Generalized Dynamics about Forces Acting on Charge Moving in Capacitor and Solenoid.

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Kaufman's paper published in 1901 on electrons' deviation in electric and magnetic fields became a corner stone in experimental substantiation of special relativity theory. It is shown in this paper that generalized electrodynamics proposed by the author implies this result.

1. Introduction.

Fundamental step in electricity theory was taken in 1846 when W. Weber proposed force formula generalizing Coulomb law for the case of moving charges. This formula describes force appearing between two charges moving with certain velocities and accelerations. This formula showed beautiful coordination with experiments and became a basis for an investigation program in the process of which other formulas describing charges interaction were proposed. Let us mention here Neumann's, Ampere's, Grassman's, Whittaker's formulas which accurate investigation and comparison with Weber's formula may be found in the author's paper published in Russian and now translating into English (also see Marinov's paper [1]).

A little bit later Maxwell in great Britain proposed his field approach to electrodynamics description. This approach thanks to Herz experiments and Heaviside efforts became prevailing and partly eclipsed Weber's one. But these new concepts didn't have as plausible physical meaning as Weber's force ones. Such meaning was allotted to field concept by well-known formula apparently proposed by Heaviside and later called Lorentz force formula. It can be readily shown this formula in field terms repeat Grassman's formula attached force meaning to field concept.

If Maxwell equations are considered as postulates which describe changes in surrounding space which a certain set of charges creates then Lorentz formula is an additional axiom describing consequences to which changes lead for a certain charge called probe. It is assumed that probe charge does not have its own field although it moves just in the same way as active charge which creates the field. It is quite nonsymmetrically assumed that electric field acts on "static part" and magnetic field acts on "dynamic part" of the probe charge.

It is mentioned above that Lorentz formula gives not more and not lese in comparison with Grassman formula i.e. it describes rather a narrow class of phenomena. This fact realization led to attempt of direct force interpretation of Maxwell equation, i.e. to "flow rules" which are used in modern physics together with Lorentz force formula. Although "flow rules" widened the class of describing phenomena but first it is not sufficient and the second (and this is the main point) it turned to be absolutely nonsatisfactory in logical aspect.

Maxwell equations describe only fields (changes in space) originated by a certain set of charges and they are not capable to describe fields' interaction. Such interaction should be described by a certain additional formula.

Although Lorentz force formula is not universal enough its role in electrodynamics is just this one, it is additional to Maxwell equations axioms, which describes fields' interaction.

Recently one additional problem became clear. As we understand now Maxwell equations self are not universal enough. Their multiple experimental proves led to their dogmatisation. The gaps were filled with additional postulates in the framework of relativity theory, retarded potentials etc. These additional axioms together with plain mathematical mistakes led to refusal of Galileo invariance and to some other such paradoxical assumptions such that new theory "insanity" is now considered to be necessary condition for its validity. Popularizers of physics and journalists inculcated such insane theories into public mentality creating auras of mystery and mysticism around physical theories. In physics self it led to predomination of overcomplicated mathematics over sober physical mentality.

Apparently it is a high time to return to sources and reunderstand many habitual assumptions. Such an attempt was done by the author in his paper [2]. A digest of it is reproduced in section 2 here. Section 3 is devoted to explanation of Kaufman's experiment in the proposed terms.

2. Equation of generalized Dynamics.

Let rectangular right hand coordinate triple is fixed in three-dimensional Euclidian space. Let $\mathbf{x}=(x_1, x_2, x_3)$ be a point in this space, t be time and **i**, **j**, **k** be orts. Let q_1, q_2 be electric charges 1 and 2. $\mathbf{V_1}, \mathbf{V_2}$, and $\mathbf{a}_1$, $\mathbf{a}_2$ be their velocities and accelerations. If other assertion is not declared, charges q_1 and q_2 are considered to be evenly distributed in a ball of radius r_0. Let $\mathbf{E_1}$, $\mathbf{E_2}$, $\mathbf{B_1}$, $\mathbf{B_2}$ be electric and magnetic fields' tensities originated by the charges in space. Double index from below means field tensity created by the charge whose index goes first in the point where the charge whose index goes second is situated. For instance $\mathbf{E}_{21}$ means electric field tensity created by the second charge in the point where the first charge is situated. Let $\mathbf{r}_{21}$ be the radius-vector from charge 2 to charge 1, r be its modulus, $r \gg r_0$, and ε_0 be electric constant.

Generalized formula for Lorentz force. Charge 2 produces the following force on charge 1:

$$F_{21} = -\mathrm{grad}\left[4\pi\varepsilon_0 c r^3 \left(\mathbf{B}_{12} \cdot \mathbf{E}_{21}\right)\right] + \frac{d}{dt}\left[4\pi\varepsilon_0 c r^3 \left(\mathbf{B}_{12} \times \mathbf{B}_{21}\right)\right] \qquad (2.1)$$

Gradient is calculated with respect to passive charge 1 coordinates. Here and everywhere below $c = c_0 [\mathbf{i} \times \mathbf{j}] \cdot \mathbf{k}$, where c_0 is light velocity. This quantity is called pseudoscalar light velocity.

Two notion of force are used in modern physics: idea inherited after Newton and Descartes as an impulse derivative with respect to time and idea inherited after Huygens and Leibnitz as an energy gradient. (2.1) combines both ideas. Every charge creates electric and magnetic fields in space. Scalar product of passive charge magnetic field and active charge electric field describes interactive energy density originated by the charges. Its integral is in square brackets in the first item. Vector product of charges' magnetic field defines interactive impulse density. Its integral is in square brackets in the second item.

One needs to find the field originated by the charges. One can get it from equation describing the fields. Maxwell equations is such a system in classical theory. But Maxwell equations should be modernized in order to be coordinated to formula (2.1).

Generalized Maxwell equations. Electric charge q distributed in the space with density ρ, originates electric and magnetic fields which are solution of following system:

$$\mathrm{div}\mathbf{E} = \frac{\rho}{\varepsilon_0} \qquad (2.2)$$

$$\mathrm{rot}\mathbf{E} = -d\mathbf{B}/dt \qquad (2.3)$$

$$\mathrm{div}\mathbf{B} = -\frac{\rho}{c\varepsilon_0} \qquad (2.4)$$

$$c^2 \mathrm{rot}\mathbf{B} = d\mathbf{E}/dt \qquad (2.5)$$

Let us begin our explanations with the equation (2.5).

$$\frac{d\mathbf{E}}{dt} = (\mathbf{V} \cdot \mathrm{grad})\mathbf{E} + \frac{\partial \mathbf{E}}{\partial t} \qquad (2.6)$$

where $\mathbf{V}$ is the charge velocity. The first item in the right hand part of (2.6) generalizes the idea of **a** current in classical theory and comes to it if $\mathbf{E}$ satisfies some additional conditions.

$$(\mathbf{V} \cdot \mathrm{grad})\mathbf{E} = \mathbf{V}\mathrm{div}\,\mathbf{E} + \mathrm{rot}(\mathbf{E} \times \mathbf{V}) = \frac{\mathbf{j}}{\varepsilon_0} + \mathrm{rot}(\mathbf{E} \times \mathbf{V}),$$

where $\mathbf{j}$ is current density. So right hand part of (2.5) contains a rotor component in addition to classical one. This item is manifested for instance in a light wave. Or in creation force lines not enveloping currents.

(2.4) means that equations (2.3) - (2.5) generalize the idea of magnetic field. Magnetic field **B** that is the solution of (2.3) - (2.5) possesses not only rotor but divergent components as well. Divergent component of **B** is defined by pseudoscalar electric charge (usual electric charge divided by mixed product of orts and light velocity). **B** opens to be pseudovector just like in classical theory.

Right hand part of (2.4) may be considered as "another incarnation" for electric charge because existence of electric charge is necessary and sufficient for its existence. One may consider it as a "magnetic charge". But it is necessary to emphasize that such a "magnetic charge" does not coincide with Dirac's monopole. Let us pinpoint some of the differences.

1. Such a "magnetic charge" is pseudoscalar, i.e. its sign changes when right hand coordinate triple is changed for left hand one.
2. It is c times less than electric charge, correspondingly its dimension differs from electric charge dimension.
3. And last but not least (2.1) implies that two static "magnetic charges" do not interact, because second item in (2.1) responsible for magnetic field' interaction is zero in this case. I ask reader to pay attention to this fact because "ordinary physical mentality" usually identifies field and force.

The right hand part of (2.3) looks as

$$\frac{d\mathbf{E}}{dt} = (\mathbf{V} \cdot \mathrm{grad})\mathbf{B} + \frac{\partial \mathbf{B}}{\partial t} \tag{2.7}$$

So (2.3) differs from classical one in that it includes gradient derivative of **B** originated by electric charge (and correspondingly "magnetic charge") movement with velocity **V**.

Classical theory associates the appearance of magnetic field just with the movement of electric charges but does not include the originating movement into (2.3) equation.

(2.2) coincides with classical one.

(2.2) - (2.5) define in differential form the fields **E** and **B** originated by moving charges. Just this fields one needs in order to use formula (2.1).

Mathematically system (2.2) - (2.5) dissociates into two groups. Equations (2.3) and (2.5) defines **E** and **B** which are their solutions. Equations (2.2) and (2.4) fix boundary-value conditions in a peculiar Neumann problem: not a gradient but a divergence is defined on the boundary, i.e. in the point where $\rho \neq 0$. When **E** and **B** are found on the boundary they are extended on the whole domain. It is possible because potential φ is harmonic. **E** and **B** got from these conditions define part of fields' tensities.

If velocity **V** does not depend with respect to space coordinates then equations (2.2) - (2.5) imply

$$\frac{d\rho}{dt} = \frac{\partial \rho}{\partial t} + \mathbf{V} \cdot \mathrm{grad}\rho = 0 \tag{2.8}$$

This correlation defines an intensified charge conservation law: the charge is not only conserved but it behaves like incompressible liquid. Let us investigate case when ρ is independent with respect to t explicitly, i.e.

$$\frac{\partial \rho}{\partial t} = 0 \tag{2.9}$$

Then (2.8) implies because of arbitrariness of **V**:

$$\mathrm{grad}\rho = 0 \tag{2.10}$$

It is supposed that **V** is independent with respect to space coordinates and is a function with respect to only t.

$$\mathbf{V} = \mathbf{V}(t) \tag{2.11}$$

Charges evenly distributed in a ball of radius $r_0 << r$ evidently satisfy conditions (2.9) and (2.10). if these conditions are valid then one can define one partial solution of (2.20 - (2.5):

$$\mathbf{E} = \frac{\rho}{3\varepsilon_0}\left[-\frac{(\mathbf{r} \times \mathbf{V})}{c} + \mathbf{r}\right] \tag{2.12}$$

$$\mathbf{B} = -\frac{\rho}{3\varepsilon_0 c}\left[\frac{(\mathbf{r} \times \mathbf{V})}{c} + \mathbf{r}\right] \tag{2.13}$$

where **r** is radius-vector from the charge to observation point.

Let us verify by direct substitution that (2.12) and (2.13) are solutions of modified Maxwell equations (2.2) - (2.5).

$$\mathrm{div}\mathbf{E} = \frac{\mathrm{grad}\rho}{3\varepsilon_0}\left[-\frac{(\mathbf{r} + \mathbf{V})}{c} + \mathbf{r}\right] + \frac{\rho}{3\varepsilon_0}\left[-\frac{(\mathbf{r} \times \mathbf{V})}{c} + \mathbf{r}\right] = \frac{\rho}{\varepsilon_0}$$

$$\mathrm{div}\mathbf{B} = -\frac{\mathrm{grad}\rho}{3\varepsilon_0 c}\left[\frac{(\mathbf{r} + \mathbf{V})}{c} + \mathbf{r}\right] - \frac{\rho}{3\varepsilon_0}\left[\frac{(\mathbf{r} \times \mathbf{V})}{c} + \mathbf{r}\right] = -\frac{\rho}{\varepsilon_0 c}$$

Let us find left and right hand parts of (2.3)

$$\varepsilon_0 \mathrm{rot}\mathbf{E} = \frac{1}{2}\left\{\mathrm{grad}\frac{\rho}{3} \times \left[-\frac{\mathbf{r} \times \mathbf{V}}{c} + \mathbf{r}\right] + \frac{\rho}{3c}\left[-(\mathbf{V} \cdot \mathrm{grad})\mathbf{r} + (\mathbf{r} \cdot \mathrm{grad})\mathbf{V} + \mathbf{V}(\mathrm{div}\mathbf{r})\right]\right\} = +\frac{\rho \mathbf{V}}{3c}$$

$$\varepsilon_0 \frac{d}{dt}\mathbf{B} = -\frac{1}{3}\frac{d\rho}{dt}\left[\frac{\mathbf{r} \times \mathbf{V}}{c^2} + \frac{\mathbf{r}}{c}\right] - \frac{\rho}{3c}\left[\frac{\mathbf{V} \times \mathbf{V}}{c} + \frac{\mathbf{r} \times \mathbf{a}}{c} + \mathbf{V}\right] = -\frac{\rho}{3c}\left[\frac{\mathbf{r} \times \mathbf{a}}{c} + \mathbf{V}\right].$$

But the first item in last square brackets is radiated by a changing field. So one get finally:

$$\frac{d}{dt}\mathbf{B} = -\frac{\rho\mathbf{V}}{3c\varepsilon_0}$$

(2.5) is verified in the same way.

Let us write down in an explicit way for this case all the items included in (2.1).

1. $\mathbf{B}_{12} = \frac{-q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{12}\times\mathbf{V}_1}{c} - \mathbf{r}_{12}\right] = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{V}_1}{c} + \mathbf{r}_{21}\right]$

2. $\mathbf{E}_{21} = \frac{q_2}{4\pi\varepsilon_0 r^3}\left[-\frac{\mathbf{r}_{21}\times\mathbf{V}_2}{c} + \mathbf{r}_{21}\right]$

Let us find gradient of scalar product of these fields calculating the corresponding derivatives with respect to passive first charge coordinates.

3. $-\mathbf{B}_{12}\cdot\mathbf{E}_{21} = \frac{q_1 q_2}{16\pi^2\varepsilon_0^2 r^6 c}\left[\frac{(\mathbf{r}_{21}\times\mathbf{V}_1)\cdot(\mathbf{r}_{21}\times\mathbf{V}_2)}{c^2} - r^2\right]$

4. $-\operatorname{grad}\left[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\cdot\mathbf{E}_{21})\right] =$

$$= \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\left[\mathbf{r}_{21} - \frac{3\mathbf{r}_{21}((\mathbf{r}_{21}\times\mathbf{V}_1)\cdot(\mathbf{r}_{21}\times\mathbf{V}_2))}{r^2c^2} - \frac{(\mathbf{r}_{21}\cdot\mathbf{V}_1)\mathbf{V}_2 + (\mathbf{r}_{21}\cdot\mathbf{V}_2)\mathbf{V}_1}{c^2} + \frac{2\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)}{c^2}\right]$$

5. $\mathbf{B}_{21} = -\frac{q_2}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{V}_2}{c} + \mathbf{r}_{21}\right]$

6. $\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{\mathbf{r}_{21}\times\mathbf{V}_1}{c} + \mathbf{r}_{21}\right]$

7. $4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21}) = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c}\left[\frac{(\mathbf{r}_{21}\times\mathbf{V}_2)\times(\mathbf{r}_{21}\times\mathbf{V}_1)}{c^2} + \mathbf{r}_{21}\times\frac{\mathbf{r}_{21}\times(\mathbf{V}_1-\mathbf{V}_2)}{c}\right]$

Radius-vector derivatives

$$\frac{d\mathbf{r}_{21}}{dt} = \mathbf{V}_1 - \mathbf{V}_2, \quad \frac{d^2\mathbf{r}_{21}}{dt^2} = \mathbf{a}_1 - \mathbf{a}_2.$$

If the time of signal's lagging behind is not essential with respect to the problem's conditions then the derivatives are calculated at the same time t. Otherwise the active charge velocity and acceleration should be calculated at the previous time.

$$\tau = t - \frac{r}{c_0}$$

8. $\frac{d}{dt}\left[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21})\right] = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c^2}\Big\{\left[(\mathbf{V}_1-\mathbf{V}_2)\times(\mathbf{r}_{21}\times(\mathbf{V}_1-\mathbf{V}_2))\right] -$

$$-\frac{3\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2)}{r^2}\cdot\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{V}_1-\mathbf{V}_2))\right] + \mathbf{r}_{21}\times\left[\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2)\right] +$$

$$+\frac{(\mathbf{V}_1\times\mathbf{V}_2)\times\left[(\mathbf{r}_{21}\times\mathbf{V}_1)-(\mathbf{r}_{21}\times\mathbf{V}_2)\right] + \left[(\mathbf{r}_{21}\times\mathbf{V}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-(\mathbf{r}_{21}\times\mathbf{V}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]}{c}\Big\}$$

One gets finally: the force which the second charge produces on the first one is

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} + \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c^2}\Big\{\Big[2\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2) - \mathbf{V}_1(\mathbf{r}_{21}\cdot\mathbf{V}_2) - \mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1) - \frac{3\mathbf{r}_{21}}{r^2}((\mathbf{r}_{21}\times\mathbf{V}_1)\cdot(\mathbf{r}_{21}\times\mathbf{V}_2))\Big] +$$

$$+\left[(\mathbf{V}_1-\mathbf{V}_2)\times(\mathbf{r}_{21}\times(\mathbf{V}_1-\mathbf{V}_2))\right] - \frac{3\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)}{r^2}\cdot\left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{V}_1-\mathbf{V}_2))\right] + \left[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2))\right] +$$

$$+\frac{(\mathbf{V}_1\times\mathbf{V}_2)\times\left[(\mathbf{r}_{21}\times\mathbf{V}_1)-(\mathbf{r}_{21}\times\mathbf{V}_2)\right] + \left[(\mathbf{r}_{21}\times\mathbf{V}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-(\mathbf{r}_{21}\times\mathbf{V}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]}{c}\Big\} \quad (2.14)$$

One gets another form for the force when vector triple products are revealed:

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\left\{-\left[\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)+\mathbf{V}_1(\mathbf{r}_{21}\cdot\mathbf{V}_2)+\mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1)-\frac{3\mathbf{r}_{21}}{\mathbf{r}^2}((\mathbf{r}_{21}\cdot\mathbf{V}_1)\cdot(\mathbf{r}_{21}\cdot\mathbf{V}_2))\right]+\right.$$
$$\left[\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2-(\mathbf{V}_1-\mathbf{V}_2)\cdot(\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2))\right]-\frac{3\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2)}{\mathbf{r}^2}\left[\mathbf{r}_{21}(\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2))-(\mathbf{V}_1-\mathbf{V}_2)\mathbf{r}^2\right]+$$
$$\left.+\left[\mathbf{r}_{21}(\mathbf{r}_{21}\cdot(\mathbf{a}_1-\mathbf{a}_2))-(\mathbf{a}_1-\mathbf{a}_2)\mathbf{r}^2\right]+\frac{(\mathbf{V}_2-\mathbf{V}_1)(\mathbf{r}_{21}\cdot(\mathbf{V}_1\times\mathbf{V}_2))}{c}+\frac{\mathbf{r}_{21}\left[(\mathbf{r}_{21}\times\mathbf{V}_2)\cdot\mathbf{a}_1-(\mathbf{r}_{21}\times\mathbf{V}_1)\cdot\mathbf{a}_2\right]}{c}\right\}\quad(2.15)$$

Let us write out additional form of (2.15) using explicitly the angles between vectors. Let

θ_1 - be angle between $\mathbf{r}_{21}$ and $\mathbf{V}_1$

θ_2 - be angle between $\mathbf{r}_{21}$ and $\mathbf{V}_2$

θ_3 - be angle between $\mathbf{V}_1$ and $\mathbf{V}_2$

θ_4 - be angle between $\mathbf{r}_{21}$ and $(\mathbf{V}_1-\mathbf{V}_2)$

θ_5 - be angle between $\mathbf{r}_{21}$ and $(\mathbf{a}_1-\mathbf{a}_2)$

θ_6 - be angle between $\mathbf{r}_{21}$ and $(\mathbf{V}_1\times\mathbf{V}_2)$

θ_7 - be angle between $(\mathbf{r}_{21}\times\mathbf{V}_2)$ and $\mathbf{a}_1$

θ_8 - be angle between $(\mathbf{r}_{21}\times\mathbf{V}_1)$ and $\mathbf{a}_2$

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\left\{-\left[\mathbf{V}_2|\mathbf{V}_1|r\,\mathrm{Cos}\theta_1+\mathbf{V}_1|\mathbf{V}_2|r\mathrm{Cos}\theta_2+\mathbf{r}_{21}|\mathbf{V}_1||\mathbf{V}_2|(\mathrm{Cos}\theta_3-3\mathrm{Cos}\theta_1\mathrm{Cos}\theta_2)\right]+\right.$$
$$+\left[\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2(1-3\mathrm{Cos}^2\theta_4)+2(\mathbf{V}_1-\mathbf{V}_2)r|\mathbf{V}_1-\mathbf{V}_2|\mathrm{Cos}\theta_4\right]+\left[\mathbf{r}_{21}r|\mathbf{a}_1-\mathbf{a}_2|r^2\right]+$$
$$\left.+\frac{(\mathbf{V}_1-\mathbf{V}_2)r|\mathbf{V}_1||\mathbf{V}_2|\mathrm{Cos}\theta_6\mathrm{Sin}\theta_3}{c}+\frac{\mathbf{r}_{21}\left[r|\mathbf{a}_1||\mathbf{V}_2|\mathrm{Sin}\theta_2\mathrm{Cos}\theta_7-r|\mathbf{a}_2||\mathbf{V}_1|\mathrm{Sin}\theta_1\mathrm{Cos}\theta_8\right]}{c}\right\}\quad(2.16)$$

All derivatives here are calculated with respect to laboratory frame of reference for "nude charges" and with respect to conductors for currents in neutral conductors. Let us return to function (2.12) and (2.13). The second item in their right hand parts define static component and is manifested only for "nude charges". The first one defines dynamic component and is manifested not only for charged but for neutral currents as well. This quality is inherited when these components are multiplied and when derivatives are calculated in formula (2.1). for instance the first item in (2.14) - (2.16) is got as a gradient of static components' product. Therefore it is valid only for "nude charges" (Coulomb force). On the contrary the first square bracket is a result of dynamic components' product. So it is valid for neutral currents as well. One can easily see that this square bracket is a symmertization of classical Lorentz force. The first two items correspond to this classical case and the second two ones work in symmetrical cases.

The second square bracket (2.14) - (2.16) is product of dynamic and static components. So it is equal to zero between two neutral currents. It is valid if at least one of the currents is charged. This square bracket depends on the charges velocities' difference and predicts some effects of Relativity theory. It also predicts the force produced on the "nude charge" at rest near the neutral current.

The third square bracket depends on the charges' accelerations and describes field radiation. It is valid for all kinds of currents because radiated field should be considered as a "nude one". It usually predicts the same results as classical theory but it can 3 readily be show that it predicts no radiation for an electron rotating around nucleus.

The last two items in braces have the third small rank with respect to light velocity c. They are apparently essential in elecro-weak interaction.

3. Force Acting on a Charge Moving in a Capacitor.

Let us find forces acting on charge q_1 near an infinite plane charged with δ density using the formulas of the previous section. We are interested in the case when the plain charges are immovable, i.e. $V_2 = 0$.

$$\mathbf{F}_{21}=\frac{q_1\delta}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1\delta V_1^2}{4\pi\varepsilon_0 r^3c^2}\mathbf{r}_{21}[1-\cos^2\theta]\qquad(3.1)$$

were $\theta(\mathbf{r}_{21},\mathbf{v}_1)$ is the angular between radius-vector $\mathbf{r_{21}}$ from point x_2 on the charged plane to q_1 and velocity vector $\mathbf{V_1}$ of the charge q_1. Let us note that only the first item in (3.1) is taken into account in modern physics. The second one is not taken into account because it is assumed that Coulomb field acts only on static part of q_1.

Usually we are interested not to understand force acting from a separate point of the plane but to define integral force acting from the whole plane.
We shall find it if integrate force (3.1) from a to infinity, where a is the distance q_1 from the plane. When having integrated the first item one gets the following force

$$F_1 = \frac{q_1\delta}{2\varepsilon_0} \tag{3.2}$$

which is directed from the plane and is independent with respect to q_1 distance from it. The second item integral contains a component directed along the plane in general case because this force depends on the cosines between radius-vector and $\mathbf{V}_1$.

But we are interested in the case when V_1 is parallel to the plane. For this case

$$\cos\theta = \frac{r-a}{r} \tag{3.3}$$

where r is the distance from the plane points. If (3.3) is put into the second item of (3.1) and it is integrated one gets

$$F_2 = \frac{q_1\delta a^2 V_1^2}{2\varepsilon_0 c^2}\int_a^\infty [1-1+\frac{2}{r^3}-\frac{a}{r^4}]dr = +\frac{q_1\delta V_1^2}{3\varepsilon_0 c^2} \tag{3.4}$$

This force is also perpendicular to the plane.

$$F = F_1 + F_2 = \frac{q_1\delta}{2\varepsilon_0}[1+\frac{2V_1^2}{3c^2}] \tag{3.5}$$

The second item in (3.5) depends on the charge velocity and “helps” Coulomb force. This item is not taken into account in modern physics and was not used when Kaufman’s experiments were explained. Such explanation was proposed by relativity theory.

The force acting an a charge in an infinite capacitor is doubled

$$F_c = \frac{q_1\delta}{\varepsilon_0}[1+\frac{2V_1^2}{3c^2}] \tag{3.6}$$

4. Force moving in a charged tube with current.

For this case

$$\mathbf{E}_{21} = \frac{\delta}{\varepsilon_0 r}[-\frac{\mathbf{r}_{21}\times\mathbf{V}_2}{c}+\mathbf{r}_{21}] \tag{4.1}$$

$$\mathbf{B}_{21} = \frac{\delta}{\varepsilon_0 rc}[\frac{\mathbf{r}_{21}\times\mathbf{V}_2}{c}+\mathbf{r}_{21}] \tag{4.2}$$

$$\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon_0 cr^3}[\frac{\mathbf{r}_{21}\times\mathbf{V}_1}{c}+\mathbf{r}_{21}] \tag{4.3}$$

Here δ is the charge density on the tube, V_2 is the charge velocity moving on the tube surface, $\mathbf{V_1}$ is q_1 velocity moving inside the tube, r_{21} is radius-vector from the points on the tube surface to charge $q_{1.}$ One gets having repeated the calculation from section 2: force acting from point x_2 on the tube surface on q_1 is:

$$\mathbf{F}_{21} = \frac{q_1\delta}{\varepsilon_0 rc^2}\{-c^2\mathbf{r}_{21}+\mathbf{V}_1(\mathbf{r}_{21}\cdot\mathbf{V}_2)+\mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1)-\frac{[(\mathbf{r}_{21}\cdot\mathbf{V}_1)(\mathbf{r}_{21}\cdot\mathbf{V}_2)]}{r^2}\mathbf{r}_{21}-(\mathbf{V}_1\cdot\mathbf{V}_2)\mathbf{r}_{21}+$$

$$+\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2-\frac{\mathbf{r}_{21}(\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2))^2}{r^2}+[\mathbf{r}_{21}\times(\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2))]\} \tag{4.4}$$

Force (4.4) does not depend on radius-vector modulus and depends only on its direction. In any cavity (not only in infinite tube or sphere) for any direction from the surface there exists an inverse one from the symmetrical point. Null contribution to integral force is done by an item if its coefficient is constant. The first item in braces (Coulomb force) is such an item in (4.4). The second the third the fourth and the fifth items do contribution of full value to integral force because $\mathbf{V_2}$ also change sign when radius-vector change it.

Therefore forces acting from symmetrical surface points are added constructively, i.e. are doubled. The third and the fifth items are just classical Lorentz force. It becomes especially evident if they are described as triple product

$$\mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1)-\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)=\mathbf{V}_1\times(\mathbf{V}_2\times\mathbf{r}_{21}) \qquad (4.5)$$

Vector product in brackets defines tube magnetic field.

We are interested in the case of solenoid, i.e. the case when V_2 is directed along directrix tangent. Radius-vector r_{21} in (4.5) is directed from the solenoid surface inside it. Therefore the second item in the left-hand part of (4.5) predicts force directed from solenoid axis. But experiment shows existence just centripetal and not centrifugal force. One finds explanation investigating the sixth item in (4.4). One gets for two symmetric points on solenoid surface

$$\mathbf{r}_{21}(\mathbf{V}_1+\mathbf{V}_2)^2-\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2=+4\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)$$

This force is added to the radical component of Lorentz force.

We neglect charge acceleration, i.e. assume the last item in (4.4) to be null.

One finally receives integral force acting on q_1 from two symmetrical points on solenoid surface:

$$F=\frac{2q_1\delta}{\varepsilon_0 rc^2}[\mathbf{V}_1(\mathbf{r}_{21}\cdot\mathbf{V}_2)+\mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1)-\mathbf{r}_{21}\frac{(\mathbf{r}_{21}\cdot\mathbf{V}_1)(\mathbf{r}_{21}\cdot\mathbf{V}_2)}{r^2}+\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)-\mathbf{r}_{21}\frac{(\mathbf{r}_{21}\cdot(\mathbf{V}_1-\mathbf{V}_2))^2}{r^2}] \qquad (4.6)$$

What is the physical essence of different items? The second one is a part of classical Lorentz force directed along cylinder directrix. It rotates q_1. The forth item modulo coincide with the second part of Lorentz force but is oppositely directed. The third and fifth items produce additional radial force depending on cosines of angles between $\mathbf{r}_{21}$ and $\mathbf{V}_1$ and $\mathbf{V}_2$.

The first item predict appearance of a force directed along $\mathbf{V}_1$.

It is shown in the author's paper [2] that external force accelerate charge only during short time after which it just maintains constant charge velocity.

Let q_1 comes into solenoid strictly perpendicular to its axis. What is its trajectory?

Rotating force V_2 ($r_{21}\cdot V_1$) and radial forces curve its trajectory. In steady mode the trajectory becomes circumference (Larmor orbit). If then charge comes with a certain angel to the axis, i.e. $\mathbf{V}_1$ possesses nonzero projection on the axis because of the first item. The trajectory becomes helix wich is shown in experiment. This first item appears only in generalized dynamics proposed by the author in [1].

This item symmetries Lorentz force formula and removes its contradiction to the third Newton law. For this case it predicts helix character of the charge movement which is not done by classical Lorentz force.

Let us briefly consider the case when the tube current is directed along generatrix, i.e. the usual case of current in a conductor.

The first Coulomb item produces null contribution into integral force just as previously. Now $\mathbf{r}_{21}\perp\mathbf{V}_2$. Therefore the second and the fifth items are null identically. If $\mathbf{V}_1$ is perpendicular to cylinder axis then the fourth item is also null because $\mathbf{V}_1\perp\mathbf{V}_2$ and the sixth and the seventh items are mutually annihilated because $\mathbf{r}_{21}\|\mathbf{V}_1$. Only the third item directed along $\mathbf{V}_2$, i.e. along cylinder axis is preserved. Such charge q_1 is swept along current.

If $\mathbf{V}_1$ is not strictly perpendicular to cylinder axis there appears a radial force on account of the fourth, the sixth and the seventh items. This force grows with decrease of the angle between $\mathbf{V}_1$ and the current. Meanwhile the axis force defined by the third item decreases. When $\mathbf{V}_1\|\mathbf{V}_2$ this third item becomes zero and the radial force comes to its maximum. The seventh item becomes null. Apparently just this force is responsible for current flow along conductor surface.

In general the force is

$$\mathbf{F}_{21}=\frac{q_1\delta}{c^2\varepsilon_0 r}\left[\mathbf{V}_2(\mathbf{r}_{21}\cdot\mathbf{V}_1)-\mathbf{r}_{21}(\mathbf{V}_1\cdot\mathbf{V}_2)+\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2-\mathbf{r}_{21}\frac{\left(\mathbf{r}_{21}(\mathbf{V}_1-\mathbf{V}_2)^2\right)}{r^2}\right].$$

And what is this force distribution inside the tube? In the case of solenoid force is distributed steadily along its section. But it is not so here.

Integral force is null on the cylinder axis because of the cylinder surface symmetry with respect to it. If charge q_1 is on a cylinder directrix radius with distance a from the axis then symmetry is preserved only with respect to cylinder generatrix but is invalid with respect to its directrix. Force from the greater arc exceeds the force from the minor one and the integral force is equal to their difference.

Let φ be angle leaning on the minor arc and r_0 is the directrix radius. The greater arc A is equal to $r_0(2\pi-\varphi)$ and the minor arc B is equal to $r_0\varphi$. Their difference ratio to the circumference length is

$$\frac{A-B}{2\pi r_0}=\frac{\pi-\varphi}{\pi},\ \varphi\in[\pi,0].$$

φ can be expressed with the help of the distance a from the cylinder axis to charge q_1

$$a=r_0\cos\varphi/2$$

Hence

$$\varphi=2\arccos a/r_0$$

When a=0, $\varphi=\pi$, when $a=r_0$, φ=0.

One finally gets : when $\mathbf{V}_1\perp\mathbf{V}_2$ the integral force

$$F=\frac{q_1\delta[\pi-2\arccos(a/r_0)]}{c^2\varepsilon_0\pi}\mathbf{V}_2$$

when $\mathbf{V}_1\|\mathbf{V}_2$

$$F=\frac{q_1\delta[\pi-2\arccos(a/r_0)]\left[(\mathbf{V}_1-\mathbf{V}_2)^2-(\mathbf{V}_1\cdot\mathbf{V}_2)\right]}{c^2\varepsilon_0\pi}\mathbf{r}$$

Here r is radius-vector from the cylinder surface going through q_1 and cylinder axis.

Equi-force surfaces here are cylinders coaxial to the initial tube. Such forces lines were experimentally detected by E. A. Grigoriev. Let us not that such force lines do not envelope current but are contained in it. This fact contradicts the orthodox theory but is implied by generalized electrodynamics.

Let as summarize our narration. Generalized dynamics equations proposed by the author predict additional integral forces action on charge moving as inside capacitor as inside solenoid. The forces depend on the charge velocity and final distribution of the charges on screen in fact depends on their velocities. In order to understand the character of such dependence one should describe charge movement under such forces action. This problem is investigated in the second article of the author in this collection [3].

P.S.: It was assumed above that ε is steady (in accordance to the author's concept ε is aether density [2]). For capacitor this means that space between its plates is not filled with matter. If this space is filled with dielectric then an additional force appears because of ε space change. This additional force is

$$F=-\frac{q_1\delta r}{\varepsilon_2}\left[1-\frac{V^2}{c^2}(1+\mathrm{Cos}\theta)\right]\mathrm{grad}\,\varepsilon \tag{4.7}$$

Here q_1 is the charge inside dielectric, θ is the angle between radius-vector from the plate to q_1, r is its module, V is charge velocity on the capacitor's plates.

The first item here has multiplicity of Coulomb force and is directed against grad ε. Just this force is the reason why plastic of dielectric is drawn into capacitor. To-day theory explains this effect by dielectric polarization. The majority of experimental facts known to the author can be explained either by orthodox or by the proposed theory. Therefore it is essential to find an experiment which would help to select between these two approaches.

Let us investigate a capacitor with dielectric of decreasing ε between its plates. Orthodox theory does not predict any considerable changes. It believes that field inside capacitor is decreasing as integral ε value.

The proposed theory predicts a force acting on capacitor's plates and directed to ε decrease, i.e. such a capacitor moves.

The second item in (4.7) has a multiplicity of magnetic force, it is directed along grad ε and apparently defines paramagnetic and diamagnetic characteristics of matter. It is necessary to note that these forces increase with r.

References

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