant in conductors is absent, but also that which for the correct description of their physical properties is necessary of the application of a concept of the kinetic inductance of charges.

In radio engineering exists the simple method of the idea of radio-technical elements with the aid of the equivalent diagrams. This method is very visual and gives the possibility to present in the form such diagrams elements both with that concentrated and with the distributed parameters. The use of this method will make it possible better to understand, why were committed such significant physical errors during the introduction of the concept of that depending on the frequency dielectric constant.

In order to show that the single volume of conductor or plasma according to its electrodynamic characteristics is equivalent to parallel resonant circuit with the lumped parameters, let us examine parallel resonant circuit. The connection between the voltage U, applied to the outline, and the summed current I_Σ, which flows through this chain, takes the form

$$I_\Sigma = I_C + I_L = C\frac{dU}{dt} + \frac{1}{L}\int U\ dt\,,$$

where $I_C = C\frac{dU}{dt}$ - current, which flows through the capacity, and $I_L = \frac{1}{L}\int U\ dt$ - current, which flows through the inductance.

For the case of the harmonic stress $U = U_0 \sin\omega t$ we obtain

$$I_\Sigma = \left(\omega C - \frac{1}{\omega L}\right)\ U_0 \cos\omega t\,. \tag{2.12}$$

In relationship (2.12) the value which stands in the brackets presents summary susceptance of this medium σ_Σ and it consists the capacitive σ_C and the inductive σ_L of the conductivity

$$\sigma_\Sigma = \sigma_C + \sigma_L = \omega C - \frac{1}{\omega L}\,.$$

In this case relationship (2.5) can be rewritten as follows

$$I_\Sigma = \omega C\left(1 - \frac{\omega_0^2}{\omega^2}\right)\ U_0 \cos\omega t\,,$$

where $\omega_0{}^2 = \frac{1}{LC}$ - resonance frequency of parallel circuit.

And here, just as in the case of conductors, appears temptation, to name the value

$$C^*(\omega) = C\left(1 - \frac{\omega_0^2}{\omega^2}\right) = C - \frac{1}{\omega^2 L} \tag{2.13}$$

by the depending on the frequency capacity. Conducting this symbol it is permissible from a mathematical point of view however inadmissible is awarding to it the proposed name, since. this parameter of no relation to the true capacity has and includes in itself simultaneously and capacity and the inductance of outline, which do not depend on frequency.

Is accurate another point of view. Relationship (2.12) can be rewritten and differently

$$I_\Sigma = -\frac{\left(\frac{\omega^2}{\omega_0^2} - 1\right)}{\omega L}\; U_0 \cos \omega t\,,$$

and to consider that the chain in question not at all has capacities, and consists only of the inductance depending on the frequency

$$L^*(\omega) = \frac{L}{\left(\frac{\omega^2}{\omega_0^2} - 1\right)} = \frac{L}{\omega^2 LC - 1}\,. \tag{2.14}$$

$C^*(\omega)$, the value $L^*(\omega)$ cannot be called inductance, since this is the also composite parameter, which includes simultaneously capacity and inductance, which do not depend on frequency.

Using expressions (2.13) and (2.14), let us write down

$$I_\Sigma = \omega C^*(\omega)\; U_0 \cos \omega t \tag{2.15}$$

or

$$I_\Sigma = -\frac{1}{\omega L^*(\omega)}\; U_0 \cos \omega t\,. \tag{2.16}$$

Relationship (6.15) and (6.16) are equivalent, and separately mathematically completely is characterized the chain examined. But view neither $C^*(\omega)$nor

$L^*(\omega)$ by capacity and inductance are from a physical point, although they have the same dimensionality. The physical sense of their names consists of the following

$$C^*(\omega) = \frac{\sigma_X}{\omega},$$

i.e. $C^*(\omega)$ presents the relation of susceptance of this chain and frequency, and

$$L^*(\omega) = \frac{1}{\omega\sigma_X},$$

it is the reciprocal value of the work of summary susceptance and frequency.

Accumulated in the capacity and the inductance energy, is determined from the relationships

$$W_C = \frac{1}{2}CU_0^2, \tag{2.17}$$

$$W_L = \frac{1}{2}LI_0^2. \tag{2.18}$$

How one should enter for enumerating the energy, which was accumulated in the outline, if at our disposal are $C^*(\omega)$ and $L^*(\omega)$? Certainly, to put these relationships in formulas (2.17) and (2.18) cannot for that reason, that these values can be both the positive and negative, and the energy, accumulated in the capacity and the inductance, is always positive. But if we for these purposes use ourselves the parameters indicated, then it is not difficult to show that the summary energy, accumulated in the outline, is determined by the expressions:

$$W_\Sigma = \frac{1}{2}\,\frac{d\sigma_X}{d\omega}\,U_0^2, \tag{2.19}$$

or

$$W_\Sigma = \frac{1}{2}\,\frac{d\left[\omega C^*(\omega)\right]}{d\omega}\,U_0^2 \tag{2.20}$$

or

$$W_{\Sigma} = \frac{1}{2}\,\frac{d\left(\dfrac{1}{\omega L^{*}(\omega)}\right)}{d\omega}\,U_0^{\,2}. \tag{2.21}$$

If we paint equations (2.19) or (2.20) and (2.21), then we will obtain identical result, namely

$$W_{\Sigma} = \frac{1}{2}CU_0^{\,2} + \frac{1}{2}LI_0^{\,2},$$

where U_0 - amplitude of voltage on the capacity, and I_0- amplitude of the current, which flows through the inductance.

If we compare the relationships, obtained for the parallel resonant circuit and for the conductors, then it is possible to see that they are identical, if we make $E_0 \to U_0$, $j_0 \to I_0, \varepsilon_0 \to C$, $L_k \to L$. Thus, the single volume of conductor, with the uniform distribution of electrical pour on and current densities in it, it is equivalent to parallel resonant circuit with the lumped parameters indicated. In this case the capacity of this outline is numerically equal to the dielectric constant of vacuum, and inductance is equal to the specific kinetic inductance of charges.

A now let us visualize this situation. In the audience, where are located specialists, who know radio engineering and of mathematics, comes instructor and he begins to prove, that there are in nature of no capacities and inductances, and there is only depending on the frequency capacity and that just she presents parallel resonant circuit. Or, on the contrary, that parallel resonant circuit this is the depending on the frequency inductance. View of mathematics will agree from this point. However, radio engineering they will calculate lecturer by man with the very limited knowledge. Specifically, in this position proved to be now those scientists and the specialists, who introduced into physics the frequency dispersion of dielectric constant.

Thus, are obtained all necessary given, which characterize the process of the propagation of electromagnetic waves in the media examined, and it is also shown that in the quasi-static regime the electrodynamic processes in the conductors are similar to processes in the parallel resonant circuit with the lumped parameters. However, in contrast to the conventional procedure [2-5] with this examination nowhere was introduced polarization vector, but as the basis of examination assumed equation of motion and in this case in the second equation of Maxwell are extracted all components of current densities explicitly.

Based on the example of work [2] let us examine a question about how similar problems, when the concept of polarization vector is introduced are solved for their solution. Paragraph 59 of this work, where this question is examined, it begins with the words: "We pass now to the study of the most important question about the rapidly changing electric fields, whose frequencies are unconfined by the condition of smallness in comparison with the frequencies, characteristic for establishing the electrical and magnetic polarization of substance" (end of the quotation). These words mean that that region of the frequencies, where, in connection with the presence of the inertia properties of charge carriers, the polarization of substance will not reach its static values, is examined. With the further consideration of a question is done the conclusion that "in any variable field, including with the presence of dispersion, the polarization vector $\vec{P} = \vec{D} - \varepsilon_0 \vec{E}$ (here and throughout all formulas cited they are written in the system SI) preserves its physical sense of the electric moment of the unit volume of substance" (end of the quotation). Let us give the still one quotation: "It proves to be possible to establish (unimportantly - metals or dielectrics) maximum form of the function $\varepsilon(\omega)$ with the high frequencies valid for any bodies. Specifically, the field frequency must be great in comparison with "the frequencies" of the motion of all (or, at least, majority) electrons in the atoms of this substance. With the observance of this condition it is possible with the calculation of the polarization of substance to consider electrons as free, disregarding their interaction with each other and with the atomic nuclei" (end of the quotation).

Further, as this is done and in this work, is written the equation of motion of free electron in the ac field

$$m\frac{d\vec{v}}{dt}=e\vec{E},$$

from where its displacement is located

$$\vec{r}=-\frac{e\vec{E}}{m\omega^2}.$$

Then is indicated that the polarization $\vec{P}$ is a dipole moment of unit volume and the obtained displacement is put into the polarization

$$\vec{P}=ne\vec{r}=-\frac{ne^2\vec{E}}{m\omega^2}.$$

In this case point charge is examined, and this operation indicates the introduction of electrical dipole moment for two point charges with the opposite signs, located at a distance $\vec{r}$

$$\vec{p}_e=-e\vec{r},$$

where vector $\vec{r}$ is directed from the negative charge toward the positive charge. This step causes bewilderment, since the point electron is examined, and in order to speak about the electrical dipole moment, it is necessary to have in this medium for each electron another charge of opposite sign, referred from it to the distance $\vec{r}$. In this case is examined the gas of free electrons, in which there are no charges of opposite signs. Further follows the standard procedure, when introduced thus illegal polarization vector is introduced into the dielectric constant

$$\vec{D}=\varepsilon_0\vec{E}+\vec{P}=\varepsilon_0\vec{E}-\frac{ne^2\vec{E}}{m\omega^2}=\varepsilon_0\left(1-\frac{1}{\varepsilon_0 L_k\omega^2}\right)\vec{E},$$

and since plasma frequency is determined by the relationship

$$\omega_p{}^2=\frac{1}{\varepsilon_0 L_k},$$

the vector of the induction immediately is written

$$\vec{D} = \varepsilon_0 \left(1 - \frac{\omega_p{}^2}{\omega^2} \right) \vec{E}.$$

With this approach it turns out that constant of proportionality

$$\varepsilon(\omega) = \varepsilon_0 \left(1 - \frac{\omega_p{}^2}{\omega^2} \right),$$

between the electric field and the electrical induction, illegally named dielectric constant, depends on frequency.

Precisely this approach led to the fact that all began to consider that the value, which stands in this relationship before the vector of electric field, is the dielectric constant depending on the frequency, and electrical induction also depends on frequency. And this it is discussed in all, without the exception, fundamental works on the electrodynamics of material media [2-6].

But, as it was shown above this parameter it is not dielectric constant, but presents summary susceptance of medium, divided into the frequency. Thus, traditional approach to the solution of this problem from a physical point of view is erroneous, although formally this approach is permitted from a mathematical point of view. With this approach to consider initial conditions with the calculation of integral in the relationships, which determine conduction current.

Further into §61 of work [2] is examined a question about the energy of electrical and magnetic field in the media, which possess by the so-called dispersion. In this case is done the conclusion that relationship for the energy of such pour on

$$W = \frac{1}{2}\left(\varepsilon E_0{}^2 + \mu H_0{}^2 \right), \tag{2.22}$$

that making precise thermodynamic sense in the usual media, with the presence of dispersion so interpreted be cannot. These words mean that the knowledge of real electrical and magnetic pour on on Wednesday with the dispersion insufficiently for determining the difference in the internal energy per unit of volume of substance in the presence pour on in their absence. After such statements is given the formula, which gives correct result for enumerating the specific energy of electrical and magnetic pour on when present the dispersion

$$W = \frac{1}{2}\frac{d\left(\omega\varepsilon(\omega)\right)}{d\omega}E_0^2 + \frac{1}{2}\frac{d\left(\omega\mu(\omega)\right)}{d\omega}H_0^2 . \qquad (2.23)$$

But if we compare the first part of the expression in the right side of relationship (2.23) with relationship (2.9), then it is evident that they coincide. This means that in relationship (2.23) this term presents the total energy, which includes not only potential energy of electrical pour on, but also kinetic energy of the moving charges. Therefore conclusion about the impossibility of the interpretation of formula (2.22), as the internal energy of electrical and magnetic pour on in the media with the dispersion it is correct. However, this circumstance consists not in the fact that this interpretation in such media is generally impossible. It consists in the fact that for the definition of the value of specific energy as the thermodynamic parameter in this case is necessary to correctly calculate this energy, taking into account not only electric field, which accumulates potential energy, but also current of the conduction electrons, which accumulate the kinetic kinetic energy of charges (6.8). The conclusion, which now can be made, consists in the fact that, introducing into the custom some mathematical symbols, without understanding of their true physical sense, and, all the more, the awarding to these symbols of physical designations unusual to them, it is possible in the final analysis to lead to the significant errors.

Let us focus attention on the fact that with the examination of this question, which gives complete information about the electrodynamic processes, proceeding in the conductors, we used only equations of motion and did not adapt the concept of polarization vector.

3. Transverse plasma resonance

Now let us show how the poor understanding of physics of processes in conducting media it led to the fact that proved to be unnoticed the interesting physical phenomenon transverse plasma resonance in the nonmagnetized plasma.This phenomenon can have important technical appendices [11].

Is known that the plasma resonance is longitudinal. But longitudinal resonance cannot emit transverse electromagnetic waves. However, with the explosions of nuclear charges, as a result of which is formed very hot plasma, occurs electromagnetic radiation in the very wide frequency band, up to the long-wave radio-frequency band. Today are not known those of the physical mechanisms, which could explain the appearance of this emission. On existence in the nonmagnetized plasma of any other resonances, except Langmuir, earlier known it was not, but it occurs that in the confined plasma the transverse resonance can exist, and the frequency of this resonance coincides with the frequency of Langmuir resonance, i.e., these resonances are degenerate. Specifically, this resonance can be the reason for the emission of electromagnetic waves with the explosions of nuclear charges.

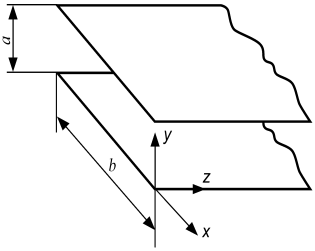

Fig. 1. The two-wire circuit, which consists of two ideally conducting planes.

For explaining the conditions for the excitation of this resonance let us examine the long line, which consists of two ideally conducting planes, as shown in Fig.

Linear (falling per unit of length) capacity and inductance of this line without taking into account edge effects they are determined by the relationships [8,9]

$$C_0 = \varepsilon_0 \frac{b}{a} \text{ and } L_0 = \mu_0 \frac{a}{b}$$

Therefore with an increase in the length of line its total capacitance $C_\Sigma = \varepsilon_0 \frac{b}{a} z$ and summary inductance $L_\Sigma = \mu_0 \frac{a}{b} z$ increase proportional to its length.

If we into the extended line place the plasma, charge carriers in which can move without the losses, and in the transverse direction pass through the plasma the current I, then charges, moving with the definite speed, will accumulate kinetic energy. Let us note that here are not examined technical questions, as and it is possible confined plasma between the planes of line how. In this case only fundamental questions, which are concerned transverse plasma resonance in the nonmagnetic plasma, are examined.

Since the transverse current density in this line is determined by the relationship

$$j = \frac{I}{bz} = nev,$$

that summary kinetic energy of the moving charges can be written down

$$W_{k\Sigma} = \frac{1}{2}\ \frac{m}{ne^2}\ abzj^2 = \frac{1}{2}\ \frac{m}{ne^2}\ \frac{a}{bz} I^2. \tag{3.1}$$

Relationship (3.1) connects the kinetic energy, accumulated in the line, with the square of current, therefore the coefficient, which stands in the right side of this relationship before the square of current, is the summary kinetic inductance of line.

$$L_{k\Sigma} = \frac{m}{ne^2} \cdot \frac{a}{bz}. \tag{3.2}$$

Thus, the value

$$L_k = \frac{m}{ne^2} \tag{3.3}$$

presents the specific kinetic inductance of charges. This value was already previously introduced by another method (see relationship (2.4)). Relationship (3.3) is obtained for the case of the direct current, when current distribution is uniform.

subsequently for the larger clarity of the obtained results, together with their mathematical idea, we will use the method of equivalent diagrams. The section, the lines examined, long dz can be represented in the form the equivalent diagram, shown in Fig. 2 (a).

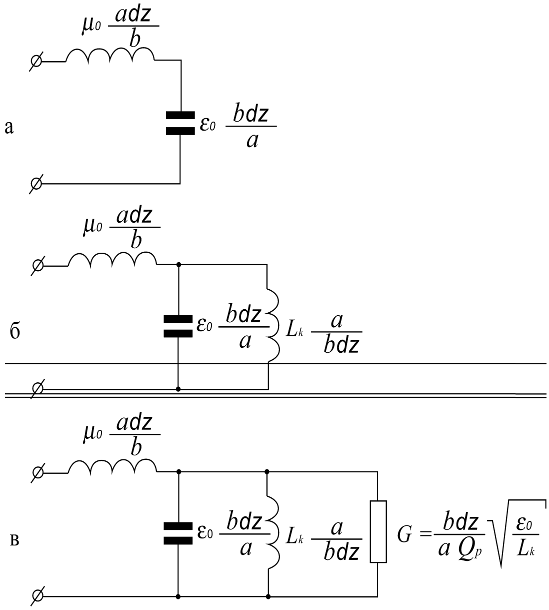

Fig. 2.

a - the equivalent the schematic of the section of the two-wire circuit,

б - the equivalent the schematic of the section of the two-wire circuit, filled with nondissipative plasma,

в - the equivalent the schematic of the section of the two-wire circuit, filled with dissipative plasma.

From relationship (3.2) is evident that in contrast to C_Σ and L_Σ the value $L_{k\Sigma}$ with an increase in z does not increase, but it decreases. Connected this with the fact that with an increase in z a quantity of parallel-connected inductive elements grows.

The equivalent the schematic of the section of the line, filled with nondissipative plasma, it is shown in Fig. 2(б). Line itself in this case will be equivalent to parallel circuit with the lumped parameters

$$C = \frac{\varepsilon_0 bz}{a},$$

$$L = \frac{L_k a}{bz},$$

in series with which is connected the inductance

$$\mu_0 \frac{adz}{b}.$$

But if we calculate the resonance frequency of this outline, then it will seem that this frequency generally not on what sizes depends, actually

$$\omega_\rho^2 = \frac{1}{CL} = \frac{1}{\varepsilon_0 L_k} = \frac{ne^2}{\varepsilon_0 m}.$$

Is obtained the very interesting result, which speaks that the resonance frequency macroscopic of the resonator examined does not depend on its sizes. Impression can be created, that this is plasma resonance, since. the obtained value of resonance frequency exactly corresponds to the value of this resonance. But it is known that the plasma resonance characterizes longitudinal waves in the long line they, while occur transverse waves. In the case examined the value of the phase speed in the direction of z is equal to infinity and the wave vector $\vec{k} = 0$.

This result corresponds to the solution of system of equations (2.10) for the line with the assigned configuration. In this case the wave number is determined by the relationship:

$$k_z^2 = \frac{\omega^2}{c^2}\left(1 - \frac{\omega_\rho^2}{\omega^2}\right) \qquad (3.4)$$

and the group and phase speeds

$$v_g^2 = c^2\left(1 - \frac{\omega_\rho^2}{\omega^2}\right) \qquad (3.5)$$

$$v_F^2 = \frac{c^2}{\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)} \qquad (3.6)$$

where $c = \left(\frac{1}{\mu_0 \varepsilon_0}\right)^{1/2}$ - speed of light in the vacuum.

For the present instance the phase speed of electromagnetic wave is equal to infinity, which corresponds to transverse resonance at the plasma frequency. Consequently, at each moment of time pour on distribution and currents in this line uniform and it does not depend on the coordinate z , but current in the planes of line in the direction of is absent. This, from one side, it means that the inductance L_Σ will not have effects on electrodynamic processes in this line, but instead of the conducting planes can be used any planes or devices, which limit plasma on top and from below.

From relationships (3.4), (3.5) and (3.6) is evident that at the point $\omega = \omega_p$ occurs the transverse resonance with the infinite quality. With the presence of losses in the resonator will occur the damping, and in the long line in this case $k_z \neq 0$, and in the line will be extended the damped transverse wave, the direction of propagation of which will be normal to the direction of the motion of charges. It should be noted that the fact of existence of this resonance is not described by other authors.

Before to pass to the more detailed study of this problem, let us pause at the energy processes, which occur in the line in the case of the absence of losses examined.

Pour on the characteristic impedance of plasma, which gives the relation of the transverse components of electrical and magnetic, let us determine from the relationship

$$Z = \frac{E_y}{H_x} = \frac{\mu_0 \omega}{k_z} = Z_0 \left(1 - \frac{\omega_\rho^2}{\omega^2}\right)^{-1/2} ,$$

where $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}}$ - characteristic resistance of vacuum.

The obtained value Z is characteristic for the transverse electrical waves in the waveguides. It is evident that when $\omega \to \omega_p$, then $Z \to \infty$, and $H_x \to 0$. When $\omega > \omega_p$ in the plasma there is electrical and magnetic component of field. The specific energy of these fields on it will be written down

$$W_{E,H} = \frac{1}{2}\varepsilon_0 E_{0y}^2 + \frac{1}{2}\mu_0 H_{0x}^2$$

Thus, the energy, concluded in the magnetic field, in $\left(1 - \frac{\omega_\rho^2}{\omega^2}\right)$ of times is less than the energy, concluded in the electric field. Let us note that this examination, which is traditional in the electrodynamics, is not complete, since. in this case is not taken into account one additional form of energy, namely kinetic energy of charge carriers. Occurs that pour on besides the waves of electrical and magnetic, that carry electrical and magnetic energy, in the plasma there exists even and the third - kinetic wave, which carries kinetic energy of current carriers. The specific energy of this wave is written

$$W_k = \frac{1}{2} L_k j_0^2 = \frac{1}{2} \cdot \frac{1}{\omega^2 L_k} E_0^2 = \frac{1}{2} \varepsilon_0 \frac{\omega_\rho^2}{\omega^2} E_0^2 .$$

Thus, total specific energy is written as

$$W_{E,H,j} = \frac{1}{2} \varepsilon_0 E_{0y}^2 + \frac{1}{2} \mu_0 H_{0x}^2 + \frac{1}{2} L_k j_0^2 \ .$$

Thus, for finding the total energy, by the prisoner per unit of volume of plasma, calculation only fields E and H it is insufficient.

At the point $\omega = \omega_p$ are carried out the relationship

$$W_H = 0$$

$$W_E = W_k$$

I.e. magnetic field in the plasma is absent, and plasma presents macroscopic electromechanical resonator with the infinite quality, ω_p resounding at the frequency.

Since with the frequencies $\omega > \omega_p$ the wave, which is extended in the plasma, it bears on itself three forms of the energy: electrical, magnetic and kinetic, then this wave can be named elektromagnetokinetic wave. Kinetic wave is the wave of the current density $\vec{j} = \frac{1}{L_k} \int \vec{E}\, dt$. This wave is moved with respect to the electrical wave the angle $\frac{\pi}{2}$.

If losses are located, moreover completely it does not have value, by what physical processes such losses are caused, then the quality of plasma resonator will be finite quantity. For this case of Maxwell equation they will take the form

$$\begin{aligned} rot\ \vec{E} &= -\mu_0 \frac{\partial \vec{H}}{\partial t}, \\ rot\ \vec{H} &= \sigma_{p.ef}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt. \end{aligned} \qquad (3.7)$$

The presence of losses is considered by the term $\sigma_{p.ef}\vec{E}$, and, using near the conductivity of the index ef, it is thus emphasized that us does not interest very mechanism of losses, but only very fact of their existence interests. The value σ_{ef} determines the quality of plasma resonator. For measuring σ_{ef} should be selected the section of line by the length of z_0, whose value is considerably lower than the wavelength in the plasma. This section will be equivalent to outline with the lumped parameters

$$C = \varepsilon_0 \frac{bz_0}{a}, \tag{3.8}$$

$$L = L_k \frac{a}{bz_0}, \tag{3.9}$$

$$G = \sigma_{\rho.ef} \frac{bz_0}{a}, \tag{3.10}$$

where G - conductivity, connected in parallel C and L.

Conductivity and quality in this outline enter into the relationship:

$$G = \frac{1}{Q_\rho}\sqrt{\frac{C}{L}},$$

from where, taking into account (3.8 - 3.10), we obtain

$$\sigma_{\rho.ef} = \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}. \tag{3.11}$$

Thus, measuring its own quality plasma of the resonator examined, it is possible to determine $\sigma_{p.ef}$. Using (3.2) and (3.11) we will obtain

$$\begin{aligned} rot\ \vec{E} &= -\mu_0 \frac{\partial\, \vec{H}}{\partial\, t}, \\ rot\ \vec{H} &= \frac{1}{Q_\rho}\sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial\, \vec{E}}{\partial\, t} + \frac{1}{L_k}\int \vec{E}\, dt. \end{aligned} \tag{3.12}$$

The equivalent the schematic of this line, filled with dissipative plasma, is represented in Fig. 2 (в).

Let us examine the solution of system of equations (3.12) at the point $\omega = \omega_p$, in this case, since

$$\varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt = 0,$$

we obtain

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

$$rot\ \vec{H} = \frac{1}{Q_P} \sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E}.$$

These relationships determine wave processes at the point of resonance.

If losses in the plasma, which fills line are small, and strange current source is connected to the line, then it is possible to assume

$$\begin{gathered} rot\ \vec{E} \cong 0, \\ \frac{1}{Q_p} \sqrt{\frac{\varepsilon_0}{L_k}}\ \vec{E} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E}\, dt = \vec{j}_{CT}, \end{gathered} \tag{3.13}$$

where $\vec{j}_{CT}$ - density of strange currents.

After integrating (3.13) with respect to the time and after dividing both parts to ε_0, we will obtain

$$\omega_p^2\, \vec{E} + \frac{\omega_p}{Q_p} \cdot \frac{\partial \vec{E}}{\partial t} + \frac{\partial^2 \vec{E}}{\partial t^2} = \frac{1}{\varepsilon_0} \cdot \frac{\partial \vec{j}_{CT}}{\partial t}. \tag{3.14}$$

If we relationship (3.14) integrate over the surface of normal to the vector $\vec{E}$ and to introduce the electric flux $\Phi_E = \int \vec{E} d\vec{S}$, we will obtain

$$\omega_p^2 \Phi_E + \frac{\omega_p}{Q_p} \cdot \frac{\partial \Phi_E}{\partial t} + \frac{\partial^2 \Phi_E}{\partial t^2} = \frac{1}{\varepsilon_0} \cdot \frac{\partial I_{CT}}{\partial t} \tag{3.15}$$

where I_{CT} - strange current.

Equation (3.15) is the equation of harmonic oscillator with the right side, characteristic for the two-level laser [12]. If the source of excitation was opened, then relationship (3.14) presents "cold" laser resonator, in which the fluctuations will attenuate exponentially

$$\Phi_E(t) = \Phi_E(0)\ e^{i\omega_P t} \cdot e^{-\frac{\omega_P}{2Q_P}t} ,$$

i.e. the macroscopic electric flux of $\Phi_E(t)$ will oscillate with the frequency ω_p, relaxation time in this case is determined by the relationship

$$\tau = \frac{2Q_P}{\omega_P} .$$

The problem of developing of laser consists to now only in the skill excite this resonator.

If resonator is excited by strange currents, then this resonator presents band-pass filter with the resonance frequency to equal plasma frequency and the passband $\Delta\omega = \dfrac{\omega_p}{2Q_p}$.

Another important practical application of transverse plasma resonance is possibility its use for warming-up and diagnostics of plasma. If the quality of plasma resonator is great, then can be obtained the high levels of electrical pour on, and it means high energies of charge carriers.

4. Kinetic capacity

If we consider all components of current density in the conductor, then the second equation of Maxwell can be written down

$$rot\vec{H} = \sigma_E \vec{E} + \varepsilon \frac{\partial \vec{E}}{\partial t} + \frac{1}{L_k} \int \vec{E} dt, \tag{4.1}$$

where σ_E - conductivity of metal.

At the same time, the first equation of Maxwell can be written down as follows

$$rot\vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}, \tag{4.1}$$

where μ - magnetic permeability of medium. It is evident that equations (4.1) and (4.2) are asymmetrical.

To somewhat improve the symmetry of these equations are possible, introducing into equation (4.2) term linear for the magnetic field, that considers heat losses in the magnetic materials in the variable fields

$$rot\vec{E} = -\sigma_H \vec{H} - \mu \frac{\partial \vec{H}}{\partial t} \tag{4.3}$$

where σ_H - conductivity of magnetic currents. But here there is no integral of such type, which is located in the right side of equation (4.1), in this equation. At the same time to us it is known that the atom, which possesses the magnetic moment $\vec{m}$, placed into the magnetic field, and which accomplishes in it precessional motion, has potential energy $U_m = -\mu\vec{m}\vec{H}$. Therefore potential energy can be accumulated not only in the electric fields, but also in the precessional motion of magnetic moments, which does not possess inertia. Similar case is located also in the mechanics, when the gyroscope, which precesses in the field of external gravitational forces, accumulates potential energy. Regarding mechanical precessional motion is also noninertial and immediately ceases after the removal of external forces. For example, if we from under the precessing gyroscope, which revolves in the field of the earth's gravity, rapidly remove support, thus it will begin to fall, preserving in the space the direction of its axis, which was at the moment, when support was removed. The same situation occurs also for the case of the precessing magnetic moment. Its precession is noninertial and ceases at the moment of removing the magnetic field.

Therefore it is possible to expect that with the description of the precessional motion of magnetic moment in the external magnetic field in the right side of relationship (4.3) can appear a term of the same type as in relationship (4.1). It will only stand L_k, i.e. instead C_k the kinetic capacity, which characterizes that potential energy, which has the precessing magnetic moment in the magnetic field

$$rot\vec{E} = -\sigma_H \vec{H} - \mu \frac{\partial \vec{H}}{\partial t} - \frac{1}{C_k} \int \vec{H} dt . \qquad (4.4)$$

For the first time this idea of the first equation of Maxwell taking into account kinetic capacity was given in the work [13].

Let us explain, can realize this case in practice, and that such in this case kinetic capacity. Resonance processes in the plasma and the dielectrics are characterized by the fact that in the process of fluctuations occurs the alternating conversion of electrostatic energy into the kinetic energy of charges and vice versa. This process can be named electrokinetic and all devices: lasers, masers, filters, etc, which use this process, can be named electrokinetic. At the same time there is another type of resonance - magnetic. If we use ourselves the existing ideas about the dependence of magnetic permeability on the frequency, then it is not difficult to show that this dependence is connected with the presence of magnetic resonance. In order to show this, let us examine the concrete example of ferromagnetic resonance. If we magnetize ferrite, after applying the stationary field H_0 in parallel to the axis z, the like to relation to the external variable field medium will come out as anisotropic magnetic material with the complex permeability in the form of tensor [14]

$$\mu = \begin{pmatrix} \mu_T{}^*(\omega) & -i\,\alpha & 0 \\ i\,\alpha & \mu_T{}^*(\omega) & 0 \\ 0 & 0 & \mu_L \end{pmatrix},$$

where

$$\mu_T{}^*(\omega) = 1 - \frac{\Omega\ |\gamma|\ M_0}{\mu_0(\omega^2 - \Omega^2)}, \qquad \alpha = \frac{\omega\ |\gamma|\ M_0}{\mu_0(\omega^2 - \Omega^2)}, \qquad \mu_L = 1,$$

moreover

$$\Omega = |\gamma|\ H_0 \tag{4.4}$$

is natural frequency of precession and

$$M_0 = \mu_0(\mu - 1)H_0 \tag{4.5}$$

is a magnetization of medium. Taking into account (4.4) and (4.5) for $\mu_T{}^*(\omega)$, it is possible to write down

$$\mu_T{}^*(\omega) = 1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2}. \tag{4.6}$$

That magnetic permeability of magnetic material depends on frequency, and can arise suspicions, that, as in the case with the plasma, here is some misunderstanding.

If we consider that the electromagnetic wave is propagated along the axis of x *of* and there are components fields H_y and H_z, then in this case the first Maxvell equation will be written down

$$rot\ \vec{E} = \frac{\partial\ \vec{E}_Z}{\partial\ x} = \mu_0\mu_T \frac{\partial\ \vec{H}_y}{\partial\ t}.$$

Taking into account (4.6), we will obtain

$$rot\ \vec{E} = \mu_0\left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2}\right]\frac{\partial\ \vec{H}_y}{\partial\ t}.$$

For the case $\omega >> \Omega$ we have

$$rot\ \vec{E} = \mu_0\left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2}\right]\frac{\partial\ \vec{H}_y}{\partial\ t}. \tag{4.7}$$

assuming $H_y = H_{y0}\sin\omega t$ and taking into account that in this case

$$\frac{\partial\ \vec{H}_y}{\partial\ t} = -\omega^2\int \vec{H}_y\ d\ t,$$

we obtain from (4.7)

$$rot\ \vec{E} = \mu_0 \frac{\partial \vec{H}_y}{\partial t} + \mu_0\ \Omega^2(\mu - 1)\int \vec{H}_y\ d\ t\,,$$

or

$$rot\ \vec{E} = \mu_0 \frac{\partial \vec{H}_y}{\partial t} + \frac{1}{C_k}\int \vec{H}_y\ d\ t\,. \tag{4.8}$$

For the case of $\omega << \Omega$ we find

$$rot\ \vec{E} = \mu_0 \mu \frac{\partial \vec{H}_y}{\partial t}\,.$$

Value

$$C_k = \frac{1}{\mu_0\ \Omega^2(\mu - 1)}\,,$$

which is introduced in relationship (4.8), let us name kinetic capacity.

With which is connected existence of this parameter, and its what physical sense? If the direction of magnetic moment does not coincide with the direction of external magnetic field, then the vector of this moment begins to precess around the vector of magnetic field with the frequency Ω. The magnetic moment $\vec{m}$ possesses in this case potential energy $U_m = -\vec{m}\cdot\vec{B}$. This energy similar to energy of the charged capacitor is potential, because precessional motion, although is mechanical, however, it not inertia and instantly it does cease during the removal of magnetic field. However, with the presence of magnetic field precessional motion continues until the accumulated potential energy is spent, and the vector of magnetic moment will not become parallel to the vector of magnetic field.

The equivalent diagram of the case examined is given in Fig. 3. At the point of $\omega = \Omega$ occurs magnetic resonance, in this case $\mu_H{}^*(\omega) \to -\infty$. The resonance frequency of macroscopic magnetic resonator, as can easily be seen of the equivalent diagram, also does not depend on the dimensions of line and is equal Ω. Thus, the parameter

$$\mu_H{}^*(\omega) = \mu_0\left[1 - \frac{\Omega^2(\mu - 1)}{\omega^2 - \Omega^2}\right]$$

is not the frequency dependent magnetic permeability, but it is the combined parameter, including μ_0 μ and C_k, which are included on in accordance with the equivalent diagram, depicted in Fig. 3.

Is not difficult to show that in this case there are three waves: electrical, magnetic and the wave, which carries potential energy, which is connected with the precession of magnetic moments around of the vector H_0.

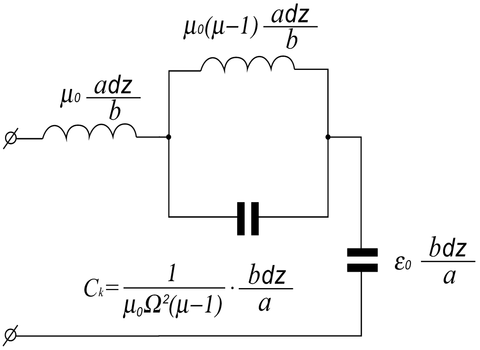

Fig. 3. Equivalent the schematic of the two-wire circuit of that filled with magnetic material.

For this reason such waves can be named electromagnetic-potential wave. All devices, in which are used such waves, also can be named electromagnetic-potential devices.

Before the appearance of a work [13] in the electrodynamics this concept, as kinetic capacity it was not used, although this the real parameter has very intelligible physical interpretation.

5. Kinetic inductance of the dielectrics

In the existing literature there are no indications that the kinetic inductance of charge carriers plays some role in the electrodynamic processes in the dielectrics. This not thus. This parameter in the electrodynamics of dielectrics plays not less important role, than in the electrodynamics of conductors. Let us examine the simplest case, when oscillating processes in atoms or molecules of dielectric obey the law of mechanical oscillator

$$\left(\frac{\beta}{m}-\omega^2\right)\vec{r}_m=\frac{e}{m}\vec{E}, \tag{5.1}$$

where $\vec{r}_m$ - deviation of charges from the position of equilibrium, β - coefficient of elasticity, which characterizes the elastic electrical binding forces of charges in the atoms and the molecules. Introducing the resonance frequency of the bound charges

$$\omega_0=\frac{\beta}{m},$$

we obtain from (5.1)

$$r_m=-\frac{e\ E}{m(\omega^2-\omega_o^2)}. \tag{5.2}$$

Is evident that in relationship (5.2) as the parameter is present the natural vibration frequency, into which enters the mass of charge. This speaks, that the inertia properties of the being varied charges will influence oscillating processes in the atoms and the molecules.

Since the general current density on Wednesday consists of the bias current and conduction current

$$rot\vec{H}=\vec{j}_\Sigma=\varepsilon_0\frac{\partial\vec{E}}{\partial t}+ne\vec{v},$$

that finding the speed of charge carriers in the dielectric as the derivative of their displacement through the coordinate

$$\vec{v} = \frac{\partial r_m}{\partial t} = -\frac{e}{m(\omega^2 - \omega_o^2)}\frac{\partial \vec{E}}{\partial t},$$

from relationship (5.2) we find

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{1}{L_{kd}(\omega^2 - \omega_0{}^2)}\frac{\partial \vec{E}}{\partial t}. \qquad (3.5)$$

But the value

$$L_{kd} = \frac{m}{ne^2}$$

presents the kinetic inductance of the charges, entering the constitution of atom or molecules of dielectrics, when to consider charges free. Therefore relationship (5.3) it is possible to rewrite

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{1}{\varepsilon_0 L_{kd}(\omega^2 - \omega_0{}^2)}\right)\frac{\partial \vec{E}}{\partial t}. \qquad (5.4)$$

Since the value

$$\frac{1}{\varepsilon_0 L_{kd}} = \omega_{pd}{}^2$$

It represents the plasma frequency of charges in atoms and molecules of dielectric, if we consider these charges free, then relationship (5.4) takes the form

$$rot\vec{H} = \vec{j}_\Sigma = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0{}^2)}\right)\frac{\partial \vec{E}}{\partial t}. \qquad (5.5)$$

To appears temptation to name the value

$$\varepsilon^*(\omega) = \varepsilon_0 \left(1 - \frac{\omega^2{}_{pd}}{(\omega^2 - \omega_0{}^2)}\right) \qquad (5.6)$$

by the depending on the frequency dielectric constant of dielectric. But this, as in the case conductors, cannot be made, since this is the composite parameter, which includes now those not already three depending on the frequency of the parameter: the dielectric constant of vacuum, the natural frequency of atoms or molecules and plasma frequency for the charge carriers, entering their composition.

Let us examine two limiting cases:

1. If $\omega << \omega_0$ then from (5.5) we obtain

$$rot\vec{H} = \vec{j}_{\Sigma} = \varepsilon_0 \left(1 + \frac{\omega_{pd}{}^2}{\omega_0{}^2} \right) \frac{\partial \vec{E}}{\partial t}. \tag{5.7}$$

in this case the coefficient, confronting the derivative, does not depend on frequency, and it presents the static dielectric constant of dielectric. As we see, it depends on the natural frequency of oscillation of atoms or molecules and on plasma frequency. This result is intelligible. Frequency in this case proves to be such low that the charges manage to follow the field and their inertia properties do not influence electrodynamic processes. In this case the bracketed expression in the right side of relationship (9.7) presents the static dielectric constant of dielectric. As we see, it depends on the natural frequency of oscillation of atoms or molecules and on plasma frequency. Hence immediately we have a prescription for creating the dielectrics with the high dielectric constant. In order to reach this, should be in the assigned volume of space packed a maximum quantity of molecules with maximally soft connections between the charges inside molecule itself.

2. The case when $\omega >> \omega_0$ then

$$rot\vec{H} = \vec{j}_{\Sigma} = \varepsilon_0 \left(1 - \frac{\omega_{pd}{}^2}{\omega^2} \right) \frac{\partial \vec{E}}{\partial t},$$

and dielectric became conductor (plasma), since the obtained relationship exactly coincides with the equation, which describes plasma.

One cannot fail to note the circumstance that in this case again nowhere was used this concept as polarization vector, but examination is carried out by the way of finding the real currents in the dielectrics on the basis of the equation of motion of charges in these media. In this case as the parameters are used the electrical characteristics of the media, which do not depend on frequency.

From relationship (5.5) is evident that in the case of fulfilling the equality $\omega=\omega_0$, the amplitude of fluctuations is equal to infinity. This indicates the presence of resonance at this point. The infinite amplitude of fluctuations occurs because of the fact that they were not considered losses in the resonance system, in this case its quality was equal to infinity. In a certain approximation it is possible to consider that lower than the point indicated we deal concerning the dielectric, whose dielectric constant is equal to its static value. Higher than this point we deal already actually concerning the metal, whose density of current carriers is equal to the density of atoms or molecules in the dielectric.

Now it is possible to examine the question of why dielectric prism decomposes polychromatic light into monochromatic components or why rainbow is formed. So that this phenomenon would occur, it is necessary to have the frequency dispersion of the phase speed of electromagnetic waves in the medium in question. If we to relationship (9.5) add the first Maxwell equation, then we will obtain

$$rot\vec{E}=-\mu_0\frac{\partial\vec{H}}{\partial t}$$

$$rot\vec{H}=\varepsilon_0\left(1-\frac{\omega^2{}_{pd}}{(\omega^2-\omega_0{}^2)}\right)\frac{\partial\vec{E}}{\partial t}\ ,$$

from where we immediately find the wave equation

$$\nabla^2\vec{E}=\mu_0\varepsilon_0\left(1-\frac{\omega_{pd}{}^2}{\omega^2-\omega_0{}^2}\right)\frac{\partial^2\vec{E}}{\partial t^2}.$$

If one considers that

$$\mu_0\varepsilon_0=\frac{1}{c^2}$$

where c - speed of light, then no longer will remain doubts about the fact that with the propagation of electromagnetic waves in the dielectrics the frequency dispersion of phase speed will be observed. In the formation of this dispersion it will participate immediately three, which do not depend on the frequency, physical quantities: the self-resonant frequency of atoms themselves or molecules, the plasma frequency of charges, if we consider it their free, and the dielectric constant of vacuum.

Now let us show, where it is possible to be mistaken, if with the solution of the examined problem of using a concept of polarization vector. Let us introduce this polarization vector

$$\vec{P} = -\frac{ne^2}{m} \cdot \frac{1}{(\omega^2 - \omega_0^2)} \vec{E}.$$

Its dependence on the frequency, is connected with the presence of mass in the charges, entering the constitution of atom and molecules of dielectrics. The inertness of charges is not allowed for this vector, following the electric field, to reach that value, which it would have in the permanent fields. Since the electrical induction is determined by the relationship

$$\vec{D} = \varepsilon_0 \vec{E} + \vec{P}\vec{E} = \varepsilon_0 \vec{E} - \frac{ne^2}{m} \cdot \frac{1}{(\omega^2 - \omega_0^2)} \vec{E} \tag{5.8}$$

that introduced thus electrical induction depends on frequency.

If this induction was introduced into the second Maxwell equation, then it signs the form

$$rot\vec{H} = j_{\Sigma} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} + \frac{\partial \vec{P}}{\partial t}$$

or

$$rot\vec{H} = j_{\Sigma} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{ne^2}{m} \frac{1}{(\omega^2 - \omega_0{}^2)} \frac{\partial \vec{E}}{\partial t} \tag{5.9}$$

where j_{Σ} - the summed current, which flows through the model. In expression (5.9) the first member of right side presents bias current in the vacuum, and the second - current, connected with the presence of bound charges in atoms or molecules of dielectric. In this expression again appeared the specific kinetic inductance of the charges, which participate in the oscillating process

$$L_{kd} = \frac{m}{ne^2} .$$

This kinetic inductance determines the inductance of bound charges. Taking into account this relationship (5.9) it is possible to rewrite

$$rot\vec{H} = j_{\Sigma} = \varepsilon_0 \frac{\partial \vec{E}}{\partial t} - \frac{1}{L_{kd}} \frac{1}{(\omega^2 - \omega_0^2)} \frac{\partial \vec{E}}{\partial t} ,$$

obtained expression exactly coincides with relationship (5.3). Consequently, the eventual result of examination by both methods coincides, and there are no claims to the method from a mathematical point of view. But from a physical point of view, and especially in the part of the awarding to the parameter, introduced in accordance with relationship (5.8) of the designation of electrical induction, are large claims, which we discussed. Is certain, this not electrical induction, but the certain composite parameter. But, without having been dismantled at the essence of a question, all, until now, consider that the dielectric constant of dielectrics depends on frequency. In the essence, physically substantiated is the introduction to electrical induction in the dielectrics only in the static electric fields.

Let us show that the equivalent the schematic of dielectric presents the sequential resonant circuit, whose inductance is the kinetic inductance L_{kd} and capacity is equal to the static dielectric constant of dielectric minus the capacity of the equal dielectric constant of vacuum. In this case outline itself proves to be that shunted by the capacity, equal to the specific dielectric constant of vacuum. For the proof of this let us examine the sequential oscillatory circuit, when the inductance L and the capacity C are connected in series.

The connection between the current I_C, which flows through the capacity C, and the voltage U_C, applied to it, is determined by the relationships

$$U_C = \frac{1}{C}\int I_C dt$$

and

$$I_C = C\frac{dU_C}{dt}. \qquad (5.10)$$

This connection will be written down for the inductance

$$I_L = \frac{1}{L}\int U_L dt$$

and

$$U_L = L\frac{dI_L}{dt}.$$

If the current, which flows through the series circuit, changes according to the law $I = I_0 \sin\omega t$, then a voltage drop across inductance and capacity they are determined by the relationships of

$$U_L = \omega L I_0 \cos\omega t$$

and

$$U_C = -\frac{1}{\omega C} I_0 \cos\omega t,$$

and total stress applied to the outline is equal

$$U_\Sigma = \left(\omega L - \frac{1}{\omega C}\right) I_0 \cos\omega t.$$

In this relationship the value, which stands in the brackets, presents the reactance of sequential resonant circuit, which depends on frequency. The stresses, generated on the capacity and the inductance, are located in the reversed phase, and, depending on frequency, outline can have the inductive, the whether capacitive reactance. At the point of resonance the summary reactance of outline is equal to zero.

It is obvious that the connection between the total voltage applied to the outline and the current, which flows through the outline, will be determined by the relationship

$$I=-\frac{1}{\omega\left(\omega L-\frac{1}{\omega C}\right)}\frac{\partial U_{\Sigma}}{\partial t}. \qquad (5.11)$$

Taking into account that the resonance frequency of the outline

$$\omega_0=\frac{1}{\sqrt{LC}},$$

let us write down

$$I=\frac{C}{\left(1-\frac{\omega^2}{\omega_0{}^2}\right)}\frac{\partial U_{\Sigma}}{\partial t}. \qquad (5.12)$$

Comparing this expression with relationship (5.10) it is not difficult to see that the sequential resonant circuit, which consists of the inductance L and capacity C, it is possible to present to the capacity ofin the form dependent on the frequency

$$C(\omega)=\frac{C}{\left(1-\frac{\omega^2}{\omega_0{}^2}\right)}. \qquad (5.13)$$

This idea does not completely mean that the inductance is somewhere lost. Simply it enters into the resonance frequency of the outline ω_0. Relationship (5.12) this altogether only the mathematical form of the record of relationship (5.11). Consequently, this is $C(\omega)$ the certain composite mathematical parameter, which is not the capacity of outline.

Relationship (5.11) can be rewritten and differently:

$$I = -\frac{1}{L\left(\omega^2 - \omega_0{}^2\right)}\frac{\partial U_\Sigma}{\partial t}$$

and to consider that

$$C(\omega) = -\frac{1}{L\left(\omega^2 - \omega_0{}^2\right)}. \tag{5.14}$$

Is certain, the parameter $C(\omega)$, introduced in accordance with relationships (5.13) and (5.14) no to capacity refers.

Let us examine relationship (5.12) for two limiting cases:

1. When $\omega << \omega_0$ we have

$$I = C\frac{\partial U_\Sigma}{\partial t}.$$

This result is intelligible, since. at the low frequencies the reactance of the inductance, connected in series with the capacity, is considerably lower than the capacitive and it is possible not to consider it.

2. For the case when $\omega >> \omega_0$ we have

$$I = -\frac{1}{\omega^2 L}\frac{\partial U_\Sigma}{\partial t}. \tag{5.15}$$

Taking into account that for the harmonic signal

$$\frac{\partial U_\Sigma}{\partial t} = -\omega^2 \int U_\Sigma dt,$$

we obtain from (5.15)

$$I_L = \frac{1}{L}\int U_\Sigma dt.$$

In this case the reactance of capacity is considerably less than in inductance and chain has inductive reactance.

The carried out analysis speaks, that is in practice very difficult to distinguish the behavior of resonant circuits of the inductance or of the capacity. In order to understand the true composition of the chain being investigated it is necessary to remove the amplitude and phase response of this chain in the range of frequencies. In the case of resonant circuit this dependence will have the typical resonance nature, when on both sides resonance the nature of reactance is different. However, this does not mean that real circuit elements: capacity or inductance depend on frequency.

The equivalent the schematic of the dielectric, located between the planes of long line is shown in Fig. 4.

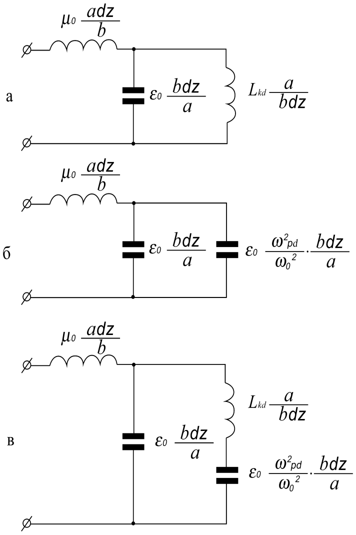

Fig. 4.

a - equivalent the schematic of the section of the line, filled with dielectric, for the case $\omega >> \omega_0$,

б - the equivalent the schematic of the section of line for the case $\omega << \omega_0$,

в - the equivalent the schematic of the section of line for entire frequency band.

In Fig. 4 (a) and 4 (б) are shown two limiting cases. In the first case when $\omega >> \omega_0$ dielectric according to its properties corresponds to conductor, in the second case when $\omega << \omega_0$ it corresponds to the dielectric, which possesses the static dielectric constant $\varepsilon = \varepsilon_0 \left(1 + \frac{\omega_{pd}{}^2}{\omega_0{}^2} \right)$.

Thus, it is possible to make the conclusion that the introduction, the depending on the frequency dielectric constants of dielectrics, are physical and terminological error. If the discussion deals with the dielectric constant of dielectrics, with which the accumulation of potential energy is connected, then the discussion can deal only with the static permeability. And precisely this parameter as the constant, which does not depend on the frequency, enters into all relationships, which characterize the electrodynamic characteristics of dielectrics.

The most interesting results of applying such new approaches occur precisely for the dielectrics. In this case each connected pair of charges presents the separate unitary unit with its individual characteristics and its participation in the processes of interaction with the electromagnetic field (if we do not consider the connection between the separate pairs) strictly individually. Certainly, in the dielectrics not all dipoles have different characteristics, but there are different groups with similar characteristics, and each group of bound charges with the identical characteristics will resound at its frequency. Moreover the intensity of absorption, and in the excited state and emission, at this frequency will depend on a relative quantity of pairs of this type. Therefore the partial coefficients, which consider their statistical weight in this process, can be introduced. Furthermore, these processes will influence the anisotropy of the dielectric properties of molecules themselves, which have the specific electrical orientation in crystal lattice. By these circumstances is determined the variety of resonances and their intensities, which is observed in the dielectric media. The lines of absorption or emission, when there is the electric coupling between the separate groups of emitters, acquire even more complex structure. In this case the lines can be converted into the strips. Such individual approach to each separate type of the connected pairs of charges could not be realized within the framework earlier than the existing approaches.

This examination showed that the kinetic inductance of the charges, connected in atoms or molecules of dielectrics, also has very important significance with the description of their physical properties.

6 . Surface kinetic inductance

Until now was considered that the kinetic inductance most effectively can appear only in the superconductors, and it was introduced by phenomenological method. But in the electrodynamics of conducting media, besides volumetric kinetic inductance, it is possible to introduce still and the concept of surface kinetic inductance, after enlarging by such means of the limit of the applicability of this term.

If there is a material medium, to boundary of which the plane electromagnetic wave will give, then some part of the energy of this wave passes into the material medium, and some is reflected. The process of the propagation of wave in medium itself is connected with its properties. For the introduction to surface kinetic inductance let us examine the case, when the frequency of the incident wave is considerably lower than the plasma [7].

Maxwell equations for the complex amplitudes pour on in this case they will be written down as follows

$$\begin{aligned} rot\vec{E} &= -i\omega\mu_0\vec{H}, \quad rot\vec{H} = \vec{j} \\ div\vec{E} &= 0, \quad div\vec{H} = 0 \end{aligned} . \qquad (6.1)$$

Here and throughout the law of variation in the electromagnetic field is undertaken in the form $e^{i\omega t}$.

The surface resistance R and the surface reactance X are the numerical characteristics, which establish the connection between the tangential components of electrical and magnetic field on the surface, and those also determining the energy characteristics of interaction of surface with the electromagnetic field. The complex amplitudes of tangential components pour on on the surface they are connected with the relationship

$$E_T = ZH_T$$

from which it is not difficult to obtain the connection between the real fields on the surface

$$|\tilde{E}_T| = |Z||\tilde{H}_T|\cos(\omega t + \varphi)$$

where

$$Z = \frac{E_x(0)}{H_y(0)} = i\omega\mu_0 \frac{1}{H_y(0)} \int_0^{\infty} H_y(z)dz$$

is the surface impedance of surface. The module of surface impedance gives the ratio of the amplitudes of the tangential components of electrical and magnetic pour on on the surface, and phase - phase displacement between them.

For establishing the connection R and X with the energy characteristics of surface layer let us take the single section of surface, for which are valid the Leontovich boundary conditions. Let us multiply first equation (6.1) by $\vec{H}^*$ and the second to $\vec{E}$ and let us piecemeal deduct one of another. After simple conversions we will obtain

$$div\vec{P} = -\frac{1}{2}\vec{j}^*\vec{E} - i\omega\frac{\mu_0|\vec{H}|^2}{2} \tag{6.2}$$

where $\vec{P} = \frac{1}{2}\left[\vec{E}\times\vec{H}^*\right]$ - complex Poynting vector. Integrating (6.2) by the volume, which lies under the single area after the conversion of left side from the formula of gauss let us find

$$\int\limits_S \vec{P}d\vec{S} = -\frac{1}{2}\int\limits_V \vec{j}^*\vec{E}dSdz - i2\omega\int\limits_V \frac{\mu_0 \, | \, \vec{H} \, |^2}{4}dSdz \tag{6.3}$$

where the integration is conducted according to the surface of the chosen area and element of volume is recorded in the form $dSdz$.

We will consider that in the limits of the chosen area are small changes pour on in the tangential direction, and also that these fields become zero with $z \to \infty$. in the surface integral in equation (6.3) is accepted $\vec{P}d\vec{S} = -\vec{P}\vec{n}dS = -P_n dS$, where the vector $\vec{n}$ is directed into the depths of the medium in question. In relationship (10.3) are essential only tangential components $\vec{E}$ and $\vec{H}$ and taking into account that

$$\left[\vec{E}_T \times H_T^{\,*}\right] = Z \, | \, \vec{H}_T \, |^2 \, \vec{n} ,$$

this equation is reduced to the form

$$\frac{1}{2}Z \, | \, \vec{H}_T(0) \, |^2 = \frac{1}{2}\int\limits_0^\infty \vec{j}^*\vec{E}dz + i2\omega\int\limits_0^\infty \frac{\mu_0 \, | \, \vec{H} \, |^2}{4}dz . \tag{6.4}$$

After isolating the real part of this equality, we will obtain:

$$P_R = \frac{1}{2}R \, | \, H_T(0) \, |^2 = \mathrm{Re}\frac{1}{2}\int\limits_0^\infty \vec{j}^*\vec{E}dz ,$$

where P_R - average power of losses to the single square of surface.

Separating the imaginary part of equation (10.4), we find

$$P_X = \frac{1}{2}X \, | \, \vec{H}_T(0) \, |^2 = \mathrm{Im}\frac{1}{2}\int\limits_0^\infty \vec{j}^*\vec{E}dz + 2\omega\int\limits_0^\infty \frac{\mu_0 \, | \, \vec{H} \, |^2}{4}dz ,$$

where P_X - average reactive power, which falls to the single square of surface.

Is evident that the reactive power consists of two members. The first of them represents the reactive power, connected with the kinetic energy of current carriers, and the second - gives the reactive power, connected with the presence on Wednesday of magnetic field.

Boundary conditions

$$\vec{E}_T(0) = Z\left[\vec{H}_T(0)\times\vec{n}\right],$$

where $Z = R + iX$ in connection with to real values fields $\tilde{E}_T$ and $\tilde{H}_T$ it is possible to write down in the form

$$\tilde{E}_T = R\tilde{H}_T + L\frac{d\tilde{H}}{dt},$$

where $L = \frac{X}{\omega}$ - there is surface inductance of surface.

Now it is possible to introduce still and such new concepts as the kinetic and field surface of the inductance

$$L_K = \frac{1}{\omega|\vec{H}_T(0)|^2}\operatorname{Im}\int_0^\infty \vec{j}^*\vec{E}dz,$$

$$L_\Pi = \frac{1}{|\vec{H}_T(0)|^2}\int_0^\infty |\vec{H}_T|^2\, dz.$$

These relationships are valid for the case of the arbitrary connection between the current and the field both in the normal metals and in the superconductors.

The examination of kinetic processes in the conductors and the dielectrics revealed one interesting special feature. If the charges are free, then in this system only collective fluctuations can exist, with which all charges, which participate in the oscillating process, are completely equal. They all are found in one and the same energy state and, if we do not consider loss, then the sum of kinetic and potential energy at any moment of time in them is identical. This conclusion is completely valid for the case of superconductors and cold plasma.

Conclusion

In practice in all equations of electrodynamics, which describe the dynamic properties of material media are used such concepts as dielectric and magnetic constant. However, practically nowhere we meet in these equations of this parameter as the kinetic inductance of charges. In the work it is shown that this state of affairs is connected with the poor understanding of physics of those processes, which occur in the material media. The carried out examination showed that the kinetic inductance of charges has not less important significance, than dielectric and magnetic constant, and the correct understanding of electrodynamic processes in such media without the use of the concept indicated is impossible.

However, as far as kinetic capacity is concerned, this concept in [the electrodynamics] was absent before the appearance of work [13].

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References

1. Александров А. Ф., Богданкевич Л. С., Рухадзе А. А. Колебания и волны в плазменных средах. Изд. Московского университета, 1990.- 272 с.
2. Ландау Л. Д., Лифшиц Е. М. Электродинамика сплошных сред. М: Наука, 1982.- 620 с.
3. Гинзбург В. Л. Распространение электромагнитных волн в плазме. – М.: Наука. 1967 г. - 684 с.
4. Ахиезер А. И. Физика плазмы М: Наука, 1974 - 719 с.
5. Тамм И. Е. Основы теории электричества М.: Наука, 1989 - 504 с.
6. Арцимович Л. А. Что каждый физик должен знать о плазме. М.: Атомиздат, 1976. -111 с.
7. Менде Ф. Ф., Спицын А. И. Поверхностный импеданс сверхпроводников. Киев, Наукова думка, 1985.- 240 с.
8. Менде Ф. Ф. Существуют ли ошибки в современной физике. Харьков, Константа, 2003.- 72 с.

9. Менде Ф. Ф. Непротиворечивая электродинамика. Харьков, НТМТ, 2008, – 153 с. ISBN 978-966-8603-23-5.

10. Mende F. F. On refinement of certain laws of classical electrodynamics, arXiv, physics/0402084.

11. Mende F. F. Transversal plasma resonance in a nonmagnetized plasma and possibilities of practical employment of it. arXiv, physics/0506081.

12. Ярив А. Квантовая электродинамика и нелинейная оптика. М: Сов. радио, 1973.- 454 с.

13. Менде Ф. Ф. К вопросу об уточнении уравнений элетромагнитной индукции. - Харьков, депонирована в ВИНИТИ, №774-В88 Деп., 1988.-32с.

14. Никольский В. В., Никольская Т. И. Электродинамика и распространение радиоволн. М: Наука, 1989.- 543 с.


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