Basic Laws of EM Theory

Branko Mišković*

Independent, Novi Sad, Serbia

.

ABSTRACT

Instead of *electric charge*, as the basic substance of EM theory, respective *static potential*, as some energetic fluid – in the *dielectric*, *non-resistive* and *reactive* medium – is here taken as the starting quantity. All the remaining EM quantities are thus defined in the succession, by the standard *differential* equations, with *algebraic* relations and *central* laws derived as their formal consequences. Not only that majority of the former results are confirmed, but some of them are completed, rationally interpreted and mutually related. On the other hand, a few formal concepts appear as inadequate or excessive at least.

Keywords: EM theory, differential equations, algebraic relations, central laws

1. INTRODUCTION

EM forces are ascribed to electricity, as the bipolar substance. Elementary forces between two charges, in the functions of their mutual position, simultaneous motion and acceleration of one of them, are to be expressed by respective central laws. On one hand, these laws should be generalized into *algebraic relations* between moving bodies – as the carriers and objects, and – on the other, into respective differential relations in the medium. Not only that such two-directional development is very complicated, but it is only incompletely carried out in [1]. Apart from convincing explanation of already known intuitive and empirical relations, remaining problems are mainly resolved in [2], with consistent fillings in of the inherited gaps. Instead, successive introduction and relation of EM quantities here starts from the static potential, as some energetic fluid, at least in the conditional sense.

Bipolar static potential, as some electric disturbances around carrying charges, is projected from 4D space, along temporal axis [3]. Tending to the absolute medium homogeneity and neutrality [4], two equipolar particles mutually repel, and opposite ones attract each other. A moving potential is followed by the medium polarization, as the opposite reaction. Its own variations form respective displacement currents. Being elastically restricted by the medium, these currents demand the continual motion of the carriers through 3D/4D space. Such two parallel currents interact by transverse *kinetic* forces, expressed by magnetic field. Against their variation, the medium reacts by the *dynamic* forces, as induction or inertia, proportional to its own density. The speed of propagation is determined by the product of the two medium features, its *density* (μ) and *elasticity* (ε): $c = 1/\sqrt{\varepsilon\mu}$.

After successive introduction of the standard *differential* equations, relating EM fields and/or potentials on the three kinematical states, their carriers and objects, as the moving bodies, are then related *algebraically*. In the final instance, *central laws* determine the elementary interactions of two punctual charges, in the functions of their respective kinematical relations: mutual position, simultaneous motion and acceleration of at least one of them. The two latter

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

basic sets are elaborated and completed. All their equations are finally formulated, and the ranges of their application precisely determined. With mutual relation of the known, so far as if independent empirical facts and/or particular mathematical relations, a few nearly forgotten problematic experimental results are convincingly explained. The completed, consistent and convincing EM theory is thus obtained and briefly presented.

2. STATIC RELATIONS

The static potential is proportional to the *energy density*. Its own gradient is balanced by the opposite medium polarization. With respect to the inverse field function, it is denser around smaller (positive), and sparser around greater (negative) particles. Tending to the medium homogeneity, equipolar particles mutually repel, and opposite ones attract each other. One medium strain, as the elementary potential, provides the energy for all other such strains, as the *objects*. This potential determines the *static field* (1a), as the medium stress. Depending on the medium *elasticity* and this field, some electric *displacement* (1b) is thus formed, and its divergence just represents the carrying *charge* (1c):

$$\nabla\boldsymbol{\Phi} = -\mathbf{E}\,, \qquad \varepsilon\mathbf{E} = \mathbf{D}\,, \qquad \nabla\cdot\mathbf{D} = Q\,. \tag{1}$$

Each new member of the four static quantities is the formal feature of the preceding one. The static field is the mere gradient of respective potential. The field line beginnings are considered as positive, and terminals – as negative charges. Thus introduced, the static quantities are the bases for following definition of kinetic ones.

3. KINETIC RELATIONS

3.1 Convective Phase

This phase of the kinetic interactions concerns the production of kinetic, by motion of static quantities. The medium non-resistance enables the smooth displacement currents, at motion of the static quantities through 3D space or along temporal axis. In parallel with the current field defined (2a), the common motion of static potential, as the medium strain, forms *kinetic* potential (2b), as respective linear momentum density:

$$\mathbf{J} = Q\mathbf{V}\,, \qquad \mathbf{A} = \varepsilon\mu\boldsymbol{\Phi}\mathbf{V}\,. \tag{2}$$

The product of the elasticity, density and strain disturbance, gives the density disturbance $(\varepsilon\mu\boldsymbol{\Phi})$, and its motion represents the kinetic potential $(\mathbf{A})$. The moving charges and their potentials form the two collinear quantities: electric current and kinetic potential. At motion of the negative static quantities, the two kinetic are opposite.

Starting from (2), as the two definitions of kinetic, – by motion of static quantities, let us now determine respective two continuity equations. *Div*-operation applied to (2) gives these two equations, via the sums of respective middle terms:

$$\nabla\cdot\mathbf{J} = Q\,\nabla\cdot\mathbf{V} + \mathbf{V}\cdot\nabla Q \;= -\,\partial_t Q\,, \tag{3a}$$

$$\nabla\cdot\mathbf{A} = \varepsilon\mu\,(\boldsymbol{\Phi}\,\nabla\cdot\mathbf{V} + \mathbf{V}\cdot\nabla\boldsymbol{\Phi}) = -\varepsilon\mu\partial_t\boldsymbol{\Phi}\,. \tag{3b}$$

Dilatations and *convections* of the two static, form respective kinetic quantities. The static potential carried by respective charge behaves as a rigid structure, of the homogeneous

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

speed. The former terms thus annul, with the convective derivatives $(\mathbf{V}\cdot\nabla = -\partial_t)$ – in the latter terms. Of course, it is opposite to the moving gradient.

In analogy with Bernoulli's effect in fluids, two parallel flows interact by transverse kinetic forces, and crosswise ones – by respective torques [4]. Both these interactions, conditioned by the transverse gradient or *curl* of the kinetic potential (2b), are determined by magnetic field (4a). On the other hand, its own *curl* will be soon identified as the total current field (4c), flowing in the conducting and dielectric structural layers.

$$\nabla\times\mathbf{A} = \mathbf{B}, \qquad \mathbf{B} = \mu\mathbf{H}, \qquad \nabla\times\mathbf{H} = \mathbf{J} + \partial_t\mathbf{D}. \tag{4}$$

The total field depends on the medium density (4b). *The force fields* (E,B), introduced via potentials (1a,4a), are called *covariant*, and two *rational* (D,H) – related with the carriers (1c,4c), – *contra-variant*. The *constitutive* relations (1b,4b) point to their cross-classification: the *total* fields (D,B) and their *vacuum* components (E,H). At least in the homogeneous isotropic media, the two constants are scalar quantities.

Each new kinetic quantity is the formal feature of preceding one. The magnetic field, as the intermediate quantity, is perpendicular to the external two, usually mutually collinear, kinetic quantities. Alike the relations (2) – of the carriers or potentials, the intermediate quantities are similarly related. The substitution of (2b) into (4a) gives:

$$\mathbf{B} = \varepsilon\mu(\mathit{\Phi}\nabla\times\mathbf{V} - \mathbf{V}\times\nabla\mathit{\Phi}) = \mu\mathbf{V}\times\mathbf{D}, \qquad \mathbf{H} = \mathbf{V}\times\mathbf{D}. \tag{5}$$

At motion of rigid, stably oriented static quantities, the former middle term annuls. In accord with (1a), the latter term gives the kinetic convective relation (5b). A moving electric, forms respective magnetic field, causing the transverse kinetic forces. Really, *curl* applied to (5b), excluding spatial derivatives of the field speed, gives (4c):

$$\nabla\times\mathbf{H} = \mathbf{V}\nabla\cdot\mathbf{D} - \mathbf{V}\cdot\nabla\mathbf{D} = \mathbf{J} + \partial_t\mathbf{D}. \tag{6}$$

Here $\mathbf{V}\nabla\cdot\mathbf{D} = \mathbf{V}Q = \mathbf{J}$ is the current of free electricity, and $\mathbf{V}\cdot\nabla\mathbf{D} = -\partial_t\mathbf{D}$ – the convective derivative of electric displacement, or respective current.

3.2 Relative Phase

The relative phase concerns the actions of kinetic fields upon moving static, or respective kinetic quantities. Apart from the present kinetic fields, respective forces also depend on the object motion. The interaction of the two kinetic potentials or respective currents, at least in their parallel position, may be expressed by the two *equivalent* (nominally – static, but in fact – kinetic) quantities, the potential and respective charge:

$$\mathit{\Phi}_k = -\mathbf{v}\cdot\mathbf{A}, \qquad Q_k = -\varepsilon\mu\mathbf{v}\cdot\mathbf{J}. \tag{7}$$

This pair of equations is formally inverse to the definitions (2), with the opposite signs, and the product $\varepsilon\mu$ – consequently replaced. They concern only the parallel motion, but speak nothing about the torque between crosswise currents. Negative signs point to the transverse attraction in the parallel motion. *Grad* applied to (7a), without spatial derivatives of punctual object speed, gives the equivalent (kinetic) electric field:

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

$$\mathbf{E}_k = \mathbf{v}\times\nabla\times\mathbf{A} + \mathbf{v}\cdot\nabla\mathbf{A} = \mathbf{v}\times\mathbf{B}\,. \tag{8}$$

Longitudinal gradient of the unidirectional potential equals to its divergence. In the case of two moving charges, with the divergence (3b) – of the potential, the latter term thus tends to equalize the two speeds. It forms the torque acting on the 'dipole' consisting of two charges moving at their different speeds. In the case of a line current, with longitudinal homogeneity of its kinetic potential $(\nabla\cdot\mathbf{A} = 0)$, the latter term annuls.

At transverse object speeds, when $\nabla\mathbf{A} = \nabla\times\mathbf{A} = \mathbf{B}$, the two terms (8) cancel each other, in accord with the defective sense of (7). Therefore, the latter term must be finally missed. The remaining term causes a torque tending to the same courses of the two crosswise currents. *Div* operation applied to (8) gives the equivalent charge:

$$Q_k = \varepsilon(\mathbf{B}\cdot\nabla\times\mathbf{v} - \mathbf{v}\cdot\nabla\times\mathbf{B})\,. \tag{9}$$

The condition of the zero charge points to circular motion of a free charge around magnetic field. This is expressed by *curl* of the object speed – in the former term. At rectilinear motion – this term annuls, and the letter term just returns to (7b).

4. DYNAMIC RELATIONS

With respect to reactive medium, time derivative of the kinetic potential, as linear momentum density, gives the dynamic forces, expressed by electric field:

$$\mathbf{E} = -\partial_t\mathbf{A}\,, \qquad \nabla\times\mathbf{E} = -\partial_t\mathbf{B}\,. \tag{10}$$

Curl applied to (10a), with respect to (4a), gives (10b). On the other hand, *div* applied to (4a) gives the *trivial* Maxwell's equation: $\nabla\cdot\mathbf{B} = 0$. It only speaks against existence of the free magnetic poles and respective non-vortical field.

The kinetic potential and magnetic field are the two perpendicular vortical fields, With their gradient perpendicular to the common surface. The motion in this direction varies them at a resting point, with production of the dynamic field (10a):

$$\mathbf{E} = -\partial_t\mathbf{A} = \mathbf{U}\cdot\nabla\mathbf{A} = \mathbf{B}\times\mathbf{U}\,. \tag{11}$$

Here $\mathbf{U}$ is the transverse speed of the kinetic potential and magnetic field, restricted to the field line plains, where $\nabla\mathbf{A} = \nabla\times\mathbf{A} = \mathbf{B}$. Really, in the inverse mathematical sense, *curl* applied to the external equality of (11) just gives (10b):

$$\nabla\times\mathbf{E} = \mathbf{U}\cdot\nabla\mathbf{B} - \mathbf{U}\nabla\cdot\mathbf{B} = -\partial_t\mathbf{B}\,. \tag{12}$$

The speed derivatives of the rigid magnetic field – stably oriented in space – are missed. Magnetic field moving along its gradient, in its own field line planes, induces the dynamic forces, represented by respective electric field (11).

5. DIFFERENTIAL SET

5.1 Basic Equations

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

The three differential pairs – static (1a,c), kinetic (4a,c) and dynamic (10) – taken together form the two subsets: *gauge conditions* (13) and *Maxwell's equations* (14). The former set defines the fields by potentials, and latter – the carriers by fields. In fact, the fields are formal features of respective potentials, and the carriers – of fields.

$$-\nabla\Phi = \mathbf{E}_{\mathrm{s}} , \qquad \nabla\times\mathbf{A} = \mathbf{B} , \qquad -\partial_t\mathbf{A} = \mathbf{E}_{\mathrm{d}} ; \tag{13}$$

$$\nabla\cdot\mathbf{D} = Q , \qquad \nabla\times\mathbf{H} - \partial_t\mathbf{D} = \mathbf{J} , \qquad \nabla\times\mathbf{E} + \partial_t\mathbf{B} = \mathbf{0} . \tag{14}$$

Owing to their distinct origins, static and dynamic fields demand respective indexes (13a,c). With respect to their geometrical forms, these indexes are excessive in (14a,c). Unlike the former EM theory, founded on electricity and its currents, the two potentials appear as the most relevant EM quantities. Describing the energetic states of the medium, they are the starting notions in this brief presentation of EM theory.

The three pairs of the equations concern mutual differential relations of the quantities on respective three kinematical states – static, kinetic and dynamic – being dependent on the presence, motion or acceleration, respectively, of the three static quantities. Apart from the two potentials, time derivative of the kinetic potential may be taken as the dynamic potential. Irrespective of the trivial one, $\nabla\cdot\mathbf{B} = 0$, three relevant Maxwell's equations, in common with respective gauge conditions, form the hierarchical trinity.

5.2 Field Tensors

The two pairs of Maxwell's equations (static & kinetic with trivial & dynamic) in their componential forms represent the two sets of four partial differential equations each. With general ordinal indexation, they form the two tensor equations:

$$\Sigma_n \partial_n R_{mn} = J_m , \qquad \Sigma_n \partial_n F_{mn} = 0 . \tag{15}$$

Here $m = 0,1,2,3$ is the ordinal number of the equations, with the summation of the terms per the index $n \neq m$. The electric charge carried by the cosmic expansion along temporal axis forms respective current component (J_{o}). In the absence of the free magnetic poles and respective currents, the latter equation fails of the free term. The field components are identified by the two following tensors, as the bi-vectors:

$$R_{mn} = \begin{bmatrix} 0 & +D_x & +D_y & +D_z \\ -D_x & 0 & +H_z & -H_y \\ -D_y & -H_z & 0 & +H_x \\ -D_z & +H_y & -H_x & 0 \end{bmatrix} , \qquad F_{mn} = \begin{bmatrix} 0 & -B_x & -B_y & -B_z \\ +B_x & 0 & +E_z & -E_y \\ +B_y & -E_z & 0 & +E_x \\ +B_z & +E_y & -E_x & 0 \end{bmatrix} . \tag{16}$$

They express all the field components, the former – of *rational* $(R_{mn} = D,H)$, and latter – of the *force fields* $(F_{mn} = B,E)$. Their formal distinction, as *contra-variant* and *co-variant*, is neglected. The six term pairs accord to the six planes, as the field locations. The first rows and columns concern longitudinal planes (tx, ty, tz) – in the temporal, and remaining sub-tensors – transverse planes (xy, yz, zx) – in spatial domains. Due to disparate term signs, these two tensors cannot be dually related even at vacuum.

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

Each tensor affirms 4D space, as the ambient of EM phenomena. The opposite positions of the rational and force fields point to the two structural levels, electric and magnetic ones. With respect to the *apparent* – electric, and *transparent* magnetic poles, the former tensor is more relevant. Therefore, EM potentials, forming 4D vector, belong to the four axes: static to t, and kinetic to x, y, z. The field carriers, as the tri-vector, belong to respective 3D sub-spaces. The projection into 3D reduces t-axis into the scalar time, and electric quantities (from respective subspaces) lose this one dimension.

5.3 Derived Equations

Apart from the three relevant Maxwell's equations and respective gauge conditions, relating the successive ranks of EM quantities, the carriers and potentials can be related directly, by the two Riemannian, second order differential equations:

$$\varepsilon\mu\,\partial_t^2\Phi - \nabla^2\Phi = Q/\varepsilon\,, \qquad \varepsilon\mu\,\partial_t^2\mathbf{A} - \nabla^2\mathbf{A} = \mu\mathbf{J}\,. \tag{17}$$

With respect to (3b), (14a) applied to the sum of (13a,c) relates the two electric quantities, charge and static potential (17a). With respect to (2b), (17a) multiplied by $\varepsilon\mu\mathbf{V}$ gives (17b). Their temporal terms arise from dynamic, and spatial – from static electric fields. Maxwell's equations understand both electric fields $(\mathbf{E}_s + \mathbf{E}_d)$, speaking in favour of their final unity in tr-planes. At dielectric media, without free electricity and current, these two reduce into the wave equations, with the known solution: $r = t/\sqrt{\varepsilon\mu} = ct$.

The moving fields carry their energies. Dot multiplication of the kinetic Maxwell's equation by $\mathbf{E}$, and of dynamic one – by $\mathbf{H}$, with subtraction of the latter from former results, gives a 5D continuity equation, with the *spatial*, *temporal* and *substantial* terms. As such, it affirms a *structural* dimension, as the fifth. EM phenomena thus develop in and/or between the four structural layers: *vacuum*, *dielectric*, *magnetic* & *conducting* ones.

$$\nabla\cdot(\mathbf{E}\times\mathbf{H}) + \partial_t W + \mathbf{E}\cdot\mathbf{J} = 0\,, \qquad \mathbf{S} = \mathbf{E}\times\mathbf{H} = \mathbf{D}\times\mathbf{B}c^2\,. \tag{18}$$

The equation (18a) is well-known as Poynting's theorem. Its temporal term expresses the variation of energy density, and substantial one $(\mathbf{E}\cdot\mathbf{J} = \mathbf{F}\cdot\mathbf{V})$ – the power of its dissipation. This term may be understood as the energy dislocation along the fifth axis, from one into another structural layers. Cross product of the two fields, in the spatial term, is the *current field* $(\mathbf{S})$ of EM energy (18b). In comparison with Einstein's equation, the product of the two total fields is equivalent with the linear momentum density.

6. ALGEBRAIC SET

6.1 Basic Equations

The algebraic equations, derived from differential ones, may be taken as the basic set. The associated total fields, moving in common with their carriers, produce dissimilar vacuum fields (19): *transverse motion of one, produces the other EM field*. Apart from the electric field (19b), affecting all present electricity – in the field line direction, the magnetic field (19a) acts kinetically on moving electricity or respective current, by magnetic, – or equivalent electric field (20a). And finally, two EM fields – mutually causally related by (19) – form the energetic current (20b), perpendicular to the related fields.

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

$$\mathbf{H} = \mathbf{V} \times \mathbf{D}, \qquad \mathbf{E} = \mathbf{B} \times \mathbf{U}; \qquad (19)$$

$$\mathbf{E}_k = \mathbf{v} \times \mathbf{B}, \qquad \mathbf{S} = \mathbf{E} \times \mathbf{H}. \qquad (20)$$

Though formally similar, the two relations (19) are distinctly restricted. With respect to the differential elaboration, a field motion is effective only along the field gradient. Unlike non-vortical fields, generally inhomogeneous in any direction, the gradients of vortical fields are usually restricted to the field line planes. Excluding electro-static, this restriction concerns both – magnetic and electro-dynamic – moving fields.

The simplest technical basis, convenient for the measurement and consideration, is the motion and mutual affection of the line – current carrying and object – conductors. The free electrons and their electric fields, moving along a conductor, form magnetic field (19a). This is the case irrespective of the resting protons and their associated fields, compensating only statically the moving fields. Transverse motion of the carrying conductor, in the planes of magnetic field lines, causes the longitudinal induction (19b). In fact, the moving field gradient changes the field in the observed locations, with respective medium reaction. Similar effect arises around a variable current, as the accelerated electricity, causing the circular magnetic field, expanding or shrinking radially. These contractions cause the longitudinal inductions in parallel conductors, including the carrying conductor itself.

On the other hand, the relative relation (20a) is effective in any direction – perpendicular to magnetic field. A parallel object conductor – moving transversally – suffers the longitudinal induction, and vice versa. Two parallel currents thus attract, and anti-parallel – repel each other. Consequently, by such interactions in the pairs of their legs, two crosswise conductors tend to the same courses of their currents. A punctual object charge is thus compelled to the circular motion, around a tube of the present magnetic field.

The two convective relations (19) were initially emphasized by J. J. Thomson. With respect to the neglected spatial derivatives of the field speeds, during their derivation – from the differential set, this pair is restricted to the rigid moving fields stably oriented in space. *The moving fields form the gyroscopes in common with their apparent elementary carriers.* In the absence of this explanation, the two convective relations seemed to be nearly problematic. In spite of their simple forms and practical evidences, they have so far been neglected in the standard presentations of EM theory, as possible basic laws.

6.2 Derived Equations

Above basic relations are combined in various practical situations. In the case of two parallel conductors, one of them with its free electricity, and the other with its current and magnetic field (19a), moving transversally – along the field gradient, the dynamic (19b) and kinetic (20a) inductions superimpose (21). On the basis of this case, the *principle of relativity* is understood, calculating by the mutual speed: $\mathbf{v}' = \mathbf{v} - \mathbf{U}$. However, in the case of the two crosswise conductors, at motion along the current, in the direction of the field homogeneity, the dynamic induction (19b) fails, and (21) reduces to (20a).

$$\mathbf{E}_{kd} = (\mathbf{v} - \mathbf{U}) \times \mathbf{B}. \qquad (21)$$

In the case of a dielectric medium, without free electricity and conduction currents, the two moving fields can form EM wave only. The substitution of (19a) into (19b), or vice versa, gives (22a/b). Their former terms concern the collinear speeds of the two transverse EM

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

fields. The latter terms express the boundary region of the wave beam, with the longitudinal direction of one of the two fields. With respect to the energetic current (20b), these terms express transverse expansion or diffraction of the wave beam.

$$\mathbf{E} = \varepsilon\mu[(\mathbf{U}\cdot\mathbf{V})\mathbf{E} - (\mathbf{E}\cdot\mathbf{U})\mathbf{V}], \qquad \mathbf{H} = \varepsilon\mu[(\mathbf{U}\cdot\mathbf{V})\mathbf{H} - (\mathbf{H}\cdot\mathbf{V})\mathbf{U}]. \qquad (22)$$

The kinetic interactions of two moving (punctual or distributed) charges is achieved by the production of magnetic field – at motion of one, and action of this field on the other moving charge. In this sense, (19a) substituted into (20a) gives:

$$\mathbf{E}_k = \mu[(\mathbf{v}\cdot\mathbf{D})\mathbf{V} - (\mathbf{v}\cdot\mathbf{V})\mathbf{D}]. \qquad (23a)$$

The double cross product resolves the interaction into the two vector components: *axial* and *radial* ones. Though both obey the force symmetry, $\mathbf{f}(-\mathbf{r}) = -\mathbf{f}(\mathbf{r})$, the axial interaction would produce some torque on a moving dipole consisting of the two mutually connected charges. In fact, the above made substitution implicitly understood resting magnetic field of a moving charge. Its indispensable motion is taken into account by substitution of (19a) into (21), thus obtaining the adequate, more complex equation:

$$\mathbf{E}_{kd} = \mu[(\mathbf{v}-\mathbf{U})\cdot\mathbf{D}]\mathbf{V} - \mu[(\mathbf{v}-\mathbf{U})\cdot\mathbf{V}]\mathbf{D}. \qquad (23b)$$

The zero torque on a dipole moving at the common speed $(\mathbf{V}=\mathbf{v})$ is satisfied by the zero axial force, and this one – by the *transverse* field speed, $U = V\cot\theta$, where θ is the polar angle between moving electric field and its speed. Magnetic field lines expand in the front, and shrink behind the carrying charge. This result can be interpreted and confirmed by the transverse convective derivative of a moving central potential:

$$U = \frac{\partial y}{\partial t} = -\frac{\partial y}{\partial x}\frac{\partial x}{\partial t} = \frac{x}{y}V = V\cot\theta. \qquad (24)$$

As in (3), the convective derivative is opposite to the moving gradient, where $\partial y/\partial x = -x/y$ is the derivative of a moving circle: $x^2 + y^2 = r^2$. The transverse gradient of the moving static potential (2b) is nothing else than magnetic field (13b).

The moving fields carry by themselves their energies. In this sense, the substitution of (19) into (20b) gives two respective energetic currents:

$$\mathbf{S}_e = (\mathbf{E}\cdot\mathbf{D})\mathbf{V} - (\mathbf{V}\cdot\mathbf{E})\mathbf{D}, \qquad \mathbf{S}_m = (\mathbf{H}\cdot\mathbf{B})\mathbf{U} - (\mathbf{U}\cdot\mathbf{H})\mathbf{B}. \qquad (25)$$

Their former terms express the two main currents, and two latter – accessory ones, existent in respective physical processes. In the case of EM waves, these terms have the same roles as respective terms of (22). In the open causal processes, with only one moving field, one of the two equations (25) is applied. Around a moving punctual charge, with the transverse motion of its magnetic field (24), the latter term of (25b) annuls.

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

7. CENTRAL LAWS

7.1 Static Law

The elementary EM interactions are caused by the *presence*, *motion* and *acceleration* of the punctual charges. At first, the application of the static equation (14a) to such a carrying charge (q_1) gives the force acting on similar object (q_2), or vice versa. One of the charges thus affects the other, in accord with the *static central law*:

$$\mathbf{f}_s = n\mathbf{r}_o/\varepsilon\mu = n\mathrm{c}^2\mathbf{r}_o\,, \qquad n = \mu q_1 q_2/4\pi r_{1,2}^2\,. \tag{26}$$

The factor n simplifies the equations and enables their comparison. Radial integration of this force gives respective potential energy, expressed by the *alternative static law* (27), with the new factor $m = nr$, determining the *induction* or *self-induction*:

$$w = m/\varepsilon\mu = m\mathrm{c}^2\,, \qquad m = \mu q^2/4\pi r\,. \tag{27}$$

This is Einstein's equation, with the factor (m) – of self-induction, as the *proper* mass. As the condition of the two laws (26a,27a) equivalence, (27b) is the basis for calculation of the particle radius. It thus expresses the proper particle mass, where r denotes its radius, as the distance of the *surface charge* from its own centre.

With respect to (27b), *a lesser charged particle is of the greater mass and energy, and vice versa.* This fact points to indispensable location of the mass and energy in the surrounding electric field. If this mass were equivalent to the *inertial* mass, a complex – globally neutral – body, as the structural multi-pole, would manifest the resultant summary mass of all its constituent poles. Owing to cancelation of the distant fields of the opposite poles in the multi-pole, this sum is slightly *defected*. There is very difficult to believe that possibly exists some another cause of the inertial mass and respective forces.

7.2 Kinetic Law

The substitution of the transverse speed (24) of magnetic field into the combined force (23b) gives this force resolved into the following three terms:

$$\mathbf{f}_{kd} = nV[(v_t\,\mathbf{i}_l - v_l\,\mathbf{i}_t)\,sin\theta - Vcos\theta\,\mathbf{i}_l]\,. \tag{28}$$

The two former components represent the kinetic force (20a) acting on an object charge moving through the resting magnetic field. Apart from the carrier, it also depends on the object motion, or – on that of a detector substituting the object. In the case of the two parallel speeds $(v_t = 0)$, it is restricted to the transverse component:

$$\mathbf{f}_{kd} = -nV(v\,sin\theta\,\mathbf{i}_t + Vcos\theta\,\mathbf{i}_l)\,. \tag{29}$$

The last force component, of the dynamic field (11) – directed towards the moving charge, from both axial sides – is independent of the object (or respective detector) motion. Affecting all present charges, it looks as an associated wave period. Subtracted from the static field – extracted from (26), it gives the *ellipsoidal* field deformation, initially somehow predicted by H. A. Lorentz, without a needed causal explanation.

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

Radial integration of (29) gives the *mutual kinetic* energy (30). In such the ellipsoidal form, this energy depends on the angle of integration.

$$w = -mV(v\sin^2\theta + V\cos^2\theta) \ . \qquad (30)$$

In the case of the equal speeds of the field carrier and its object, the force (29) and energy (30) reduce into respective, *centrally symmetric* forms:

$$\mathbf{f} = -n(\mathbf{V}\cdot\mathbf{v})\,\mathbf{r}_\mathrm{o} \,, \qquad w = -m\,\mathbf{V}\cdot\mathbf{v} \ . \qquad (31)$$

Though mutually equal – in this particular case, the two speeds keep their distinct roles, concerning the carrier or object. Apart from the force symmetry, this case also satisfies the zero torque on a moving dipole. The comparison with (26a,27a) identifies the static laws as the particular cases of these ones, at the speed ic – of all the particles. This analogy points to a common motion along temporal axis, possibly related with the cosmic expansion. The imaginary unit (i) points to some circulation in tr-planes.

7.3 Mass Variation

Affecting in return the carrier itself (at $\mathbf{V} = \mathbf{v}$ thus understood), the combined central force (31a) is subtracted from the static force (26). Thus obtained total force is evenly distributed about the particle surface, forming respective pressure:

$$f_\mathrm{tot} = n(\mathrm{c}^2 - v^2) = n\mathrm{c}^2(1 - v^2/\mathrm{c}^2) = n\mathrm{c}^2 g^2 \ . \qquad (32)$$

The factor n depends on the radius, and g – on speed. Tending to zero approaching the speed c, from $f_\mathrm{o} = n_\mathrm{o}\mathrm{c}^2$, where $n_\mathrm{o} = n(r_\mathrm{o})$ – at rest, this force strives to expand the particle. This is controlled by the opposite internal reaction of the *polarized medium*, the same as at rest. The balance $(f = f_\mathrm{o})$ gives the two following relations:

$$r = r_\mathrm{o} g \,, \qquad m = m_\mathrm{o}/g \ . \qquad (33)$$

The latter of them is nothing else but Lorentz' *mass function*, estimated on the empirical bases. It is here derived directly, by the simple theoretical procedure. Thus dependent on speed, mass is minimal when resting in a *preferred* frame! This frame, as the basis for the speed determination, is somehow related with the medium [4].

The mass function (33b) further confirms the above reduction of inertia to induction. As such, it was the known basis for indirect derivation of Einstein's equation (27a). According to the mass function, there finally follows its differential (34a). The further formal procedure gives the *proper kinetic energy* of a moving (charged) particle:

$$\partial m = mv\partial v/(\mathrm{c}^2 - v^2) \,, \qquad \mathrm{c}^2\partial m = mv\partial v + v^2\partial m : \qquad (34)$$

$$\partial w_\mathrm{k} = p\partial t = vf\partial t = v\partial(mv) \,, \qquad v\partial(mv) = mv\partial v + v^2\partial m = \mathrm{c}^2\partial m \,; \qquad (35)$$

$$w_\mathrm{k} = w - w_\mathrm{o} = (m - m_\mathrm{o})\mathrm{c}^2 \,, \qquad w - w_\mathrm{o} = q^2(1/r - 1/r_\mathrm{o})/4\pi\varepsilon \ . \qquad (36)$$

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

Assuming the constant mass $(\partial m = 0)$, with annulment of the latter term in (35b), the former term integral gives the classical kinetic energy $(mv^2/2)$. The complete integral gives (36a). The substitution of (27b) relates the kinetic energy with that of the electric field between the two radii, – of the moving and resting particle (36b).

7.4 Dynamic Law

Variation in time of the kinetic energy can be caused only by acceleration or deceleration of the carrier. In this sense, time derivative of (31b), partially – per mV, gives the *power* of the energy transfer – on the left of (37a). The two speeds of the same particle just concern its two roles, – of the field carrier (qV) and object (qv).

$$\partial_t w_k = \mathbf{v}\cdot\partial_t(m\mathbf{V}) = -\mathbf{v}\cdot\mathbf{f}_\mathrm{d} , \qquad \mathbf{f}_\mathrm{d} = -\partial_t(m\mathbf{V}) . \tag{37}$$

On the other hand, the same power equals to the negative scalar product of the object speed and *reactive* dynamic force – in continuation. The reduction finally gives *force action law* (37b), dependent on the *variable* mass and its acceleration.

With respect to (33b) and its derivative (34a), the dynamic force can be further elaborated, with the linear momentum as the product of the three factors:

$$\partial_t(mv\mathbf{v}_\mathrm{o}) = v\mathbf{v}_\mathrm{o}\partial_t m + m\mathbf{v}_\mathrm{o}\partial_t v + mv\partial_t\mathbf{v}_\mathrm{o} \ . \tag{38}$$

Here v is the speed modulus, and $\mathbf{v}_\mathrm{o}$ – unit vector. The two former terms are transformed into *inertial*, and latter one gives well-known *centrifugal* forces:

$$\mathbf{f}_\mathrm{i} = -v\frac{\partial m}{\partial v}\frac{\partial v}{\partial t}\mathbf{v}_\mathrm{o} - m\frac{\partial v}{\partial t}\mathbf{v}_\mathrm{o} = -\frac{m}{g^2}\frac{\partial v}{\partial t}\mathbf{v}_\mathrm{o} , \tag{39}$$

$$\mathbf{f}_\mathrm{c} = -mv\frac{\partial \mathbf{v}_\mathrm{o}}{\partial t} = -mv\frac{\partial \mathbf{v}_\mathrm{o}}{\partial s}\frac{\partial s}{\partial t} = \frac{mv^2}{r}\mathbf{r}_\mathrm{o} . \tag{40}$$

Here $\mathbf{r} = r\mathbf{r}_\mathrm{o}$ is the path curvature radius. Both force components are additionally scaled, by the variable mass. Instead of the two *different masses* estimated empirically, there are just the two distinct *functions* of the same *variable mass*.

The former force changes the energy of the moving body, and latter one only strives to strait motion. The former of them may be understood as the difference of the opposite *dynamic* forces from (29), being unequal at acceleration. On the other hand, the transverse direction of the centrifugal force, and its independence of the linear acceleration, point to its *kinetic* nature. The terms 'static, kinetic & dynamic' are here used in the relative sense, dependent on the observed objects and respective levels of observation.

8. CONCLUSIONS

1. EM quantities and standard differential equations are introduced in the axiomatic order, starting from the static potential and its linear motion. 2. The four algebraic relations are thus reaffirmed, re-examined and prepared for application. 3. On the basis of the magnetic field

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.

motion, the general kinetic law is finally formulated. 4. These considerations mutually relate a number of former independent results: Coulomb's law, Einstein's equation, classical radius and EM mass, EM induction, force action law, inertial and centrifugal forces, mass function, mass defect, associated wave and the ellipsoidal field deformation. 5. The three basic sets supplement each other in the interpretations and applications. 6. The principle of relativity and assumption of elementary mass are convincingly called in question.

REFERENCES

1. Mišković B, Essential Overview of EM Theory, Springer-Verlag, Selected Topics in Nonlinear Dynamics and TEE, Volume 459, Chapter 13, 2013

2. Mišković B, Systematic Foundation of EM Theory, SAP, International Journal of Electromagnetics and Applications, Vol. 4, No. 2, 2014.

3. Mišković B, Re-examination of Physics, SAP, International Journal of Theoretical and Mathematical Physics, Vol. 4, No. 3, 2014.

4. Mišković B, Medium of Natural Phenomena, still under consideration

Note: The above references represent the former development and wider context. Their own references may be also taken into account. In the final instance, as being fully deductive, the presented article is self-sufficient, irrespective of the references.

* Tel.: +381 654606563
E-mail address: aham.brami@gmail.com.