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To the Theory of a Unified Field

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Abstract **Review Article**

Maxwell-like equations are offered that are valid not only for electromagnetic, but also for gravitational fields. They are based on an expanded form of the law of energy conversion, which explicitly takes into account the nonequilibrium of systems and the ability of energy to transfer from one energy carrier to another. This makes it possible to eliminate the distinction between electromechanics and the field theory, to find out the meaning of the magnetic vector potential as a function of the charge rotation speed, to reveal the tensor nature of the magnetic field and the presence of a divergent component of the scalar nature in it. The existence of the Lorentz magnetic forces and the presence of a work-performing moment therein are proved. Maxwell-like equations do not contain field operators and have a simpler form covering nevertheless a broader spectrum of phenomena due to taking into account the convective components of bias currents. Wave equations alternative to the Maxwell ones are offered and the non-electromagnetic nature of light is substantiated.

Keywords: Maxwell equations, electricity and magnetism, potentials and charges, forces and moments, interconversion of fields.

1. INTRODUCTION

One often hears that Maxwell equations "contain all electrodynamics" [1]. Meanwhile, a theory based on these equations does not provide a satisfactory answer to basic questions about what an electrical charge is and what causes the appearance of attractive and repulsive forces in it, how the conductivity and bias currents differ, or the vortex electrical and vortex-free magnetic fields, what the mechanism of their transformation is, as well as the physical meaning of the magnetic vector potential, what the reason of the Lorentz force appearing is and how to avoid its postulation, how magnetic fields work, etc., etc. Many phenomena have been discovered, the explanation of which runs into insurmountable difficulties. Some of them are quite well-known, for example, the distinction between Maxwell electromagnetic field theory and electromechanics, the inapplicability of Maxwell equations for open currents, the violation of the Newton 3rd law for cross currents, the strange exceptions to the flow rule and the features of the Faraday unipolar motor, the violation of the energy conservation law by a pulsating electromagnetic field, the existence of a non-vortex component of the magnetic field and the radiation of a non-electromagnetic nature, etc [2].

All this gives rise to a natural desire to find more reliable foundations of electrodynamics. Such a basis, in our opinion, is a unified theory of the processes of transfer and conversion of any form of energy called energy dynamics for brevity [3]. This theory differs from other fundamental disciplines in that it takes into account the heterogeneity of the systems under study and the presence of the vibrational form of energy while offering the most general form of the law of conservation of energy. In this article, we will try to set out its features in the shortest possible way and, on its basis, eliminate the paralogism of the Maxwell equations [4] and simplify them.

2. Energodynamics as Unified Theory of Energy Conversion Processes

The object of the study of energodynamics [3] is multivariate systems that have certain properties and can be described as a whole by a finite number of state parameters Θ_k such as the mass of the kth substances M_k, their charge Q_k, entropy S_k, momentum P_k, etc.) [1]. Moreover, it proceeds from the concept of short-range action, according to which the energy of the system U does not just disappear at some points in space and appears at others, but is transferred through its boundaries by some energy carrier Θ_i through thermal conductivity, electrical conductivity, diffusion, radiation, etc. For such systems, the law of energy conservation in the form proposed by the Russian scientist N. Umov (1873) [5] is valid:

$dU/dt + \oint \boldsymbol{j}_u \, d\boldsymbol{f} = 0$ ………….. (1)

Where U is the internal energy of the system; j_u is the density of its flow through the vector element $d\mathbf{f}$ of the closed surface of the fixed system of constant volume V in the direction of the outward-directed normal **n** (Figure 1).

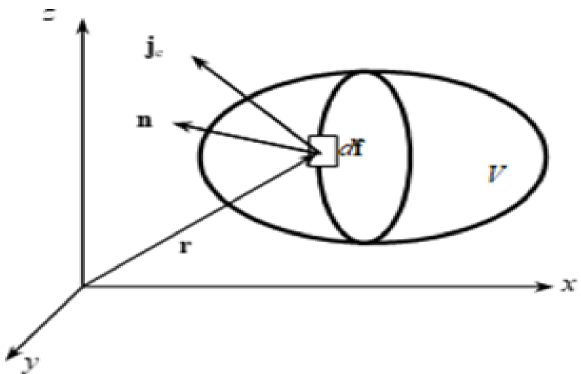

Fig 1: Energy Flow through Boundaries of System

According to the concept of short-range interaction incorporated into this equation, the energy U does not just disappear at some points in space and appears at others, but is transferred by energy carriers Θ_i through the boundaries of the system. This form of the law of conservation of energy takes into account the kinetics of real processes without making any assumptions about the mechanism of energy transfer and the internal structure of the system, i.e., considering it to be a continuous medium.

We now take into account that the energy flux j_u is composed of the j_{uk} flows of the "partial" energy of the kth type U_k, each of which is in turn expressed by the product of the energy flux j_k and its potential ψ_k (specific energy), i.e. $j_{uk}=\psi_k j_k= \psi_k\rho_k\upsilon_k$, where $\boldsymbol{\upsilon}_k$ is the rate of transfer of the kth energy carrier through the fixed boundaries of the system, $\rho_k= d\Theta_k/dV$ is its density. Then

$\boldsymbol{j}_u = \Sigma_k \boldsymbol{j}_{uk} = \Sigma_k\psi_k\boldsymbol{j}_k$ ………………….. (2)

By appealing to the Gauss-Ostrogradsky theorem expression (1) can be converted to the form $dU/dt + \int\nabla\cdot\boldsymbol{j}_u dV = 0$, which, after decomposing $\nabla(\psi_k\boldsymbol{j}_k)$ into independent components $\Sigma_k\psi_k\nabla^\bullet \boldsymbol{j}_k + \Sigma_k\boldsymbol{j}_k^\bullet \nabla\psi_{ki}$ leads to the law of conservation of energy in the form:

$dU/dt + \Sigma_k\int\psi_k\nabla\cdot\boldsymbol{j}_k dV + \Sigma_k\int\boldsymbol{j}_k^\bullet \nabla\psi_k dV = 0$ ………. (3)

[1] Without usual in such cases splitting the system into infinite number of conventionally homogeneous elements of volume or elementary particles

If the average value $\overline{\psi}_k$ of the potential ψ_k and the average value $\boldsymbol{X}_k \equiv \overline{\nabla\psi_k}$ of the gradient of the potential $\nabla\psi_k$ are taken out of the integral sign, equation (3) can be expressed in terms of the parameters of the system as a whole, as is customary in classical thermodynamics:

$dU/dt + \Sigma_k \overline{\psi}_k J_k + \Sigma_k\boldsymbol{X}_k \boldsymbol{J}_k = 0$, (W) …………….. (4)

Here $J_k = \int\nabla\cdot\boldsymbol{j}_k dV = \oint \boldsymbol{j}_k \, d\mathbf{f}$ is the scalar flow of the kth energy carrier through the system boundaries having the dimension and meaning of its "flow rate"; $\boldsymbol{J}_k = \int\rho_k\boldsymbol{\upsilon}_k dV = \Theta_k \overline{\boldsymbol{\upsilon}}_k$ is the vector flow of the same energy carrier having the meaning of its momentum; $\rho_k = d\Theta_k/dV$, $\overline{\boldsymbol{\upsilon}}_k$, is the energy carrier density and the average rate of its transfer.

A more detailed picture of the processes occurring in heterogeneous systems can be obtained by expanding the velocity $\boldsymbol{\upsilon}_k$ into independent translational $\boldsymbol{u}_k$ and rotational $\boldsymbol{w}_k = \boldsymbol{\omega}_k\times \hat{\boldsymbol{r}}_k$ components

$\boldsymbol{\upsilon}_k = \boldsymbol{u}_k + \boldsymbol{\omega}_k\times \hat{\boldsymbol{r}}_k$ …………….. (5)

Where $\boldsymbol{\omega}_k$ is the angular velocity of rotation of a unit volume of the system; $\hat{\boldsymbol{r}}_k$ is the instantaneous radius of rotation of a unit volume of the system.

Then along with the forces $\boldsymbol{F}_k$ in the equation of the law of conservation of energy, their torques $\boldsymbol{M}_k = \boldsymbol{F}_k\times \hat{\boldsymbol{r}}_k$ appear, and the law of conservation of energy takes a more general form:

$dU/dt + \Sigma_k \overline{\psi}_k J_k + \Sigma_k\boldsymbol{F}_k^\bullet \boldsymbol{u}_k + \Sigma_k\boldsymbol{M}_k^\bullet \boldsymbol{\omega}_k= 0$…………..(6)

In this case, the energy exchange of the system with the environment is carried out in three ways corresponding to its three sums. The first characterizes the *transfer* of partial energy $U_k = \int\psi_k\rho_k dV$ through the boundaries of the system without changing its shape [3]. The second and third sums (6) are associated with the *movement* and *reorientation* of the energy carrier Θ_k, i.e. with the work W_k as a quantitative measure of the transformation of the energy of the ith form U_i into some jth form Uj [3].

As follows from the expanded form of the law of conservation of energy (6*), the number of arguments of energy U as a function of the state of the system is equal to the number of independent processes taking place in it*. Moreover, for each form of internal (intrinsic) energy U_k there exists and can be found an independent energy carrier Θ_k and its potential ψ^k as its extensive and intensive measures. In the internal equilibrium (homogeneous) state these energy carriers are uniformly distributed over its volume V. However, in an inhomogeneous state, the radius vector of their center R_k shifts from its initial position, which coincides with the center occupied by the volume system, by a certain amount $\Delta \boldsymbol{r}_k = \boldsymbol{u}_k dt$, and in a more general case, it rotates by the spatial angle $d\boldsymbol{\varphi}_k = \boldsymbol{\omega}_k dt$. If the state of internal equilibrium is taken as the zero point of the displacement vector R_k, then when the system deviates from it, "distribution moments" of energy carriers $Z_k=\Theta_k R_k$ with arm R_k occur, the time derivatives of which determine the energy carrier flows $\boldsymbol{J}_k = d\boldsymbol{Z}_k/dt = \Theta_k \overline{\boldsymbol{v}}_k$. Then the energy of the system as a function of its state takes the form $U = \Sigma_k U_k(\Theta_k, \boldsymbol{r}_k, \boldsymbol{\varphi}_k)$, which allows us to give equation (6) the character of enhanced equality (identity):

$$dU \equiv \Sigma_k \Psi_k d\Theta_k + \Sigma_k \boldsymbol{F}_k^\bullet\, d\boldsymbol{r}_k + \Sigma_k \boldsymbol{M}_k^\bullet\, d\boldsymbol{\varphi}_k \quad \ldots\ldots\ldots\ldots\ldots (7)$$

Where $\Psi_k \equiv \partial U/\partial\Theta_k$; $\boldsymbol{F}_k \equiv \partial U/\partial \boldsymbol{r}_k$; $\boldsymbol{M}_k \equiv \partial U/\partial \boldsymbol{\varphi}_k$ are generalized potentials, forces and their torques in their general physical understanding [2, 3]. With this approach it becomes especially obvious that the thermodynamic forces X_k, found under the constancy of all other variables, including Θ_k, represent the specific value of the force F_k in its general physical sense and have the meaning of the *strength* of the corresponding force field $X_k= F_k/\Theta_k$. The above confirms that *any force fields represent the stress state of the material system*. Moreover, any forces X_k and flows J_k in any discipline that operates on these concepts are given unambiguous meaning of the average gradient of the corresponding potential $\boldsymbol{X}_k \equiv \overline{\nabla}\psi_k$ and the average momentum $\boldsymbol{J}_k = \Theta_k \overline{\boldsymbol{v}}_k$ of the vibrational, translational and rotational motion of the kth energy carrier. It follows that the first sum (6) characterizes the equilibrium energy transfer U_k through the boundaries of the system while maintaining its shape, and its 2nd and 3rd sums are the nonequilibrium part of energy exchange associated with its transformation. At the same time, it becomes obvious that, given the equality of the displacement vector $d\boldsymbol{R}_k$ to the displacement of the energy carrier d_r in the Cartesian coordinate system, any force $\boldsymbol{F}_k = (\partial U_k/\partial \boldsymbol{r}) = \nabla U_k$, i.e. it represents the *gradient of the corresponding energy form U_i. The force fields are generated by the heterogeneous distribution of the energy carriers Θ_k in space*.

It is characteristic that with this (systemic and phenomenological) approach equations (6) do not turn into inequalities despite the explicit inclusion of the non-static state (irreversibility) of the processes under consideration in them. This fact solves the most important "problem of thermodynamic inequalities" which still hinders the application of thermodynamics to real (occurring at a finite speed) processes. It is also important that identity (7) covers all possible processes in an isolated system involving any substances. All this makes identity (7) the most complete (today) expression of the law of conservation of energy and the definition of the concept of energy and its arguments, excluding their free interpretation.

3. Energodynamics as Alternative Basis for Electrodynamics

We apply the mathematical apparatus of energodynamics to "current-carrying" systems with the processes of polarization, magnetization and conversion of electrical energy into any other its form. This apparatus eliminates the need to search for the physical meaning of the parameters used by electrodynamics. For such systems $U_e = U_e(Q, \boldsymbol{R}_e, \boldsymbol{\varphi}_e)$, where Q, $\boldsymbol{R}_e$, $\boldsymbol{\varphi}_e$ is the electrical charge, its displacement vector and its spatial angle, respectively, in the reference frame associated with the center of the volume occupied by the system. The remaining parameters, in accordance with equation (7), acquire the meaning of the electrical potential $\varphi\equiv\partial U/\partial Q$, the moment of charge distribution $\boldsymbol{Z}_e = \rho_e \boldsymbol{R}_e$, current $\boldsymbol{I} = Q\boldsymbol{v}_e$, electrical field strength $\boldsymbol{X}_e = \boldsymbol{E} = \partial U/\partial \boldsymbol{Z}_e$, electrical force $\boldsymbol{F}_e = Q\boldsymbol{E}$ and its torque $\boldsymbol{M}_e = \partial U/\partial \boldsymbol{\varphi}_e$. The above makes the laws of electrodynamics a special case of general physical principles that are valid for the processes of conversion of any form of energy. This fact makes it possible to obtain the basic laws of electrodynamics in a more direct and short way.

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[2]The rule of signs for values Ψ_k, $\boldsymbol{F}_k$ and $\boldsymbol{M}_k$ dictated by equation (1) differs from the one accepted in thermodynamics and other disciplines where the heat to the system and the external work it does are considered positive

One of the main issues concerns the work carried out by the current-carrying system. It is generally accepted that "a magnetic field, as opposed to an electrical field, does not work on the charges moving in it (since the force acting on the charge is perpendicular to its speed" [6]. Therefore, modern electrodynamics cannot give an intelligible answer to the question what the forces rotate the rotors of numerous electric motors, hoist cargos in electromagnetic lifts, etc. It is energodynamics that gives the answers to these questions.

According to identity (7), an electrical charge is capable of doing three independent types of work $đW_e$ [3], corresponding to three sums (7). Such is the work of introducing a charge into any region of the system with potential φ, described by the expression:

$$đW_e' = \varphi dQ \quad \ldots\ldots\ldots\ldots\ldots (8)$$

The work of charge redistribution over the volume of the system associated with its polarization and the appearance of a charge displacement vector $d\boldsymbol{r}_e = \boldsymbol{u}_e dt$

$$đW_e'' = \boldsymbol{X}_e^\bullet\, d\boldsymbol{Z}_e = \boldsymbol{F}_e^\bullet\, d\boldsymbol{r}_e = -\, Qd\varphi \quad \ldots\ldots\ldots\ldots\ldots (9)$$

and the work of reorienting the moment $d\boldsymbol{Z}_e = Q(d\boldsymbol{\varphi}_e \times \boldsymbol{R}_e)$ in space (rotation through an angle $d\boldsymbol{\varphi}_e$)

$$đW_e''' = \boldsymbol{F}_e^\bullet\, (d\boldsymbol{\varphi}_e \times \boldsymbol{R}_e) = -\, \boldsymbol{M}_e^\bullet\, d\boldsymbol{\varphi}_e \quad \ldots\ldots\ldots\ldots\ldots (10)$$

For substances with a “congenital” *ordered charge movement* (for example, permanent magnets) another energy carrier appears, which is the charge momentum $Q\upsilon_e$, usually called the “molecular current”, and the associated *magnetic* component of electrokinetic energy $U_м$. The vector nature of the current $\boldsymbol{I}$ as an energy carrier leads to the fact that the potential $\psi_м = (\partial U/\partial \Theta_м)$ acquires a vector character and the meaning of the speed of the ordered charge motion υ_e:

$\boldsymbol{\psi}_м \equiv (\partial U/\partial \boldsymbol{I})_q = \boldsymbol{\upsilon}_e$ …………….. (11)

In this case the magnetic field strength $\mathbf{X}_м \equiv \boldsymbol{B}$ acquires the meaning of a vector gradient of the charge velocity:

$\mathbf{X}_м \equiv \text{Grad } \boldsymbol{\upsilon}_e \equiv \nabla \boldsymbol{\upsilon}_e$ …………….. (12)

This “magnetomotive” force $\mathbf{X}_м$ is a 2nd-rank tensor that can be decomposed into the scalar component $X_м' = \nabla^\bullet \boldsymbol{\upsilon}_e$ (trace of the tensor) and two components of vector nature: symmetric (vortex-free) $\boldsymbol{X}_м'' = (\nabla \boldsymbol{\upsilon}_e)^s$ and antisymmetric (vortex) $\boldsymbol{X}_м''' = (\nabla \boldsymbol{\upsilon}_e)^a$. The moment of their current distribution $\mathbf{Z}_м$, acquires the same tensor rank, which is defined in this case as the external product of current vectors $\boldsymbol{I} = Q\boldsymbol{\upsilon}_e$ and current displacement $\boldsymbol{R}_м$, i.e., $d\mathbf{Z}_м = \boldsymbol{I}\boldsymbol{R}_м$, as well as the magnetic flux $\mathbf{J}_м = d\mathbf{Z}_м/dt = \boldsymbol{I}\times\boldsymbol{\upsilon}_м$. This circumstance determines the specificity of the magnetic field $\mathbf{X}_м$ arising due to the ordering of molecular currents and their redistribution over the volume during magnetization of ferromagnets, as well as due to the heterogeneous distribution of current over the cross section of conductors (such as the skin-effect).

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[3] The sign of the exact differential “*d*” shows that the elementary work $đW$ depends on the path of the process

However, in electrodynamics a magnetic field is traditionally introduced as a rotor of the vector potential $\boldsymbol{B} = \nabla\times\boldsymbol{A}$[1]:

$\boldsymbol{A} = (\mu_o/4\pi)\int(\boldsymbol{j}_e/R_e)dV$…………….. (13)

Where μ_o is the magnetic permeability of the medium; R_e – the removal of the field point from the current $\boldsymbol{j}_e$.

The physical meaning of this potential and its relationship with the work done by the magnetic field remains unclear until recently, and attempts to break free of its ambiguity by imposing additional conditions (calibrations) of Coulomb, Poincare, Lorentz, the brothers London, Weil, Fock - Schwinger, Landau and, etc. – unsatisfactory [1]. The reason of these difficulties is that its vortex component $\boldsymbol{X}_м''' = (\nabla \boldsymbol{\upsilon}_e)^a$, which is proportional to the angular velocity of the charge $\boldsymbol{\omega}_e$, is taken as a magnetic field $\boldsymbol{B}$. Such a" reduction "of the magnetic field (lowering its tensor rank) excludes its divergent part $\nabla \boldsymbol{A}$ from consideration (Nikolaev's strength) [7] and distorts the physical meaning of the field strength $\boldsymbol{H}$, which in reality is the vortex-free component of the magnetic field and is proportional to the current $\boldsymbol{I}$ and the potential $\boldsymbol{X}_м'' = (\nabla \boldsymbol{\upsilon}_e)^s$. Landau also pointed to the vortex-free nature of this quantity. He considered that it “should have been sought in the form $\boldsymbol{H} = -\nabla\psi$ since rot$\boldsymbol{H}$ is equal to zero” [6]. The fact that the quantity A does not correspond to the concept of potential is at least indicated by the fact that this quantity is proportional to the total current $\boldsymbol{I} = \int \boldsymbol{j}_e dV$, i.e. is an extensive parameter of the system, which is not characteristic of any of the potentials ψ_k. As we see, the true vector magnetic potential is the charge velocity υ_e or its vector components w_e and u_e.

If we take into account the tensor character of the magnetic field $\mathbf{X}_м$, then the work of the magnetic field is expressed by the internal product (convolution) of the tensors $\mathbf{X}_м$ and $\mathbf{Z}_м$. This work can also be decomposed into three components corresponding to three sums (8). According to (8), the first of them, $đW_м'$, occurs when the energy carrier $\boldsymbol{I}$ is introduced into the space region with the potential $\boldsymbol{\upsilon}_e$ under the conditions of the constancy of all other independent variables, including the charge Q. It is determined by the expression

$đW_м' = \boldsymbol{\upsilon}_e{}^\bullet\, d\boldsymbol{I} = Qd\upsilon_e{}^2/2$ …………….. (14)

and is expressed in strengthening the disordered (vibrational or rotational) molecular motion of a free or bound charge. It is this work that “charges” the body and raises the petals of the electroscope.

To find other types of magnetic work, $đW_м''$ and $đW_м'''$, we decompose the displacement velocity of the “current tubes” $\boldsymbol{\upsilon}_м = d\boldsymbol{R}_м/dt$ similarly to (5) into the translational $\boldsymbol{u}_м$ and rotational $\boldsymbol{w}_м = \boldsymbol{\omega}_м\times\boldsymbol{R}_м$ components. The first of them, $đW_м''$, characterizes the shift of the current elements $d\boldsymbol{I}$ during the current redistribution over the system during the polarization of magnets (creating heterogeneous current distribution in them). It is expressed by the scalar product of the force $\boldsymbol{X}_м'' = \boldsymbol{H}$ by the "translational" component $d\boldsymbol{Z}_м'' = \boldsymbol{I}\times\boldsymbol{u}_м dt$ of the tensor $d\mathbf{Z}_м$ and is determined by the expression:

$đW_м'' = \boldsymbol{X}_м''{}^\bullet\, d\boldsymbol{Z}_м'' = \boldsymbol{F}_м{}^\bullet\, d\boldsymbol{r}_м$ …………….. (15)

Where $d\boldsymbol{r}_м = \boldsymbol{u}_м dt$; $\boldsymbol{F}_м = \boldsymbol{I}\times\boldsymbol{H}$ is the magnetic component of the Lorentz force. This work is accomplished, for example, in the process of magnetization of the material (creation of the “north” and “south” poles of the magnet) or when the current is displaced into the surface layer of the conductor (“skin effect”).

The last of the magnetic works, $đW_м'''$, occurs when the magnetization is reoriented, for example, when a ferromagnet rotates in a magnetic field $\boldsymbol{H}$. It is expressed by the product of the vortex component $\boldsymbol{X}_м''' = \boldsymbol{B}$ in the force $\mathbf{X}_м$ by the same component $d\boldsymbol{Z}_м''' = \boldsymbol{I}\times d\boldsymbol{\varphi}_м$, where $d\boldsymbol{\varphi}_м = \boldsymbol{w}_м dt$. If we follow the generally accepted definition of the magnetic induction vector $\boldsymbol{B} = \mu_o \boldsymbol{H}$, this work is determined by the expression similar to (15):

$đW_м''' = \boldsymbol{X}_м''' \bullet d\boldsymbol{Z}_м''' = \mu_o (\boldsymbol{I}\times\boldsymbol{H})\, d\varphi_м\, \boldsymbol{u}_м dt = \mu_o \boldsymbol{F}_м \bullet (d\varphi_м \times \boldsymbol{R}_м) = - \boldsymbol{M}_м \bullet d\varphi_м$ ………….. (16)

Where $\boldsymbol{M}_м = \mu_o \boldsymbol{F}_м \times \boldsymbol{R}_м$ is the torque of the Lorentz force $\boldsymbol{F}_м$.

As we see, finding the Lorentz force does not require either postulation or the involvement of GR. This force differs from other ones only in that it is perpendicular to current, since the latter is displaced in the transverse direction. When this displacement takes the character of rotation, the work is done by the torque of the Lorentz magnetic forces. This fact refutes the conventional wisdom that magnetic forces do not work because they are always perpendicular to the current [6].

Thus, energodynamics eliminates the difficulties of electrodynamics associated with the uncertainty of the concept of vector potential, the rejection of its diverging component, the determination of the magnetic field based on it, the need to postulate the Lorentz force, the impossibility of its work and the existence of a vortex-free component of the magnetic field. This fact not only eliminates the unnatural division between electromechanics and the theory of electromagnetic field (EMF), but also reveals the reason why Maxwell equations could not be strictly derived from the law of energy conservation so limited primarily.

4. Alternative Form of Maxwell Equations

As shown above, the nonequilibrium being explicitly taken into account in the law of energy conservation (4) supplements it with terms characterizing the energy interconversion. In such a case under conditions of isolation of the system ($dU/dt = 0$, $J_k = 0$) its 2nd sum directly vanishes:

$\Sigma_k \boldsymbol{X}_k \bullet \boldsymbol{J}_k = 0$ …………….. (17)

It follows, in particular, that in the processes of the conversion of the electrical field energy $\boldsymbol{X}_e = \boldsymbol{E}$ into magnetic field energy $\boldsymbol{X}_м = \boldsymbol{H}$ the flows $\boldsymbol{J}_e$ and $\boldsymbol{J}_м$ and forces appear to be "opposing":

$\boldsymbol{X}_e \bullet \boldsymbol{J}_e = - \boldsymbol{X}_м \bullet \boldsymbol{J}_м$ …………….. (18)

Such a character of these processes follows from the law of energy conservation and has the general physics character. Therefore we called it the "opposing directivity principle" for processes [8]. In accordance with it the Poynting vector is a superposition of opposing flows of electrical and magnetic energy and, therefore, may by no means be somewhat unified called "electromagnetic energy".

If the direction of the vectors $\boldsymbol{J}_e$ and $\boldsymbol{J}_м$ is considered invariable, expression (18) may be rewritten in the form of the relationship:

$J_м/X_e = - J_e/X_м$ …………….. (19)

From (19) the force $\boldsymbol{X}_e$ has an effect on the rate of an "extraneous" process (flow $\boldsymbol{J}_м$) to the same degree as the "extraneous" force $\boldsymbol{X}_м$ – on the rate of the "disturbing" process (flow $\boldsymbol{J}_e$), but in the direction of its attenuation. In particular, when the usual welding transformer is working, a voltage increase in the welding circuit (secondary winding) is known to lead to decreasing the current in the primary winding, while this decrease, with approaching to "short circuit" mode leads, on the contrary, to current increase in it.

We can show that relation (19 is the missing link that enables the Maxwell equations to be obtained from the first principles of energodynamics [9]. However, we have to resort to a number of artificial assumptions which upon a closer view appear to be inacceptable. Therefore, we should here apply to only such relations which ensue directly from the law of energy conservation (8). For this, we, following Maxwell, should consider the magnetic flux $\boldsymbol{J}_м$ as the total time derivative of the Faraday "magnetic coupling flux" $\boldsymbol{J}_м = d\boldsymbol{B}/dt$, and $\boldsymbol{J}_e$ – as "total current" being the sum of the Maxwell bias current $\boldsymbol{J}_e^c = (\partial\boldsymbol{D}/\partial t)$ and the conductivity current $\boldsymbol{J}_e^п$ as a convective component $(\boldsymbol{\upsilon}_e \bullet \nabla)\boldsymbol{D}$ of the total derivative of the electrical induction vector:

$d\boldsymbol{D}/dt = (\partial\boldsymbol{D}/\partial t)_{\boldsymbol{r}} + (\boldsymbol{\upsilon}_e \bullet \nabla)\boldsymbol{D}$ ………… (20)

Denoting the relation $\boldsymbol{J}_e/\boldsymbol{X}_м$ through the coefficient $L_{eм}$, and $\boldsymbol{J}_м/\boldsymbol{X}_e$ – through the coefficient $L_{мe}$, we can represent the relation (19) in the form of the following pair of equations:

$L_{eм}\boldsymbol{E} = - d\boldsymbol{B}/dt$ …………….. (21)

$L_{мe}\boldsymbol{H} = d\boldsymbol{D}/dt$ …………….. (22)

The first of them directly reflects the Faraday law of electromagnetic induction, according to which the deflection of the galvanometer needle (a value proportional to the field $\boldsymbol{E}$) is determined by the rate of change of the 'magnetic coupling flux' (expressed by the number of magnetic field lines). From the corresponding Maxwell equation expression

$\nabla\times\boldsymbol{E} = - \partial\boldsymbol{B}/\partial t$ …………….. (23)

expression (21) differs in that it does not postulate the existence of a "vortex" electric field, which is why $\boldsymbol{E} \neq - \nabla\varphi$, and does not exclude the "convective" component $(\boldsymbol{\upsilon}_м \bullet \nabla)\boldsymbol{B}$ of the bias in the expression of the total differential of the magnetic induction vector:

$d\boldsymbol{B}/dt = (\partial\boldsymbol{B}/\partial t)_{\boldsymbol{r}} + (\boldsymbol{\upsilon}_м \bullet \nabla)\boldsymbol{B}$ …………….. (24)

Which is due to the redistribution of current over the conductor cross-section and is responsible, in particular, for the skin effect.

Equally, equation (22) differs from the second Maxwell equation
$\nabla\times\boldsymbol{H} = \boldsymbol{J}_e^{п} + \partial\boldsymbol{D}/\partial t$ …………….. (25)

by replacing the "rot" operator by the coefficient L_{Me} and by the fact that it does not exclude the presence in the term $(\boldsymbol{v}_e \bullet \nabla)\boldsymbol{D}$ along with the conduction current $\boldsymbol{J}_e^{п}$ (taking into account the charge motion relative to the conductor), the "convective current" $\boldsymbol{J}_e^{к}$ associated with the movement of the conductor or dielectric in the magnetic field. Taking this component into account makes it possible to explain, for example, the appearance of a magnetic field during rotation of an electrically neutral metal disk (the Rowland–Eichenwald, and Roentgen–Eichenwald effects), as well as the polarization of the dielectric plate when it moves in a magnetic field (Wilson–Barnett effect) [1]. The movement of the charge along with the disk or plate also explains why in unipolar Faraday motors, the emf arises where the "flux" $\partial\boldsymbol{B}/\partial t$ does not change and does not occur where this flux changes. This eliminates the need to use different laws of force for the case of a moving contour and a changing field noted by R. Feynman [10]. Thus, two pairs of equations: (21), (22) and (20), (24), along with their extreme simplicity, non-postulate nature, and complete symmetry, cover a broader spectrum of phenomena than Maxwell equations. This fact makes them alternative to these equations.

On the other hand, the "Maxwell-like" equations (21) and (22) reveal the reasons why Maxwell had to resort to several postulates. The fact is that the equations of the law of conservation of mechanical and internal energy that existed at that time did not contain any specific parameters of the nonequilibrium "electrotonic" state and could not serve as the basis for obtaining relations (19). These relations were a consequence of energy conversion law (4), in which the forces $\boldsymbol{X}_i$ and flows $\boldsymbol{J}_i$ are of the vector nature. This circumstance corresponds to the universal Curie symmetry principle, according to which only phenomena of the same tensor rank can interact [11]. Therefore, the relation between the vortex magnetic field of the 2nd tensor rank $\boldsymbol{B}$ and the electric field of the 1st tensor rank $\boldsymbol{E}$ is impossible. However, this fact was not known in Maxwell's time. Therefore, the Maxwell intuition is especially noteworthy because it prompted him a bias current should be introduced. It was assumed that current should be equal to the conductivity current and prolong it even in vacuum thus allowing the creation of a closed loop circuit and expression of electric field through the "rot" operator as magnetic field. Meanwhile, the bias currents are directed towards conductivity currents. This fact causes the disappearance of their sum at the end of the capacitor charging process. Thus, the row of contradictions appeared that has finally led to the introduction of the electromagnetic field (EMF) concept [12]. All this makes the replacement of Maxwell equations with "Maxwell-like" equations (21, 22) and (20, 24) all the more appropriate, especially considering their applicability to any natural phenomena and the possibility of direct using in this case the relations (19) not requiring the knowledge of the empirical coefficients L_{eM} and L_{Me}.

5. Maxwell-Like Gravity Equations

The idea of the unified description of the relationship between electromagnetic and gravitational fields laid down in the law of energy conservation (7), was first realized in the equations of gravitoelectromagnetism (GEM) by O. Heaviside (1893) when he reformulated the original Maxwell equations [13]. In them, as an analog of the charge density ρ_e, current density $\rho_e\boldsymbol{v}_e$, strength of electric E and magnetic fields B, etc., the same parameters of the gravitational field (with the index "g") were considered, i.e. ρ_g, $\rho_g\boldsymbol{v}_g$, $\boldsymbol{E}_g$, $\boldsymbol{B}_g$, etc. In this case, the gravitational force, like the Lorentz force, was assumed to consist of two components, one of which, $\rho_g\boldsymbol{E}_g$, was responsible for the acceleration of particles, and the other, $\rho_g\boldsymbol{v}_g\times\boldsymbol{B}$ – for their rotation. Owing to this, the Heaviside equations for the GEM had the same form as for the EMF.

However, for this, he had to assume the possibility of converting a relatively weak gravitational field into an electromagnetic (and vice versa) and neglect the fundamental difference between the gravitational field from electric and magnetic fields, which are characterized by both attraction and repulsion. Finally, we also had to admit the presence of a vortex component in the gravitational field and the equality between the propagation velocity of gravity c_g and the speed of light c. All this in those days had no experimental grounds and only strengthened the nature of Maxwell equations as postulate.

All this can be avoided by applying relations (19), which follows from the law of conservation of energy and therefore is valid for any of its forms and any components of gravitational and electromagnetic fields of the same tensor rank. In particular, for the vortex (axial) components $\boldsymbol{X}_M''$ and $\boldsymbol{X}_g$ of gravitational and electromagnetic and fields, relation (19) is more conveniently written based on expression (6) through the corresponding torques $\boldsymbol{M}_e$, $\boldsymbol{M}_g$ and angular velocities $\boldsymbol{\omega}_e$ and $\boldsymbol{\omega}_g$:
$M_e/M_g = - \omega_g/\omega_e$ …………….. (26)

This expression directly implies the fundamental possibility of whirlwinds, tornadoes, cyclones and anticyclones, storms, and hurricanes in the atmosphere of our planet when it moves in outer space with different vorticity of the "hidden matter" of the Universe. It is possible that these cosmophysical factors give rise to the other geophysical phenomena on the Earth [14].

6. Alternative to Maxwell Wave Equations

As follows from the energy conservation law (6), the density ρ_k of not only the energy carrier Θ_k , but also of its energy U, is a function of time t and the position $\boldsymbol{r}_k$ of its center, i.e., $\rho_k = \rho_k(t, \boldsymbol{r}_k)$.In this case, its complete change in time includes two components

$d\rho_k/dt = \partial\rho_k/\partial t + (\boldsymbol{\upsilon}_k\cdot\nabla)\rho_k$ …………….. (27)

At its core, this expression corresponds to the wave equation in it's the so-called "single-wave" approximation. Unlike the "dynamic" second-order equation corresponding to Maxwell equations, it describes a wave propagating in only one direction (from the source). This kind of wave equation is often called "kinematic" [15]. Its belonging to the wave equations becomes especially evident if expression (27) is represented in the form of a "damping" wave (with the damping function $\Phi(\boldsymbol{r}, t) = d\rho_k/dt < 0$) or "excitation" wave (with the excitation source $f(\boldsymbol{r}, t) = d\rho_{uk}/dt > 0$):

$\partial\rho_k/\partial t + \boldsymbol{\upsilon}_k\cdot(\partial\rho_k/\partial \boldsymbol{r}) = \Phi(\boldsymbol{r}, t)$ …………….. (28)

Where $\boldsymbol{\upsilon}_k$ is the phase velocity of the wave.

This equation is based on the law of conservation of energy and, therefore, is valid for describing the vibrational motion of any energy carrier Θ_k. For nonlinear media with dispersion at low frequencies it is known as the Klein–Gordon equation, and with dispersion, at high frequencies, it is known as the Korteweg–de Vries equation [15]. It is applicable to describe the wave transfer of energy into the environment of the system.

Indeed, only the medium having the gravitational energy and, therefore, able to interact with countless kth elements and their compounds regardless of their structure and any other properties except mass, can transfer the radiant energy in space. Such a universal medium is the primal matter comprising, according to the current date, at least 95% of the mass of the entire Universe, no matter how called – "ether", "hidden mass", "physical vacuum", "unstructured", "dark", "non-baryonic" matter, etc.). Generally speaking, that should have become clear yet in Maxwell's time when there were already known several types of radiation unscreened from electromagnetic field (EMF). The concept of EMF as a material medium "detached" from its source and transferring energy "after it has left one body and has not yet reached another" was also disputable. [14]. Such a "materialization" of EMF violated the law of energy conservation due to the in-phase variation of the vectors $\boldsymbol{E}$ and $\boldsymbol{H}$ in the expression of EMF energy $U = \varepsilon_o\boldsymbol{E}^2/2 + \mu_o\boldsymbol{H}^2/2$ [2]. N. Tesla [16] also emphasized the non-electromagnetic nature of light. He experimentally proved that the electromagnetic oscillations in a matter transformed into the ones of another ("radiant") nature in luminiferous medium, and then restored their initial form in radiation detector or receiver. The inconsistency of the electromagnetic concept of light was subsequently confirmed by the absence of the magnetic component in EMF equal in power to the electrical one [12]. The absence of electrical and magnetic properties for any of the luminiferous media considered above, as well as for photons, has become an additional argument against the electromagnetic concept of EMF.

Meanwhile, not only the Maxwell equations based on many assumptions not subsequently confirmed reflect the wave character of the radiation process. The more simple "kinematic" equations of the 1st order (28) also cope with the task.

According to (8), $(\partial U_k/\partial \boldsymbol{r}) = \boldsymbol{F}_k = \Theta_k\boldsymbol{X}_k$,, so that the second summand in (27) characterizes the power of oscillations of the kth energy carrier Θ_k in the system. Under stationary conditions ($\partial U_k/\partial \boldsymbol{r} = 0$) this oscillatory process is supported by the excitation source $\Phi(\boldsymbol{r}, t)$ and accompanied by the radiation with the certain frequency spectrum ν. The power of this radiation dU_r/dt is expressed similar to other kinds of work:

$đW_r/dt = \boldsymbol{X}_r\cdot\boldsymbol{J}_r$ …………….. (29)

Where $\boldsymbol{X}_r = \nabla(A_\nu\nu)$ is the driving force of radiant energy exchange expressed through the gradient of the "amplitude-frequency" potential of the wave $\psi_\nu = A_\nu\nu$ [17]; $\boldsymbol{J}_r = \Theta_r\boldsymbol{c}_g = MA_\nu\nu\boldsymbol{c}_g$ is the radiant flux of the running wave impulse having the dimension of energy.

It follows that the process of radiation transfer by running waves follow the same regularities as the processes of thermal conductivity, electrical conductivity, diffusion, etc [17]:

$\boldsymbol{J}_r = -L_r\boldsymbol{X}_r$ …………….. (30)

Where L_r is the proportionality factor characterizing the "transparency" of intergalactic medium and defining the value of the "red shift" caused by the dispersion of radiant energy.

The wave theory explains many peculiar features of the radiation processes not outstepping the frames of classical physics [18]. According to the above, the oscillatory process in the primal matter induces in the structural elements of the baryonic matter oscillations at their resonant frequencies, due to which the baryonic radiation differs from the background one in spectral characteristics. This is what makes the baryonic matter visible (observable), and its radiation – comprising the entire frequency band.

Thus, the fact that the Maxwell wave equations may be replaced by the simpler equations (28) extends the sphere of application of the law of energy conservation (8) toward any processes of the energy conversion including those having the wave character [4].

[4] In this case the solutions found for one value of the wave potential ψ_ν may be spread to infinite combination of amplitudes A_ν and frequencies ν with the product equal to this value

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