5. Electric and magnetic fields

It is now believed that the source of the electric fields is electric charges and the source of the magnetic fields is the motion of electric charges. Model reflecting the nature of the charges themselves do not exist. In quantum electrodynamics, the electromagnetic field is treated as a discrete mechanical system with an infinite number of degrees of freedom. Particle-carrier of the electromagnetic interaction is light photons — a quanta of electromagnetic field. Photons have zero mass, integer spin and obey Bose-Einstein statistics. This makes it possible to go to the limit of the classical description of the field, it is impossible for other quantum fields.

Electromagnetic radiation is now regarded as a stream of photons. The interaction between the charges is through an electromagnetic field by exchanging photons, which are continuously emitted and absorbed by the charges. Photon exchange reaction generates the attraction or repulsion of charges. However, in details this mechanism is not specified. At sufficiently high frequency vibrations charges formed an electromagnetic field breaks away from them and distributed in the form of electromagnetic waves (radio waves). It is assumed that these waves can propagate in a vacuum (without matter). However, a clear physical model of such waves is not suggested.

In the modern formulation electromagnetic field is described by the tensor of the electromagnetic field, whose elements are the three components of the electric field and the three components of the magnetic field, and the electromagnetic four-potential.

In the vortex model the electromagnetic field is one of the discrete states of matter. Quanta of the electromagnetic field are gravitons as a dispersed flow of the medium filling the space.

The term "electromagnetic field" introduced by J. Maxwell. Maxwell was absolutely convinced that any of the wave process can not be distributed without the environment. Following Faraday's and JJ Thomson, he assumed that all space is filled with ether in the form of "molecular vortices". Maxwell created his mechanical model of the vortex solid medium [9].

Figure 5.1 shows two-dimensional model of the electromagnetic fields of Maxwell. Vortices 2 transmit rotation to each other through intermediate particles 1, which are between the vortices. The right in Figure 5.1 thickened lines in the upper part of the vortex shows a tangential compression deformation of the vortex with a displacement of particles.

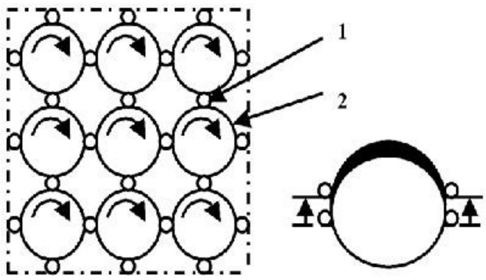

Figure 5.1. Maxwell's vortex model

List the basic properties of this two-component model of the field:

1. Linear dimensions of the vortices do not affect the properties of the model.
1. Mass and size of intermediate particles (between the vortices) rely negligible.
2. Size and shape of the vortices are not amenable to deformation. Deformation is tangential to the surface of the vortex, i.e. vortices can be thought of as bubbles, which may rotate and be subjected to deformation only the shell but not the contents.

3. The values of strains rely quite small, which ensures the linearity of force depending on the strain.
4. The particles fill the gaps between the vortices behave (in aggregate) as an incompressible fluid.
5. Friction and any other losses of energy available.

On the basis of its mechanical model and summarizing the experimental data, James Maxwell expressed the laws of the electromagnetic field in four differential equations [10]:

$$c^2\mathrm{rotB} = \frac{\mathrm{J}}{\varepsilon\varepsilon_0} + \frac{\partial \mathrm{E}}{\partial \mathrm{t}}, \qquad (5.1)$$

$$\mathrm{rotE} = -\frac{\partial \mathrm{B}}{\partial \mathrm{t}}, \qquad (5.2)$$

$$\mathrm{divE} = \frac{\rho}{\varepsilon\varepsilon_0}, \qquad (5.3)$$

$$\mathrm{divB} = 0. \qquad (5.4)$$

where E — electric field, B — magnetic induction, ρ — charge density J — current density, c — speed of light, ε — permittivity of the medium, ε_0 — dielectric constant.

In the integral form of Maxwell's equation is usually written as follows:

$$c^2 \quad B\,\mathrm{dl} = \frac{1}{\varepsilon\varepsilon_0} \quad J\,\mathrm{ds} + \frac{\partial}{\partial t} \quad E\,\mathrm{ds}, \qquad (5.1.1)$$

$$E\,\mathrm{dl} = -\frac{\partial}{\partial t} \quad Bds, \qquad (5.2.1)$$

$$E\,\mathrm{ds} = \frac{\rho}{\varepsilon\varepsilon_0}, \qquad (5.3.1)$$

$$Bds = 0. \qquad (5.4.1)$$

Here dl - contour element, ds element surface bounded by this contour.

Equations (5.1-5.4) define the vector fields E and B through the distribution of charges and currents. Equations (5.1) and (5.1.1) generalize Ampere's law, the magnetic field generated by the current in the circuit conduction current in the circuit:

$$c^2 rotB = \frac{J}{\varepsilon\varepsilon_0} \qquad \text{or} \qquad B\,\mathrm{dl} = \frac{1}{c^2\varepsilon\varepsilon_0} \quad J\,\mathrm{ds}.$$

Maxwell, in addition to the conduction current J introduces bias current $\frac{\partial E}{\partial t}$ — rate of change of electric flux through the circuit. Maxwell was a supporter of the ether. For him, it was natural to assume that for the achievement of electronic capacitor plates charge flow is not interrupted, but actually closed on a facing another stream of air. In the no stationary case forward the flow in the inter electrode space is completely equivalent to an electronic current in the conductor. Thus, the circulation of the magnetic field in a closed loop is equal to the sum of the conduction current and the displacement occurring through the surface bounded by this contour.

Equations (5.2) and (5.2.1) represent Faraday's law: the circulation of the electric field on the contour is taken with the opposite sign derivative of the time of the magnetic flux through the surface, restricting this contour. Maxwell believed that the actual electromotive force is induced not only conductive, but in any closed circuit, even a dedicated mentally or no conductivity. Conducting circuit only detects an electromotive force. This is possible only if the materiality of the medium field.

Equations (5.3) and (5.3.1) show that the source of the electric field is to charge. Feed tension E through a closed surface is equal to the charge inside divided by $\varepsilon\varepsilon_0$.

From equations (5.4) and (5.4.1) it follows that the lines of force of the magnetic induction B are continuous, and the magnetic charges are absent. Flux of the magnetic field through any closed surface is zero. Vector of magnetic induction B has only a vortex component, which is denoted as the rotor of vector potential A:

$$\mathrm{B} = \mathrm{rotA}, \ \ \mathrm{divA} = 0. \qquad (5.5)$$

From equation (5.2) with (5.5) we find:

$$rot \ \ E + \frac{\partial A}{\partial t} \ \ = 0.$$

This equality is preserved if the expressions in brackets add any potential vector, in particular, $grad\varphi$. By scalar potential you can add an arbitrary constant. Then the electric field E can be expressed through the scalar and vector potentials:

$$\mathrm{E} = -\mathrm{grad}\varphi - \frac{\partial \mathrm{A}}{\partial \mathrm{t}} \ . \qquad (5.6)$$

The system (6.1-6.4) does not determine the equation of motion of charge in an electromagnetic field. The system is completed by the expression for the Lorentz force:

$$\mathrm{F} = -\mathrm{q} \quad \mathrm{B} \times \mathrm{v} \ + \frac{\partial \mathrm{A}}{\partial \mathrm{t}} \ . \qquad (5.7)$$

Maxwell's field theory is a theory of mean values, the theory of a continuum. The statistical nature of Maxwell's theory allows the derivation of electromagnetic equations of motion do not make assumptions about the details of the mechanism of this movement. Maxwell just assumed that the ether and the charges are moving like a perfect incompressible fluid. The values of the electric and magnetic fields E and B have meaning of "density" of the vector field. Values $\varepsilon\varepsilon_0 \frac{\mathrm{E}^2}{2}$ and $\mu\mu_0 \frac{\mathrm{B}^2}{2}$ are the energy density at a given point in the medium.

The generally accepted at present is the following model interpretation of Maxwell's equations:

- static charge produces a static electric field;
- DC creates a static magnetic field of the vortex;
- Alternating current is the source of an alternating magnetic field. An alternating magnetic field is the source of alternating vortex electric field. When you place it on the ends of the conductor occurs induced EMF.;
- Alternating vortex electric field, in turn, generates an alternating magnetic field. In space there is an electromagnetic wave, in which the periodic transfer of energy from electrical to magnetic and back.

However, there are several paradoxes when the generally accepted model of the system of equations (5.1-5.4) and its decisions have been analyzed. Consider some of them.

Phase synchronism of the vectors E and B

Kind of equations (5.1) and (5.2) shows that for wave solutions of these equations the vectors E and B are in phase, i.e. simultaneously pass through a maximum. It follows that the mutual conversion of electric and magnetic fields in the wave does not occur. Consequently, the current physical model of propagation is not justified.

Photons as carriers of electric and magnetic fields

There can be no allegation that the photons are the quanta of electromagnetic field. The wave equation for free space can be written as [5]:

$\square f = 0$,

where $\square$ - d'Alembert operator $\square = \Delta - \frac{\partial^2}{\partial t^2}$,

f — any of the components A, E or B.

But photons do not have own charge and the intrinsic magnetic moment. So they can not be the material basis of continuous field functions — electric E or magnetic B fields.

Conductor with constant current absorbs energy from the environment

In conventional electrodynamics the Poynting vector is written as

$$S = \varepsilon\varepsilon_0 c^2 \ E \times B \ ,$$

that leads to paradoxes. Consider one given in the book [11] examples. Let the section of the wire with non-zero resistance flowing DC (Figure 5.2).

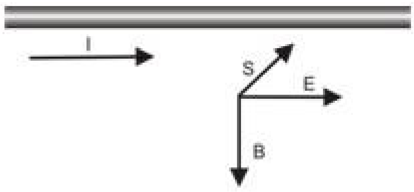

Figure 5.2. Poynting vector near the wire with a current

The current generates a magnetic field B directed along the tangents to the circles held around the wires. Along the wires outside the surface there is a parallel electric field E directed current. Vectors E and B mutually perpendicular, and hence the Poynting vector is directed radially — inside the conductor. From the surrounding space in the wire with constant current must flow into energy. But these flows of energy from the experience not found. Experience shows the flow of energy only for alternating current.

3. Incorrectness of the methodology of calculation of Electromagnetic induction

The method of calculating the current value of the EMF electromagnetic induction is as follows. The current density in the secondary winding of the transformer is determined by Ohm's law in differential form:

$$J = \sigma E = \sigma(-\text{grad}\ \varphi - \frac{\partial A}{\partial t}),$$

where we used the formula (5.6).

Typically, the secondary winding is made of metal with high conductivity σ. So the electric field E for finite values of current density J is small:

$$J/\sigma = E = -\text{grad}\ \varphi - \frac{\partial A}{\partial t} \approx 0.$$

EMF in the secondary winding is calculated by integration:

ЭДС= $\int_{0}^{L} \mathrm{grad}\varphi \, dl = -\int_{0}^{L} \frac{\partial A}{\partial t} dl$,

what corresponds to the experimental values.

Thus, the voltage at the terminals of the secondary winding of the transformer is connected with the value of the electrical conductivity of the material of the winding, which is not observed in practice. In the very basis of methods for determining the EMF based on the following contradiction. The cause of the polarization of the secondary winding of the conductor is an electric tension E as an external force, distributing charges. Therefore, obtaining the expression for the EMF, based on the prerequisite $E = 0$ violates the principle of causality and contrary to Newton's third law. E -tension in the secondary winding occurs only as a result of distributing the charges in accordance with the equation (5.3).

These contradictions in model representations of the electromagnetic phenomena are eliminated in the proposed modification of Maxwell's equations. With regard to the quantization of the electromagnetic field, the eddy gravitons are its quantum’s.

5.1 The first modification of Maxwell's equations

The electric field in the analysis of solutions of Maxwell’s equations is divided into simple "electric field" and “vortex electric field”. The source of the first is the electric charges. This is a potential field of the capacitor. Second source is an alternating magnetic field. This vortex field of external forces provides the EMF in the secondary winding of the transformer. However in Maxwell's equations these fields are indistinguishable.

The first modification is due to the requirements of applicable mathematical apparatus of vector calculus. By the Helmholtz theorem, every-one and continuous vector field**,** vanishing at infinity, can be uniquely represented as the sum of the gradient of some scalar function and of the rotor some vector function, the divergence of which is zero.

In the system of equations (5.1-5.6) vectors A and B are vortex. Vortex vectors are closed, they have no sources. Condition $\mathrm{div}A = 0$ in (5.5) is the requirement of mathematical theorems Helmholtz, and not a condition for the Lorentz gauge vector potential.

Vectors E and J - mixed, i.e. contain gradient and vortex components.

Represent the decomposition of the vector E Helmholtz's theorem:

$$E = E_{\mathrm{grad}} + E_{\mathrm{rot}} = -\mathrm{grad}\varphi + \mathrm{rot}P,$$

$$E_{\mathrm{grad}} = -\mathrm{grad}\varphi, \quad E_{\mathrm{rot}} = \mathrm{rot}P, \qquad (5.8)$$

$$\mathrm{rot}(E_{\mathrm{grad}}) = \mathrm{div}\ E_{\mathrm{rot}} = \mathrm{div}P = 0.$$

Vector J also represented as a sum of irrotational and vortical components:

$$J = J_{\mathrm{grad}} + J_{\mathrm{rot}}, \qquad (5.9)$$

$$\mathrm{div}(J_{\mathrm{rot}}) = \mathrm{rot}(J_{\mathrm{grad}}) = 0.$$

Non rotational vectors E_{grad} and J_{grad} begin at the sources, and ends either on the effluent or in infinity.

After substituting the transformation (5.6, 5.8, 5.9) in the system (5.1-5.4) of the equation will look like

$$c^2 rot\ rotA\ = \frac{J_{grad}+J_{rot}}{\varepsilon\varepsilon_0} + \frac{\partial(E_{grad}+E_{rot})}{\partial t},$$

$$rot\ -grad\varphi + E_{rot}\ = \frac{\partial(rotA)}{\partial t},$$

$$div\ E_{grad} + E_{rot}\ = div\ -grad\varphi + rotP\ = \frac{\rho}{\varepsilon\varepsilon_0}, \qquad (5.10)$$

$$div\ rotA\ = 0.$$

The solution of these equations, we must obtain two sets of values that characterize the field:

scalar φ and vectors of gradient type E_{grad} and J_{grad},

vortex vectors E_{rot}, A.

In the first equation of system (5.10) in the left part of the vector A affected operator rot. That is mean left is the vector of the vortex. Therefore, the sum of gradient vectors on the right side of the equation will be zero. Rewrite the whole system of equations in the form:

$$c^2 rot\ rotA\ = \frac{J_{rot}}{\varepsilon\varepsilon_0} + \frac{\partial(E_{rot})}{\partial t}, \qquad (5.11)$$

$$rot\ E_{rot}\ = \frac{\partial(rotA)}{\partial t}, \qquad (5.12)$$

$$div\ E_{grad}\ = \frac{\rho}{\varepsilon\varepsilon_0}, \qquad (5.13)$$

$$J_{grad} + \varepsilon\varepsilon_0 \frac{\partial(E_{grad})}{\partial t}. \qquad (5.14)$$

Acting operator div on equation (5.14) and substituting in its value div E_{grad} from equation (5.13), we obtain the equation of continuity for the gradient component of the current:

$$div(J_{grad}) + \frac{\partial\rho}{\partial t} = 0. \qquad (5.15)$$

This ratio expresses the law of conservation of charge.

To solve the equation (5.12), the expression in parentheses must be equated to zero or gradient of a scalar function grad ψ. In the latter case, this is equivalent to adding to the function φ function ψ. Formally the expression in brackets can add any potential vector, in particular, $grad\varphi$. The amount of vortex vectors can not be the gradient vector. Then we obtain an expression for E_{rot}, which is equal to the derivative of the vector potential of magnetic induction, with opposite sign:

$$E_{rot} = -\frac{\partial A}{\partial t}. \qquad (5.16)$$

Vortex electric field is the side force of the magnetic field. It is caused by a change in the time of the vector potential. Substituting this value in equation (5.11), we obtain the equation of the magnetic vortex of the process:

$$c^2 rot(rotA) + \frac{\partial^2 A}{\partial t^2} = \frac{J_{rot}}{\varepsilon\varepsilon_0}. \qquad (5.17)$$

In the right side of this equation as the source of the vector potential enters only the vortex component of the current J_{rot}.

Using the known formula of vector analysis

$$\mathrm{rot\ rot}A = -\Delta A + \mathrm{grad\ div}A ,$$

we rewrite (5.17) in the form of the usual wave equation:

$$\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = -\mu\mu_0 J_{rot}, \quad (5.18)$$

where $\mu\mu_o$ — relative permeability of the medium. Recall that $c^2 = \frac{1}{\mu\mu_0\varepsilon\varepsilon_0}$.

In the absence of currents, equation (5.18)

$$\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = 0 \quad (5.19)$$

has a nonzero solution. Applying to (5.19) operations rot and $\partial\ \partial t$, we can see that the vectors B and E_{rot} also satisfy the equation of electromagnetic wave in free space of the currents.

Finally, taking into account the requirements used mathematical apparatus of field theory, we write the modified Maxwell's equations, as follows:

$$\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = -\mu\mu_0 J_{rot}, \quad (5.20)$$

$$E_{rot} = -\frac{\partial A}{\partial t}. \quad (5.21)$$

$$B = rotA, \quad (5.22)$$

$$\mathrm{div}\ E_{grad} = \frac{\rho}{\varepsilon\varepsilon_0},$$

$$E_{grad} = -grad\varphi, \quad (5.23)$$

$$J_{grad} + \varepsilon\varepsilon_0\frac{\partial(E_{grad})}{\partial t} = 0.$$

To this must be added the following relationships

$$divA = divB = div\ E_{rot} = rot(E_{grad}) = div(J_{rot}) = rot(J_{grad}) = 0 .$$

The system of Maxwell's equations (5.20-5.23) splits into two independent parts: the description of magnetic phenomena, which serves as a source of electric current J_{rot}. and a description of the electric field E_{grad}, whose source is the charge ρ.

Equations (5.20),(5.21) and (5.22) belong to magnetodynamics. The first equation describes the vortex field vector potential A depending on the value of the eddy current J_{rot}. For the DC vector potential does not depend on time. In this case the second term on the left side is zero, and we get the Poisson equation for the vector potential of a constant magnetic field.

The second relation (5.21) gives the value of a third party (not electric) forces acting on the charge of the magnetic field. This power appears only when you change in the time of the vector potential A, (respectively, and induction B). It is this aspect of power creates the EMF in the secondary winding of the transformer.

Equation (5.23) describes the electrostatic no rotational field E_{grad}. The first equation shows that this field is stationary electric charges. The second equation says about the possibility of the potential for this field. The third equation (5.23) - continuity equation - shows that the current gradient exists only when the gradient field. The bias current J_{grad} not generate a magnetic field.

The electric field $\mathrm{E_{grad}}$ does not depend on the magnetic field. Tension induced electric field E_{rot} determined the time derivative of the vector potential. The magnetic field B derivatives determined the coordinates of the vector potential. Frequent assertion that the alternating electric fields are transformed into magnetic and magnetic variables are converted into electrical ungrounded.

5.2. The second modification of Maxwell's equations

In the system of Maxwell's equations (5.1-5.4), we are dealing only with local changes in the values of the electromagnetic field, i.e. changes in this point of the field. However, the partial derivatives with respect to time can be changed to full. This is the second modification of Maxwell's equations, proposed in this paper. This change seems quite logical. The remote charge can not distinguish due to what acting on his field has changed: due to changes in the intensity of the fix radiation source or by its movement speed v on the charge.

Full time variation of the vector field consists of two parts:

- local changes $\partial \mathrm{A} \quad \partial \mathrm{t}$;
- stationary with terms of the axes

$(\mathrm{v_x}\frac{\partial \mathrm{A_x}}{\partial \mathrm{x}} + \mathrm{v_y}\frac{\partial \mathrm{A_y}}{\partial \mathrm{y}} + \mathrm{v_z}\frac{\partial \mathrm{A_z}}{\partial \mathrm{z}})$ — and similarly for $\mathrm{A_y}$ and $\mathrm{A_z}$.

Finally the total derivative can be written as

$$\frac{\mathrm{dA}}{\mathrm{dt}} = \frac{\partial \mathrm{A}}{\partial \mathrm{t}} + (\mathrm{v} * \mathrm{grad})\mathrm{A}\ .$$

The system of equations (6.1-6.4) with the total derivatives is as follows:

$$\Delta \mathrm{A} - \frac{1}{\mathrm{c}^2}\frac{\mathrm{d}^2\mathrm{A}}{\mathrm{dt}^2} = -\mu\mu_0\,\mathrm{J_{rot}},$$

$$\mathrm{E_{rot}} = -\frac{\mathrm{dA}}{\mathrm{dt}}. \qquad (5.24)$$

$$\mathrm{div}\ \ \mathrm{E_{grad}} \ = \frac{\rho}{\varepsilon\varepsilon_0},$$

$$\mathrm{J_{grad}} + \varepsilon\varepsilon_0\frac{\mathrm{d(E_{grad})}}{\mathrm{dt}} = 0.$$

We expand the expression for the total derivative of the right side of the second equation of (6.24):

$$\mathrm{E_{rot}} = \ \mathrm{v} \times \mathrm{rotA}\ -\frac{\partial \mathrm{A}}{\partial \mathrm{t}} = \ \mathrm{v} \times \mathrm{B}\ -\frac{\partial \mathrm{A}}{\partial \mathrm{t}}. \qquad (5.25)$$

Here we used the formula of vector calculus

$\mathrm{ac\ \ b} = \ \mathrm{ab\ \ c} + \mathrm{a} \times (\mathrm{b} \times \mathrm{c})$, or

$-\ \mathrm{v}\nabla\ \mathrm{A} = \nabla \times\ \ \mathrm{v} \times \mathrm{A}\ \ - \mathrm{v}(\nabla \mathrm{A}).$

By definition of tension $\mathrm{E_{rot}}$ is the force acting on a unit positive charge. The first term in (5.25) determines the force acting in the field on a fixed charge while driving source of static magnetic field. The second term describes the force acting on a stationary charge in an alternating magnetic field of a stationary source. The negative sign in this case shows that the direction of the force is opposite to the current as the source of the magnetic field.

In discussing the parameters of the magnetic field and the induced electric field should be kept in mind the following. Outside of a cylindrical conductor with a current J_{rot} really exists helical flow of gravitons. We call it a vortex flow vector potential A. Simultaneously with the translational motion along the axis of the conductor in the opposite direction of the current it rotates around its axis. In the case of AC has the radial component of the flow of gravitons A of wire (with increasing current) or to the wire (with decreasing current). The flow of gravitons A is thus in all three cylindrical coordinates: z, r, φ.

Rotation graviton flow A to the angle φ we take the presence of a magnetic field B. The flow of gravitons in radius makes possible the movement placed in the flow of electrons in the direction perpendicular to the radial direction, i.e. for z. This possibility we perceive as having a vortex electric field E_{rot}, directed by z.

Given this observation we can write finally the modified Maxwell's equations for the electric field:

$$\mathrm{div}\ \mathrm{E_{grad}} = \frac{\rho}{\varepsilon\varepsilon_0}, \qquad (5.26)$$

$$\mathrm{E_{grad}} = -\mathrm{grad}\varphi; \qquad (5.27)$$

$$\Delta\varphi = -\frac{\rho}{\varepsilon\varepsilon_0}; \qquad (5.28)$$

$$\mathrm{J_{grad}} + \varepsilon\varepsilon_0 \frac{d(\mathrm{E_{grad}})}{dt} = 0. \qquad (5.29)$$

$$\mathrm{div}\ \mathrm{J_{grad}} + \frac{d\rho}{dt} = 0. \qquad (5.30)$$

For tension $\mathrm{E_{grad}}$ and current $\mathrm{J_{grad}}$ always condition

$$\mathrm{rot}(\mathrm{E_{grad}}) = \mathrm{rot}(\mathrm{J_{grad}}) = 0.$$

Equation (5.26) describes the electrostatic field. It allows you to find the scalar potential ϕ and electric field $\mathrm{E_{grad}}$ for a given charge distribution ρ. The continuity equation (5.27) expresses the law of conservation of charge.

We write the Maxwell equations for the vortex component of the electromagnetic field — magneto dynamic and magneto statics:

$$\Delta \mathrm{A} - \frac{1}{c^2}\frac{\partial^2 \mathrm{A}}{\partial t^2} = -\mu\mu_0\, \mathrm{J_{rot}}, \qquad (5.31)$$

$$\mathrm{E_{rot}} = \mathrm{v} \times \mathrm{B} - \frac{\partial \mathrm{A}}{\partial t}. \qquad (5.32)$$

$$\mathrm{B} = \mathrm{rotA}. \qquad (5.33)$$

This condition is always

$$\mathrm{divA} = \mathrm{divB} = \mathrm{div}\ \mathrm{E_{rot}} = \mathrm{div}(\mathrm{J_{rot}}) = 0.$$

Equation (5.31) allows you to find the vector potential A for a given current $\mathrm{J_{rot}}$. Magnetic induction B associated with the vector potential A ratio (5.33). A certain vector potential A (x,y,z,t) you can find the tension of the vortex electric field $\mathrm{E_{rot}}$ from equation (5.32). Modified Maxwell's equations describe the emergence of the vortex field $\mathrm{E_{rot}}$ not only a change of the magnetic field at a given point in time, but the motion of the point on the source.

Modified Maxwell's equations also allow you to emphasize the description of the electromagnetic field are four modes:

1. Electrostatics. The electric charges are fixed. Potential electrostatic field is described by equations (5.26) - (5.28).

2. Standing stationary electric current. Electrical charges move evenly. In this case the stationary potential electric field as described by equations (5.26) - (5.28). It exists only in the direction of the flow of current.

Outside steady flow field is described by the equations:

$$\Delta A = -\frac{1}{c^2 \varepsilon \varepsilon_0} J_{rot}, \quad (5.31.1)$$

$$B = rotA, \quad (5.32.1)$$

$$E_{rot} = v \times B \ . \quad (5.33.1)$$

Current J_{rot}, flowing in a closed circuit, creates a stationary vortex field vector potential A, which is directed in the opposite direction. A vortex field forms vortex field of magnetic induction B. Lock field B is possible by measuring the force E_{rot}, acting on a unit charge moving with velocity v regarding chain.

3. Alternating current — electrical charges — move unevenly. In this case the time-dependent potential electric field is described by equations (5.26) - (5.30). It exists only in the direction of the flow of current. In the no stationary case, the change of the charge density generates a current J_{grad}. This is an unlocked stream of charges, for example, pulse current of electrons from the cathode to the anode in radio tubes.

Outside unsteady flow field is described by equations (5.31) - (5.33). AC J_{rot} flowing in a closed circuit creates a transient eddy field vector potential A. It is described by the wave equation. Vortex field A a vortex of magnetic induction field B. The vortex field E_{rot} is proportional rate of change of the vector potential.

4. Charges and currents are absent. In this case, the wave equation (5.31) contains only the left-hand side:

$$\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = 0.$$

The equation has non-zero solutions, which describe the propagation of the helical flow of gravitons as the graviton perturbations of the medium. We take these disturbances as electromagnetic waves (radio waves).

For example, consider a monochromatic plane wave, the field of which is a periodic function of (t – x/c). Then $\mathrm{A} = \mathrm{A_0}\cos(\mathrm{kx} - \omega\mathrm{t})$, where the wave vector $\mathrm{k} = \frac{\omega}{\mathrm{c}}\mathrm{n}$, (n - unit vector in the direction of wave propagation). Differentiating, we obtain

$$\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = -\mathrm{A_0}\mathrm{k}^2 \cos\ \mathrm{kx} - \omega\mathrm{t}\ \ + \mathrm{A_0}\frac{\omega^2}{\mathrm{c}^2} \cos\ \mathrm{kx} - \omega\mathrm{t}\ \ = 0.$$

Let us try to imagine a picture of moving electrons in a constant electric current. Figure 5.3 shows a portion of the flow in the form of three electrons. Each electron is surrounded by its own attached layer of gravitons (not shown). This provides a stream of electrons in the eigenvalues vector potential A and magnetic moment. The electrons in the stream are the same orientation and follow one after another (as shown) or next to each other. They do not repel. Electrons together with its own attached layer gravitons rotate to the left screw around its axis.

Graviton mass attached layers, exceeding its own, forms the common thread for all attached layer outside the wire (or flow in a vacuum). The outer layer attached gravitons wraps around the flow of electrons, moving steadily in the opposite direction. This movement determines the vortex field of vector potential A. The lines of this field are closed directly through the center of the electrons. We can also say that outside the conductor with current counter flow of energy is flowing.

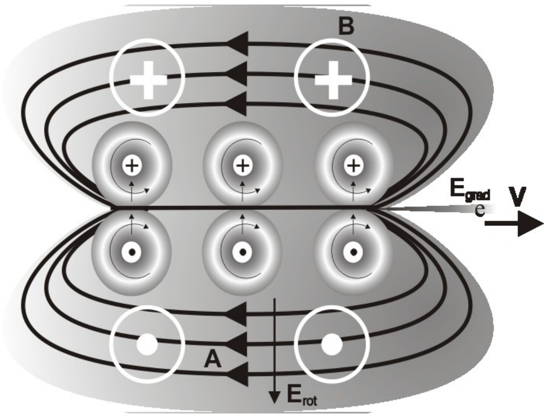

Figure 5.3. Fragment of the structure of the electric current

Simultaneously, the outer layer attached gravitons revolves around the wire (or the flow axis in a vacuum), following the rotation of electrons at a rate close to that of light. This rotation of the attached layer forms a vortex vector field B outside the wire. The field lines of the magnetic induction B are concentric circles.

With increasing current outer layer of attached gravitons will be expanded, and the value of the vector potential A at this point will increase. Formally, we can assume that the rate of change of vector potential forms on the outside of the wire swirl vector field E_{rot}. The direction of vector E_{rot} coincides with the vector potential A. AC will periodically change with time the direction of all vectors E_{grad}, A, B and E_{rot}.

The modification of Maxwell equations allows us to understand the difference between the "electric field" and "vortex electric field" in these equations. The electric field exists as a physical object in the form of forward flow of gravitons inside the wire. The physical meaning of the vector E_{grad} is that it determines the gradient of the energy in this thread. Vortex electric field as the object does not exist. Vector E_{rot} characterizes the rate of change of a vector A - helical vortex flow outside graviton beam of charged particles. The rotation of the flow of gravitons we perceive as a magnetic field, and the angular velocity of rotation measure the magnetic induction B.

It is interesting to note that Maxwell's equations describe the structure of a single electron. Equation (5.26) shows the potential graviton flow in charge tube E_{grad}. Equation (5.31.1) describes the stationary vortex vector potential A, and the magnetic field B as spinning thread A is given by (5.32.1).

It should be noted that in electrodynamics observed quantities are not scalar and vector potentials, i.e. energy and momentum. In various interactions manifest themselves only by their difference, i.e., derivatives with respect to time and coordinates:

$$E_{grad} = -grad\varphi,$$

$$E_{rot} = -\frac{\partial A}{\partial t},$$

$$B = rotA.$$

6. Examples of solutions of Maxwell's equations

Modified Maxwell's equations contain a new voltage values of the gradient E_{grad} and vortex E_{rot} electric field instead of mixed vector E. Therefore, we give a few examples of solutions of equations. While many of the provisions listed below have been opened as independent laws, they are solutions of Maxwell's equations.

6.1. Solutions of Maxwell equations

Gauss Law

Electrostatic problem is to solve the Poisson equation (5.28). As well-known electrostatic potential φ field E_{grad} is from the correlation (5.27). Let the charge density ρ is given as a function x, y, z. Charges are placed in the field (2), and the observer is at point (1).

Solution of equation (5.28) is well known:

$$\varphi\ 1\ =\ \frac{\rho\ 2\ dV(2)}{4\pi\varepsilon\varepsilon_0 r_{12}},$$

where r_{12} is the distance between points (1) and (2).

Applying the Gauss-Ostrogradskii to equation (5.26), we obtain the Gauss law:

$$_S\ (E_{grad})_n\, dS = \ _V\ \frac{\rho dV}{\varepsilon\varepsilon_0}.$$

The total flux of the electric gradient field through a closed surface is equal to the total electric charge enclosed within that surface.

Coulomb's law

Integration of equation (5.28) on the spherical surface of radius R held around the charge ρ, leads to Coulomb's law:

$$E_{grad} = \frac{\rho R}{4\pi\varepsilon\varepsilon_0 R^3}.$$

If the charge q_1 placed at the point (1), and the charge q_2 — to the point (2), then the forces acting on the charges q_1 and q_2 are, respectively:

$$F_{12} = \frac{1}{4\pi\varepsilon\varepsilon_0}\frac{q_1 q_2}{r_{12}^2} e_{12} = -F_{21},$$

where e_{12} is the unit vector directed from q_2 to q_1.

Law of conservation of charge

Charge conservation law is the continuity equation (5.30), expressed in differential form:

$$\mathrm{div}\ J_{grad}\ + \frac{d\rho}{dt} = 0.$$

Integrating over a certain volume, limited by a closed surface S we can rewrite this equation in integral form:

$$\frac{d}{dt}\ \ \rho dV = -\ \ \rho v dS.$$

The left side is positive if the total charge in a given volume increases.

Ampere law

To describe the phenomena of magnetostatic equation (5.31) is written as: $o\mathrm{tB} = \mu\mu_0\, \mathrm{J}_{\mathrm{rot}}$. Here we used the formula of vector analysis:

$$\Delta \mathrm{A} = -\mathrm{rot}\ \ \mathrm{rotA}\ \ + \mathrm{grad}(\mathrm{divA}).$$

By Stokes theorem, the integral of the vector field on a closed circuit is equal to the surface integral of normal component of the rotor of this vector on any surface spanned on the contour:

$$_{\Gamma}\ \mathrm{B\,dl} = \ _{\mathrm{S}}\ \mathrm{rotB\,dS} = \mu\mu_0\ \ _{\mathrm{S}}\ \mathrm{J}_{\mathrm{rot}}\ \mathrm{dS} = \mu\mu_0 \mathrm{I}_{\Gamma}\,.$$

Integral over the surface S from current $\mathrm{J}_{\mathrm{rot}}$ is the total current I_{Γ} through this surface and does not depend on its shape. Circulation B for any closed curve Γ is the total current I_{Γ} through the loop, multiplied by $\mu\mu_0$ (the law of the total current).

Law of Biot and Savart

We find the magnetic induction B the point (1), if current flows in the area (2). For a constant magnetic field from equation (5.31) has the attitude:

$$\Delta \mathrm{A} = -\mu\mu_0\, \mathrm{J}_{\mathrm{rot}}\,.$$

For continuous function $\mathrm{J}_{\mathrm{rot}}$ and tends A to zero at infinity of solutions of the Poisson equation is the Newtonian potential function $\mathrm{J}_{\mathrm{rot}}$:

$$\Delta \mathrm{A}(1) = -\frac{\mu\mu_0}{4\pi}\ \ \frac{\mathrm{J}_{\mathrm{rot}}(2)}{\mathrm{r}_{12}}\mathrm{dV}_2. \qquad (6.1)$$

We find the magnetic induction $\mathrm{B}\ \ 1\ \ = \mathrm{rot\,A}\,(1)$ posed by electric shock $\mathrm{J}_{\mathrm{rot}}$ (2). For this, we apply the operation rot to both sides of equation, using the known formula

$$\mathrm{rot}\ \ \mathrm{fA}\ \ = \mathrm{frotA} + [\mathrm{gradf} \times \mathrm{A}].$$

Since the differentiation is the coordinates of the observation point, the current density $\mathrm{J}_{\mathrm{rot}}$ consider constant. We finally obtain the law of Biot and Savart:

$$\mathrm{B}(1) = -\frac{\mu\mu_0}{4\pi}\ \ \frac{[\mathrm{J}_{\mathrm{rot}}(2)\times \mathrm{e}_{12}]}{\mathrm{r}_{12}{}^2}\mathrm{dV}_2.$$

where e_{12} — Unit vector directed from the field current dV_2 the observation point.

Faraday's law

Faraday formulated his law as follows: the charge Δq, past a closed circuit is proportional to the change in magnetic flux ΔΦ passing through this circuit, and inversely proportional to the resistance circuit R: Δq = ΔΦ / R.

In Maxwell's equations this law is expressed as an electromotive force that arises in the circuit when the magnetic flux. Electromotive force in the chain is defined as the tangential component of the external force per unit charge, integrated over the entire chain. This value is equal to the total work done on unit charge, when he passes once around the circuit. By Stokes theorem, the circulation E_{rot} on a closed circuit is equal to the flow of $rotE_{rot}$ through any surface bounded by the contour Γ:

$$\oint_{\Gamma} E_{rot} dl = \int_{S} rot(E_{rot}) dS. \qquad (6.2)$$

In the integrand insert value E_{rot} from equation (5.32):

$$rot\ E_{rot} = rot\ v \times B - \frac{\partial B}{\partial t} = -\ v\nabla\ B - \frac{\partial B}{\partial t} = -\frac{dB}{dt}.$$

Substituting this value in (5.35), we find that the EMF in closed loop is equal to the rate of change of magnetic flux passing through this circuit:

$$ЭДС = \oint_{\Gamma} E_{rot} dl = -\int_{S} \frac{dB}{dt} dS = -\frac{d\Phi}{dt}.$$

Note that it is taken into account variation of the flow and due to changes in the field and through the movement of the contour, which is not in Maxwell's equations.

For the secondary winding of the inductor containing n turns during the flow in the primary winding of the AC EMF will be determined by the expression

$$EMF = -n\frac{d\Phi}{dt}.$$

Magnetic induction

The phenomenon of the electromotive force (EMF) in the secondary winding of the inductor is the foundation of modern electronics. The main idea of the EMF is that the external force separates the charges in the conductor. It is equal the Coulomb force of attraction of these charges. EMF magnetic induction in the secondary winding of the inductor is operating on charges of external force, summed over the entire length of the chain. More precisely, the tangential component of the force per unit charge, integrated over a guide wire along a closed loop. Integrate both sides of expression (5.32) in a closed spiral secondary winding:

$$EMF = \oint_{\Gamma} E_{rot} dl = \oint_{\Gamma} \left(v \times B - \frac{\partial A}{\partial t}\right) dl. \qquad (6.3)$$

We apply this formula to calculate the EMF in a simple wire loop, consisting of U-shaped fixed part and movable bridges. The loop is placed in a varying magnetic field B perpendicular to the plane of the loop. In the first term, believe that the magnetic induction B does not depend on time, and speed $v = \partial L\ \partial t$ does not depend on coordinates.

Applying Stokes' theorem, we immediately receive the rule flux (Faraday's law):

$$EMF = -\oint_{\Gamma} B \times \frac{dL}{dt} dl - \frac{\partial}{\partial t}\oint_{\Gamma} rotAdS =$$

$$-\int_{S} rot[B \times \frac{dL}{dt}] dl - \frac{\partial}{\partial t}\oint_{\Gamma} BdS=$$

$$-\int_{S} \left(v\nabla\ B - B\ \nabla v \right) dS - \frac{\partial}{\partial t}\oint_{\Gamma} BdS =$$

$$-\int_S \left(v\nabla B - \frac{\partial}{\partial t}B \right) dS =$$

$$-\int_S \frac{dB}{dt} dS = -\frac{d}{dt}\Phi_{mag} ,$$

where Φ_{mag}– the magnetic flux through the surface s stretched in a loop. This takes into account changing magnetic flux and by changing the field and by changing the area of the contour.

Let us again note the following. By definition, EMF is the work on the displacement of charge external (non-electric) forces. EMF can not be obtained by integrating over a closed circuit of electrical tension E as is done now in the solution of Maxwell's equations (5.1-5.4). In our case E_{rot} is no electric and magnetic origin.

The emission of radio waves

Decisions of the wave equation (5.31) $\Delta A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = -\mu\mu_0 J_{rot}$ for the vector potential partial time of A and large distances from the source of well studied. If at all points (2) known density $J_{rot}(x, y, z, t)$, then the field at the point (1) represents the sum of all the spherical waves emitted at the moment (t-r_{12}/c) All the elements of a stationary source located at point (2):

$$A(1) = \frac{\mu\mu_0}{4\pi}\int \frac{J_{rot}(2, t-r_{12}/c)}{r_{12}} dV_2. \qquad (6.4)$$

However, in the modified equation (5.31) by taking into account dependence of the vector potential A for a moving current source in the form of a full second time derivative:

$$\Delta A - \frac{1}{c^2}\frac{d^2A}{dt^2} = -\mu\mu_0 J_{rot}. \qquad (6.5)$$

Applying the equation (6.5) operation rot, we obtain the wave equation for magnetic induction B the source $rot(J_{rot})$:

$$\Delta B - \frac{1}{c^2}\frac{d^2B}{dt^2} = -\mu\mu_0 rot(J_{rot}).$$

Applying the equation (6.5) operation $\partial/\partial t$, we obtain the wave equation for the vector E_{rot} the source $\frac{\partial}{\partial t}(J_{rot})$:

$$\Delta E_{rot} - \frac{1}{c^2}\frac{d^2E_{rot}}{dt^2} = -\mu\mu_0 \frac{\partial}{\partial t}(J_{rot}).$$

The electric potential ϕ does not satisfy the wave equation. Radio waves form a vector potential A and magnetic induction $B = rotA$. These vectors have a shift in the direction of π/2. But by the time they are in phase. Therefore we can not say that the energy in the wave flows for the period of induction B in potential A and vice versa.

Vortex electric field is $E_{rot} = [v \times rot\, A] - \frac{\partial A}{\partial t}$ There is only a change of the vector potential in time or in the source moves relative to the receiver.

Let denote the velocity of the source v. We can calculate the second time derivative in equation (6.5):

$$\frac{d^2A}{dt^2} = \frac{d}{d} \quad v\nabla \ A + \frac{\partial A}{\partial t} \quad = \quad v\nabla \quad v\nabla \ A + \frac{\partial A}{\partial t} \quad + \frac{\partial}{\partial t} \quad v\nabla \ A + \frac{\partial A}{\partial t} \quad = \mathrm{rot}\ v \times \mathrm{rot}\ v \times A \quad -$$

$$2\frac{\partial}{\partial t}\ \mathrm{rot}\ \ v \times A \ \ + \frac{\partial^2 A}{\partial t^2}. \qquad (6.6)$$

Calculate the form of equation (6.5) for the case when the current source moves along the axis OX constant speed. When calculating the expression (6.6) we make the following simplification:

- wave propagates in the direction of the OX axis, the vector $A \perp v$;
- vector A has only a component A_y,
- component A_y vector A depends only on the x-coordinate and time,
- mixed derivatives A_y zero.

Then expression (6.6) is equal $\frac{d^2A_y}{dt^2} = v^2 \frac{\partial^2 A_y}{\partial x^2} + \frac{\partial^2 A_y}{\partial t^2}$.

Equation (6.5) is written as:

$$1 - v^2 \ \ \frac{\partial^2 A}{\partial x^2} + \frac{\partial^2 A}{\partial y^2} + \frac{\partial^2 A}{\partial z^2} - \frac{\partial^2 A}{c^2\, \partial t^2} = -\mu\mu_0\ J_{rot} \qquad (6.7)$$

The values of the coordinates x we must take a retarded time$(x - vt)$. This shows that the coordinates are transformed using the Lorentz transformations:

$$x' \rightarrow \frac{x - vt}{\overline{1 - v^2 \ \ c^2}}, \qquad y' \rightarrow y, \qquad z' \rightarrow z.$$

Thus, the Lorentz transformations are the result of solutions of modified Maxwell's equations. Maxwell's equations describe the field of moving sources. Multiplier $\overline{1 - v^2 \ \ c^2}$ already contained in the equations, so Maxwell's equations are invariant to relativistic transformation. We received (6.7) only the vector potential A, i.e. for magnetodynamics.

6.2 Energy density and vector of energy field flux

In electrostatics, the energy density can be written as

$$u = \frac{\varepsilon\varepsilon_0}{2}(E_{grad} \cdot E_{grad}).$$

In magnetodynamics expression for the energy density takes the form:

$$u = \frac{\varepsilon\varepsilon_0}{2} \ \ E_{rot} \cdot E_{rot} \ \ + \frac{\varepsilon\varepsilon_0 c^2}{2}(B \cdot B).$$

Poynting vector of energy flow

$$S = \varepsilon\varepsilon_0 c^2 \ \ E_{rot} \times B \ , \qquad (6.8)$$

where $E_{rot} = v \times \mathrm{rot}A \ - \frac{\partial A}{\partial t}$, $B = \mathrm{rot}\,A$.

Poynting vector in the general case depends on the speed of the source of the vector potential and the rate of change. For a stationary source in the expression is only a partial derivative in time

$$S = -\varepsilon\varepsilon_0 c^2 \ \ \frac{\partial A}{\partial t} \times \mathrm{rot}A \ . \qquad (6.9)$$

Consider again the long current-carrying conductor (Figure 6.1).

With increasing current in the conductor in the surrounding space there is vortex electric field E_{rot} directed opposite to the original current. By formula (6.9) the Poynting vector is directed along the radius from the wire. As the current will be decreasing direction E_{rot} will be the opposite. Poynting vector is directed along the radius to the wire. The energy will return to the conductor. With a constant current there is not any stream of energy from or to the conductor.

The components of the Poynting vector are derived from the vector potential A time and space. They are shifted in phase relative A in different directions. Energy flow (7.9) is not zero only when changing the vector potential over time. Persistent currents are not accompanied by streams of energy field, which is confirmed by experiment.

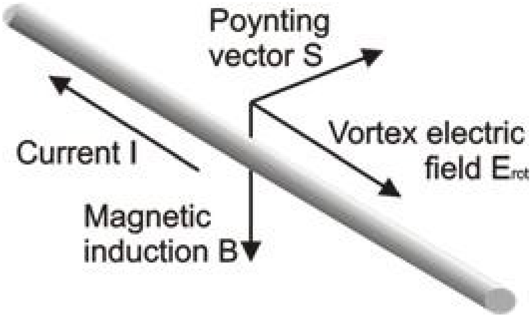

Figure 6.1. Parameters of the field with increasing current in the conductor

For example, consider a monochromatic plane wave field, which is a periodic function of (t-r/c). Then $A = A_0 \cos(kr - \omega t)$, Where the wave vector $k = \frac{\omega}{c} n$, (n — unit vector in the direction of wave propagation). Differentiating, we obtain

$$S = \varepsilon\varepsilon_0 c^2 \omega k A_0^2 \sin^2(kr - \omega t).$$

Integration of the period gives a positive value of this function.

Impulse field

Momentum flux density field (i.e. momentum per unit volume of the field) is equal to the Poynting vector divided by c^2. To obtain a stationary source

$$P = -\varepsilon\varepsilon_0 \frac{\partial A}{\partial t} \times \text{rot}A \quad .$$

Momentum of the field is different from zero only in the no stationary cases. By circulating the field has an angular momentum.

The physical meaning of the vector potential

From equation (28) shows that in the case of an unsteady vortex-party component of the external magnetic force acting on a unit positive charge is $E_{rot} = -\frac{\partial A}{\partial t}$. If we compare this expression with Newton's law, it is obvious and the physical meaning of the vector potential $(-A)$ as impulse, which has a single charge. A field pulse, respectively, equal (A). Thus, the impulse flux of charges offset oppositely directed impulse of vector potential field created by this flow of charges.

Electric potential ϕ the electrostatic field created by electric charges ρ, is the energy of a single positive charge at a given point of the field. Vector potential A magnetic field produced by eddy currents J_{rot}, is negated the impulse of a single positive charge at a given point of the field.