ORIGINAL ARTICLE

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SUMMARY

This article discusses alternative and complementary proposals to j.C.Maxwell's laws of classical electromagnetism, based on certain hypotheses, hypothetical examples and calculations, with results that may infer new interpretations about the physical phenomenon conduction current density. These new interpretations bring a new understanding to the dynamics of Gauss's Law, and, being true, make the Amperre-Maxwell Law totally symmetrical to the faraday-lenz-maxwell law, without any mathematical or physical inconsistency. These understandings inevitably bring implications and points of view

complementary to the classical theory of electromagnetism.

Keywords: Electromagnetism, current density, continuity equation.

1. INTRODUCTION

First, the solution given by J.C.Maxwell is presented so that the Ampere equation (see formula 1) becomes mathematically consistent, respecting the vector identity applied in (see formula 2), and consistent with the continuity equation (see formula 3).

Below is an example of the application of Gauss's Law (see formula 6) to a closed surface around one of the plates of a capacitor, Figure 1.

By hypothesis, it is proposed that the temporal variation of the total electrical flow, which crosses the gaussian surface totally closed, is always equal to zero. Therefore, Gauss's Law (see formula 6), applied to dynamic situations, would become the equation (see formula 9). For this hypothesis to be based, it will be considered necessary that there is a temporal variation of electric field density, of the same modulus, direction and direction of current density, in the area of intercession between the cylindrical volume of the conductor and the Gaussian surface, pointing into it, Figure 1.

In order to verify the consistency of this hypothesis, an ideal example will be considered in which there is a continuous and homogeneous current in an infinite rectilinear cylindrical wire along the z axis. Then the vector temporal variation of the electric field is calculated (see formula 12) at point P(0,0,0) due to the simultaneous and instantaneous displacement of all loads, upstream and downstream of P(0,0.0). This calculation results in equality (see formula 16).

Finally, starting from the physical veracity of equality (see formula 16), there are inevitable implications, formatting and theoretical complements for classical equations of electromagnetism, by Faraday, Lenz, Biot-Savart and Maxwell. At the end, a laboratory experiment was suggested to confirm or disprove the theory developed from the analysis of the proposed hypothesis.

2. THE DISPLACEMENT AND DRIVING CHAINS

Ampere's circuitlaw, in its punctual form (see formula 1), had mathematical inadequacies (JACKSON *et. al.*, 1998).

$$\oint \mathbf{H} \cdot d\mathbf{L} = I \quad \leftrightarrow \quad \nabla \times \mathbf{H} = \mathbf{J} \tag{1}$$

$$\nabla \cdot \nabla \times \mathbf{H} = \nabla \cdot \mathbf{J} = 0 \tag{2}$$

The result of the equation (see formula 2) should be zero, because the divergence of the rotational being equal to zero constitutes a vector identity. However, the continuity equation (HAYT; BUCK *et. al.*, 2013; SHADIKU, 2004),

$$\nabla \cdot \mathbf{J} = -\frac{\partial \rho_v}{\partial t} \tag{3}$$

is inconsistent with the equation (see formula 2). This correction was made brilliantly by J.C.Maxwell, as follows (JACKSON *et. al.*, 1998):

$$\nabla \cdot \mathbf{J} + \frac{\partial \rho_v}{\partial t} = 0 = \nabla \cdot \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right)$$

$$\nabla \cdot \nabla \times \mathbf{H} = 0 = \nabla \cdot \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right)$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} \tag{4}$$

$$\nabla \times \mathbf{H} = \mathbf{J}_C + \mathbf{J}_D \tag{5}$$

Thus the Ampere equation (see formula 1) became completely consistent in (see formula 5). Both physically, considering the generation of magnetic field from the temporal variation of the density of electric field, and mathematically, with regard to the vector identity cited in the equation (see formula 2).

The ter $\frac{\partial \mathbf{D}}{\partial t}$ m added in the equation (see formula 4) has the same unit of current density, Amperes per square meter

$$\left[\frac{\mathrm{A}}{\mathrm{m}^2}\right]$$

, being termed by J.C.Maxwell of displacement current density, represented by in the

$$\mathbf{J}_{\mathrm{D}}$$

equation (see formula 5). The identification of this term was of fundamental importance for understanding the propagation of electromagnetic waves. The term

$$\mathbf{J}_{\mathrm{C}}$$

in the equation (see formula 5) refers to the conduction current density.

3. HYPOTHESIS OF A DYNAMIC APPLICATION OF GAUSS LAW

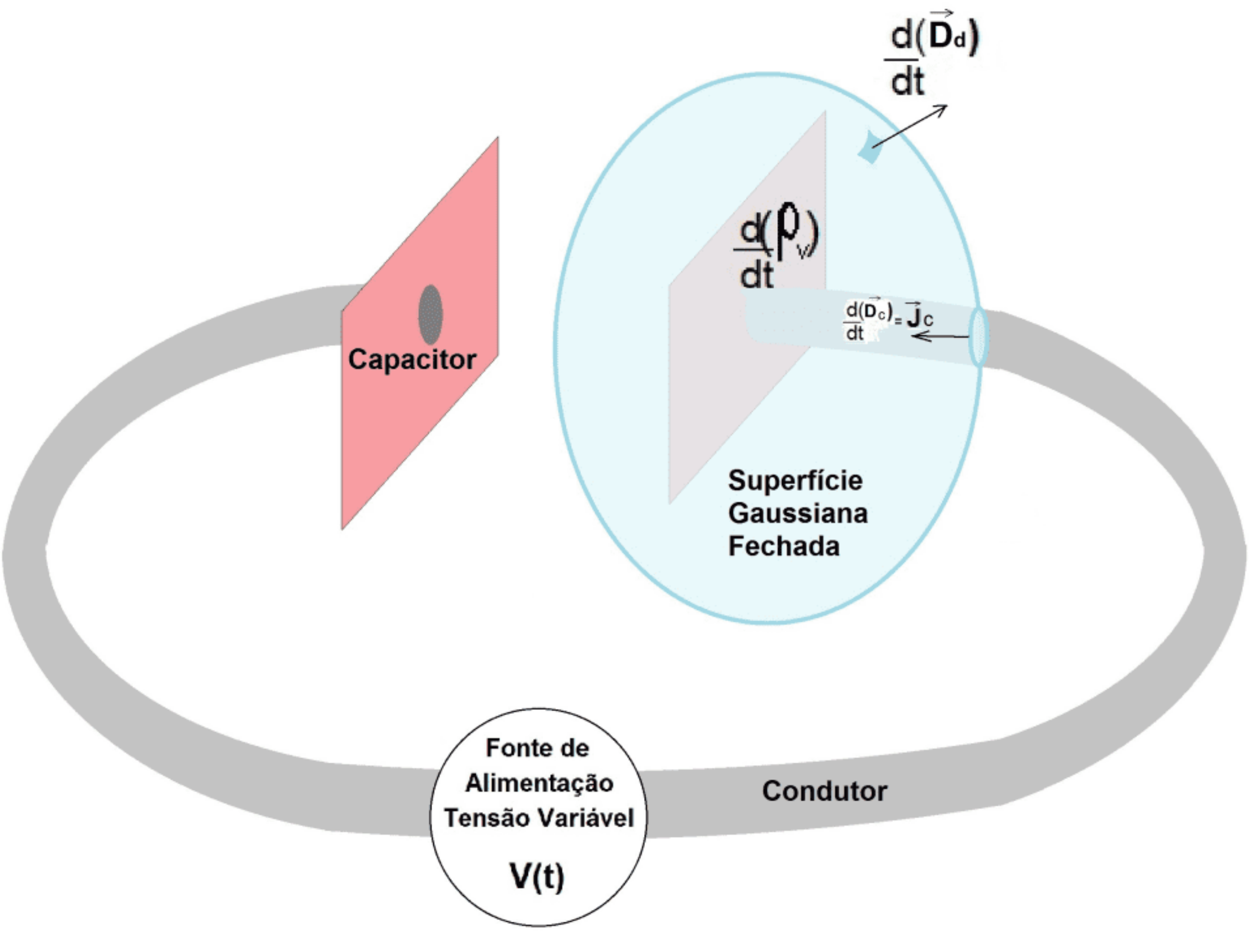
Gauss's Law, equation (see formula 6), determines that the total electric field density flow that crosses any closed surface is equal to the total electrical charge that is contained within that surface. Maxwell observed it in the point form, equation (see formula 7), known as maxwell's first equation (HAYT; BUCK *et. al*., 2013; SHADIKU, 2004).

$$\emptyset = \oint \mathbf{D} \cdot \mathrm{d}\mathbf{S} = \mathrm{Q} \qquad (6)$$

$$\nabla \cdot \mathbf{D} = \rho_{\mathrm{v}} \qquad (7)$$

Consider the first example, being a closed surface around one of the plates of a capacitor that is being loaded by a variable voltage power supply, as shown in Figure 1.

Figure 1. Gaussian surface enclosed on a capacitor plate



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Observing Figure 1, with a conduction current density in the J_C

driver, the equations (see formula 6) and (see formula 7), respectively: for a fully closed Gaussian surface; and for a point on the capacitor plate, they become equations (see formula 8) and (see formula 3). (HAYT; BUCK *et. al*., 2013; SHADIKU, 2004).

$$\frac{d}{dt}(\oint \mathbf{D_d} \cdot d\mathbf{S}) = \frac{d}{dt}(Q) \qquad (8)$$

$$\nabla \cdot \mathbf{J_c} = -\frac{d}{dt}(\rho_v) \qquad (3)$$

The equation (see formula 8) determines that the temporal variation of the total flow of density of electric field that crosses the Gaussian surface is equal to the temporal variation of the electrical charge contained internally to it.

The continuity equation (see formula 3) applied to any infinitesimal volume of the capacitor plate, positively charged, determines that the conduction current density

$\mathbf{J}_C$

, which leaves that given volume, is equal to the time rate at which the volumetric load density falls on it.

The hypothesis proposed in this article considers that the equations (see formula 8) and (see formula 3) are physically complementary. Thus, it is considered that for a fully closed Gauss surface, around a capacitor plate, under dynamic conditions, the equations (see formula 8) and (see formula 3) would have the following format.

$$\oint \frac{d}{dt}(\mathbf{D}_c + \mathbf{D}_d) \cdot d\mathbf{S} = 0 \qquad (9)$$

$$\nabla \cdot \frac{d}{dt}(\mathbf{D}_c + \mathbf{D}_d) = 0 \qquad (10)$$

Where $\frac{\partial}{\partial t}(\mathbf{D}_c)$ is the temporal variation of the vector electric field density generated by the density of conduction current, of

$\mathbf{J}_C$

, the same modulus, direction and direction of the same, on the cross-sectional surface of intersection between the cylindrical volume of the conductor and the Gaussian, pointing into it. And

$$\frac{\partial}{\partial t}(\mathbf{D}_{\mathrm{d}})$$

it is the temporal variation of the vector density of electric field, in the closed Gaussian surface pointing out of it, generated by the displacement current density

$$\mathbf{J}_{\mathbf{d}}$$

time variation of the number of electric field lines that cross the closed Gaussian due to the temporal variation of the total electrical load of the plate from the internal capacitor to the Gaussian); (HAYT; BUCK *et. al*., 2013; SHADIKU, 2004). Figure 1.

The equations (see formula 9) and (see formula 10) determine that the temporal variation of the total flow of electric field density on any fully closed Gaussian surface is equal to zero. The equation (see formula 10) does not contradict the equation of continuity (see formula 3), because it relates the flow of electrical load, of an infinitesimal volume, to the temporal variation of volumetric density of electrical charge, in it; already that, is related only to the dynamics of the electric field.

It is then assumed that the physical phenomenon conduction current density, ge $\mathbf{J}_{\mathrm{C}}$

nerates a variation of electric field density at the

$$\frac{\mathrm{d}}{\mathrm{dt}}(\mathbf{D}_{\mathrm{c}})$$

intersection of the cylindrical conductor with the Gaussian surface, of the same modulus, direction and direction of the vector

$\mathbf{J}_\mathrm{C}$

. One of the advantages of verifying this hypothesis would be to understand the Ampere-Maxwell equation (see formula 4) in the following format (see formula 11).

$$\nabla \times \mathbf{H} = \frac{\partial}{\partial \mathrm{t}} (\mathbf{D}_\mathrm{c} + \mathbf{D}_\mathrm{d}) \qquad (11)$$

Thus, it would be intuited that the interactions between fields, electrical or magnetic, and charged particles, would be, first of all, interactions between fields only.

In the search to verify the veracity of the proposed hypothesis, an example of an ideal hypothetical situation is created for the calculation of the vector temporal variation of electric field density (see formula 12), at the origin, generated by a continuous and homogeneous current in a cylindrical conductor of infinite length along the z axis.

4. EXAMPLE OF AN IDEAL HYPOTHETICAL SITUATION

Suppose the following ideal configuration: in a cylindrical, rectilinear, uniform, homogeneous conductor, of infinite length, which runs through a direct current, of positive, uniform and homogeneous loads in the positive direction of the z-axis, Figure 2.

In cylindrical coordinates, the temporal variation of the electric field vector (see formula 12) generated at point P(0,0,0) of the Cartesian plane in Figure 2, due to the volumetric displacement, simultaneous and instantaneous, of all positive loads, upstream and downstream of this point, in the positive direction of the z axis.

$$\int_{-\infty}^{\infty} \frac{d}{dt} \left[\partial \left(\boldsymbol{E}_{t,z} \right) \right] dz \qquad (12)$$

Although, in a real conductor with a difference in potential applied in its extremities, the electron is the one, by classical pattern, the displacement of positive charges in the positive direction of the z-axis was chosen for the calculation.

It is known, by symmetry, that the resulting vector electric field E generated by the sum of all loads existing along the conductor, positive and negative, at point P(0.0.0), is null.

However, let us consider, first, the calculation of the static electric field (see formula 14), generated by a cylindrical volumetric differential element, in cylindrical coordinates, of volumetric density of positive load ρ_v, centered in an initial position *z*', where *dQ* is the differential element of load, r' is the constant value assigned to the radius of the cylinder conductor, R the vector distance between the point P (0.0,0) and the volumetric differential element *dV* , a_z is the versor in the positive direction of z, and ε the electrical permissiveness of the conductor, as shown in Figure 2.

Please point out that, because we take as reference the measuring point of the electric field fixed in P(0,0,0), the direction of dE will always be opposite to the a_R versor. Therefore, the negative sign in the equation (see formula 13).

$$dQ = \rho_v dV = \rho_v (r d\varphi dr dz)$$

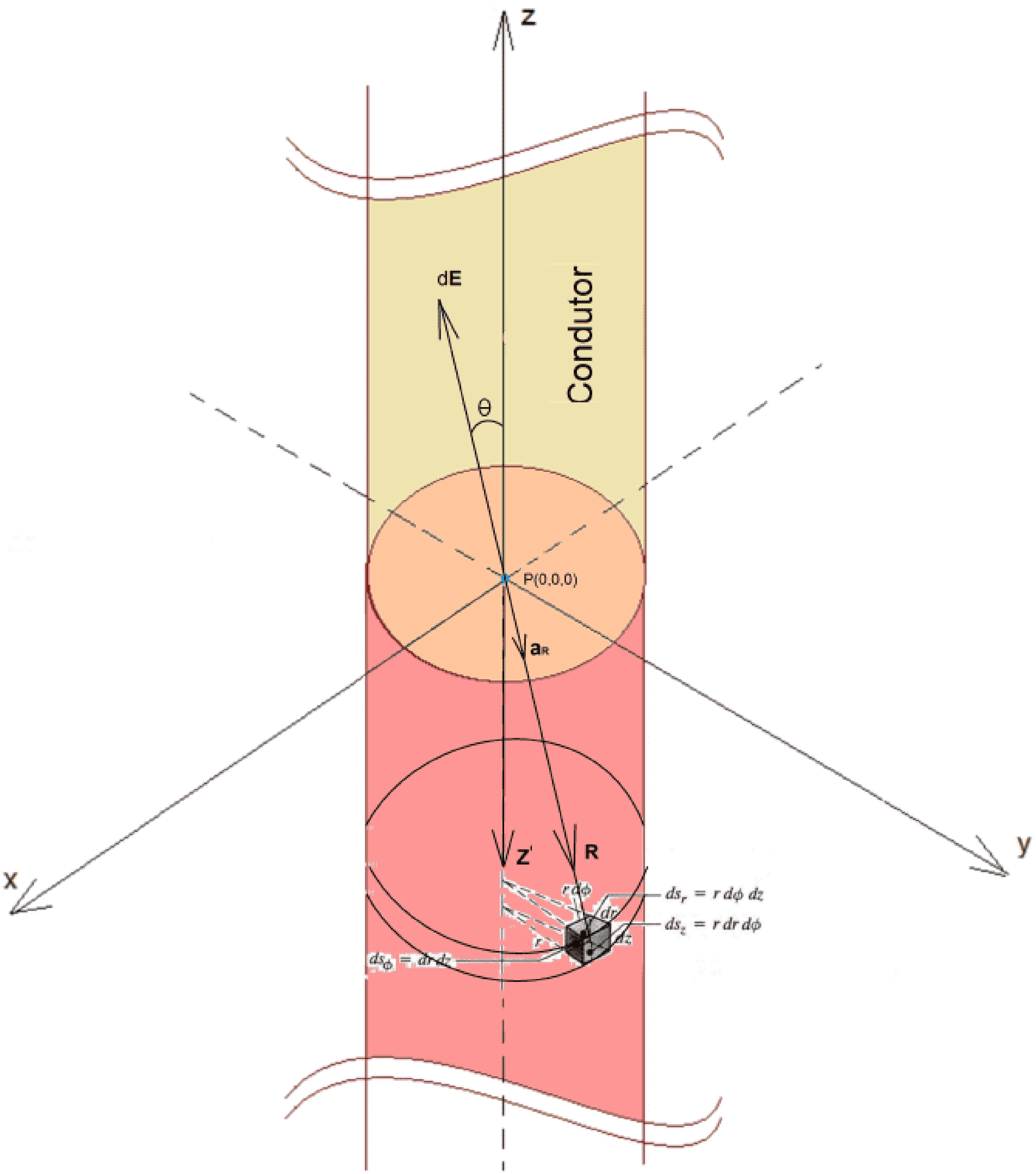
$$d\boldsymbol{E} = -\frac{1}{4\pi\varepsilon}\frac{dQ}{R^2}\boldsymbol{a_R} = -\frac{1}{4\pi\varepsilon}\frac{\rho_v(r d\varphi dr dz)}{R^2}\boldsymbol{a_R} \qquad (13)$$

$$dE cos\theta \boldsymbol{a_z} = -\frac{1}{4\pi\varepsilon}\frac{\rho_v(r d\varphi dr dz)}{R^2}\frac{z'}{R}\boldsymbol{a_z}$$

$$\partial E \boldsymbol{a_z} = -\frac{\rho_v z}{4\pi\varepsilon}\left[\int_0^{r'}\int_0^{2\pi}\frac{r}{(r^2+z'^2)^{\frac{3}{2}}}d\varphi dr\right]\partial z \boldsymbol{a_z}$$

$$\partial \boldsymbol{E} = \partial E \boldsymbol{a_z} = -\frac{\rho_v}{2\varepsilon}\left(1-\frac{z\prime}{(z\prime^2+r\prime^2)^{\frac{1}{2}}}\right)\partial z \boldsymbol{a_z} \qquad (14)$$

Figure 2. Driving Current



Author Source.

Then, considering that this loaded differential volumetric disk has constant velocity. The electric field $\partial \boldsymbol{E}$ becomes a function only of the variable time *t*. Considering the initial position *z'* and*d* the speed of the *v* disc,

$$\frac{d}{dt}[\partial(E_t)]\boldsymbol{a_z} = \frac{d}{dt}\left[-\frac{\rho_v}{2\varepsilon}\left(1-\frac{(z'+vt)}{((z'+vt)^2+r'^2)^{\frac{1}{2}}}\right)\right]\partial z\boldsymbol{a_z}$$

$$\frac{d}{dt}[\partial(E_t)]\boldsymbol{a_z} = \frac{\rho_v}{2\varepsilon}\left(\frac{vr\prime^2}{((z'+vt)^2+r\prime^2)^{\frac{3}{2}}}\right)\partial z\boldsymbol{a_z} \quad (15)$$

As what one wants to calculate is the temporal variation of the electric field (see formula 12), at the origin, caused by the displacement of each differential cylindrical element added along

$z \quad [-\infty, +\infty]$,

instantly, it will be considered exclusively for this calculation that the function of the equation (see formula 15) depends only on the variable position z, $\frac{d}{dt}\partial(E_t) \rightarrow \partial F_z$

. Because the contribution of each cylindrical differential element, along the entire z-axis, moving to the formation of the vector total temporal variation of electric field at point P(0.0.0), because it is instantaneous, does not depend on the variable time t. Thus, replacing z' = z, *and* considering the variable$t = t_0 = 0$,

$$\frac{d}{dt}[\partial(E_t)] \rightarrow \partial F_z = \frac{\rho_v}{2\varepsilon}\left(\frac{vr'^2}{(z^2+r'^2)^{\frac{3}{2}}}\right)$$

$$\int_{-\infty}^{\infty} \partial F_z \, dz \, \boldsymbol{a_z} = \frac{\rho_v v r'^2}{2\varepsilon}\int_{-\infty}^{\infty}\left(\frac{1}{\left(z^2+r'^2\right)^{\frac{3}{2}}}\right)\partial z \boldsymbol{a_z}$$

$$\varepsilon \int_{-\infty}^{\infty} \partial F_z \, dz \, \boldsymbol{a_z} = \varepsilon \frac{d}{dt}(\boldsymbol{E}) = \rho_v v \boldsymbol{a_z} = \boldsymbol{J}$$

$$\frac{d}{dt}(\boldsymbol{D}_c) = \boldsymbol{J}_c \qquad (16)$$

The equation (see formula 16), then, demonstrates the vector equivalence between the temporal variation of the electric field density at point *P*(0,0,0), generated by the instantaneous and simultaneous displacement of all positive charges along the infinite cylindrical wire, and the conduction current density $\mathbf{J}_C$

at that same point.

5. IMPLICATIONS

If there is physical veracity in the hypothesis presented, the following implications are observed:

2. Interpretation of the application of a dynamic of Gauss's Law;
4. New conception of the Laws of Ampere-Maxwell and Faraday-Lenz-Maxwell;
6. Suggested experiment to prove the theory.

5.1 INTERPRETATION OF THE APPLICATION OF A DYNAMICS OF GAUSS LAW

Equality (see formula 16) is considered to be consistent with equations (see formula 9) and (see formula 10). Thus, it is understood to be reasonable the following physical interpretation of gauss's law applied to the situation presented in Figure 1: the temporal variation of the total flow of electric field density on any fully closed Gaussian surface is exactly zero, (see formula 17) and (see formula 18).

$$\oint \frac{d}{dt}(\boldsymbol{D}_T) \cdot d\boldsymbol{S} = 0 \tag{17}$$

$$\nabla \cdot \frac{d}{dt}(\boldsymbol{D}_T) = 0 \tag{18}$$

Due to the classical choice of the current direction being that of the displacement of positive loads, to make the equations (see formula 24) and (see formula 29) symmetrical with each other, the negative sign (–) was inserted to equality (see formula 19).

$$\frac{d}{dt}(\boldsymbol{D}_T) = -\left(\frac{d}{dt}\boldsymbol{D}_c + \frac{d}{dt}\boldsymbol{D}_d\right) \tag{19}$$

The following interpretation about the physical phenomena contemplated in equality is proposed here (see formula 19).

The vector temporal variation of electric field density

$$\frac{\mathrm{d}}{\mathrm{dt}}(\mathbf{D}_c)$$

, a result of conduction current density,

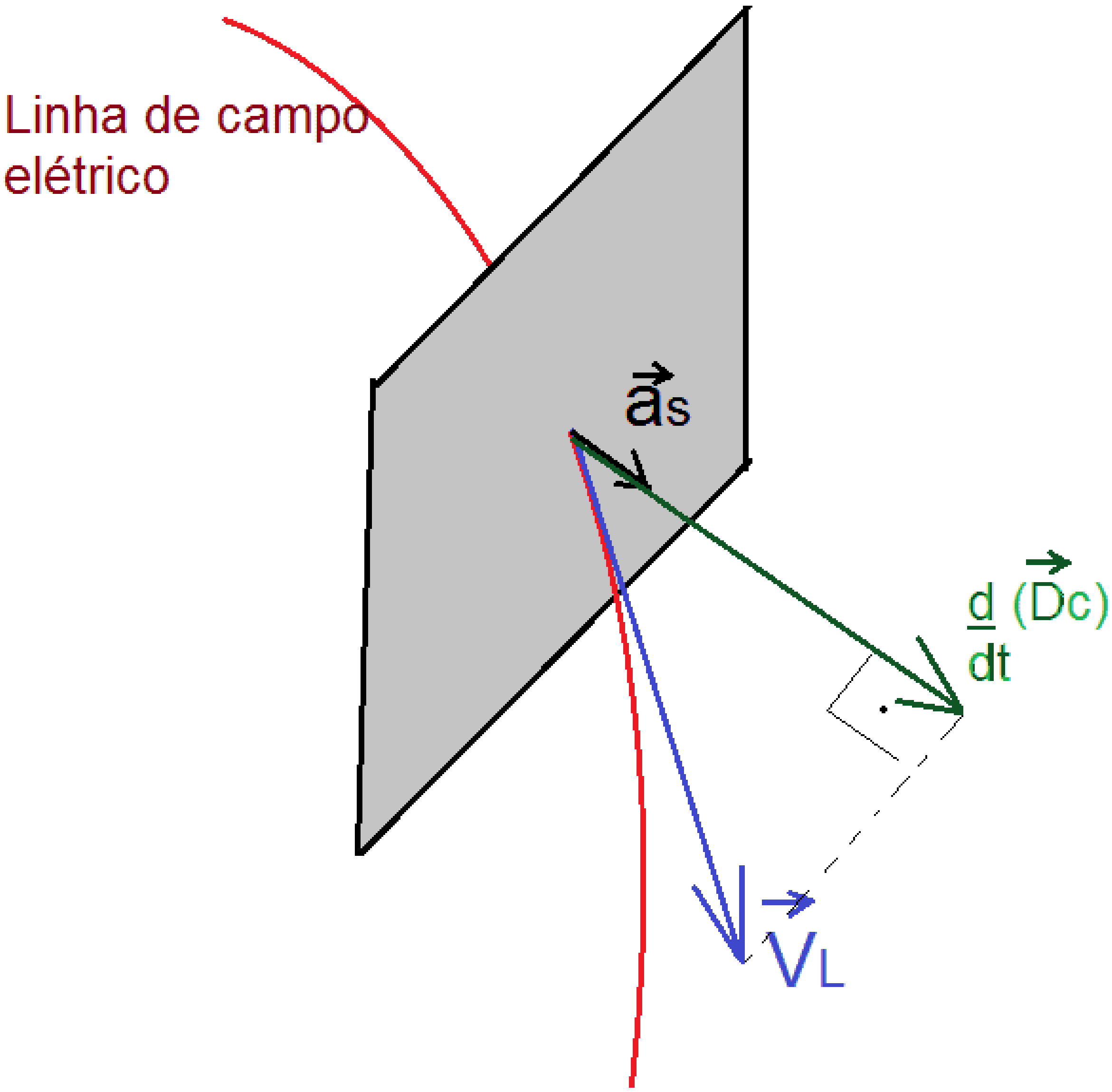
$$\mathbf{J}_C$$

appears to be proportional to the longitudinal velocity at which the electric field lines cross an area element of a Gaussian surface. Theorizing can be theorized:

$$\frac{d}{dt}(\boldsymbol{D}_c) = K1(\boldsymbol{v}_L \cdot \boldsymbol{a}_S)\boldsymbol{a}_S \qquad (20)$$

where v_L is the velocity vector of the electric field lines that cross an area element of a Gaussian surface, a_S the*v*ersor of the vector area element of that surface, and K_1 a constant, Figure 3.

Figure 3. Temporal variation of the density of electric field generated by



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The vector temporal variation of electric field density

$\frac{d}{dt}(\boldsymbol{D}_d)$;

, resulting from the displacement current density

$$\mathbf{J_d}$$

, is related to the temporal variation of the quantitative number of electric field lines that cross an area element of a Gaussian surface (HAYT; BUCK *et. al.*, 2013; SHADIKU, 2004).

Being true the theory proposed, from the initial hypothesis, that the temporal variation of the total electrical flow that crosses a Gaussian surface, can be formed both by the temporal variation of the number of electric field lines, per unit of area, which cross it

$$\frac{d}{dt}(\boldsymbol{D}_d)$$

, and by the longitudinal velocity of the electric field lines that cross an area element,

$$\frac{\mathrm{d}}{\mathrm{dt}}(\mathbf{D}_c)$$

(see formula 20); it is intuited, by symmetry to (see formula 19), that the magnetic flux passing through a Gaussian surface behaves in an equivalent way (see formula 21).

In such a way that

$$\frac{d}{dt}(\boldsymbol{B}_T)$$

it could be generated both by temporal variation of the number of magnetic field lines in an area element (HAYT; BUCK *et. al*., 2013; SHADIKU, 2004),

$$\frac{d}{dt}(\boldsymbol{B}_d)$$

; as well as the longitudinal velocity with which magnetic field lines cross an area element,

$\frac{d}{dt}(\boldsymbol{B}_c)$

(see formula 22). By symmetry, it is proposed, analogously to the equation (see formula 20), the equation (see formula 22). Where v_{mL} is the velocity vector of magnetic field lines that cross an area element of a Gaussian surface, a_S the versor of the area element vector of that surface, and K_2 a constant.

$$\frac{d}{dt}\boldsymbol{B}_T = \frac{d}{dt}(\boldsymbol{B}_c) + \frac{d}{dt}(\boldsymbol{B}_d) \qquad (21)$$

$$\frac{d}{dt}(\boldsymbol{B}_c) = K_2(\boldsymbol{v}_{mL} \cdot \boldsymbol{a}_S)\boldsymbol{a}_S \qquad (22)$$

5.2 NEW DESIGN OF AMPERE-MAXWELL AND FARADAY-LENZ-MAXWELL LAWS

Considering the possibility of veracity in the hypothesis presented, one could conceive of the Ampere-Maxwell Law (see formula 5) and the Faraday-Lenz-Maxwell Law (see formula 23)

$$\oint \boldsymbol{E} \cdot d\boldsymbol{L} = -\int \frac{\partial}{\partial t}(\boldsymbol{B}) \cdot d\boldsymbol{S} \quad \leftrightarrow \quad \nabla \times \boldsymbol{E} = -\frac{\partial}{\partial t}(\boldsymbol{B}) \qquad (23)$$

respectively, as in (see formula 24) and (see formula 25).

$$\oint \boldsymbol{H} \cdot d\boldsymbol{L} = -\int \frac{\partial}{\partial t}(\boldsymbol{D}_T) \cdot d\boldsymbol{S} \quad \leftrightarrow \quad \nabla \times \boldsymbol{H} = -\frac{\partial}{\partial t}(\boldsymbol{D}_T) \qquad (24)$$

$$\oint \boldsymbol{E} \cdot d\boldsymbol{L} = -\int \frac{\partial}{\partial t}(\boldsymbol{B}_T) \cdot d\boldsymbol{S} \quad \leftrightarrow \quad \nabla \times \boldsymbol{E} = -\frac{\partial}{\partial t}(\boldsymbol{B}_T) \qquad (25)$$

5.3 SUGGESTED EXPERIMENT TO PROVE THE THEORY.

The present article aims, succinctly, to propose a theory, based on hypothetical situations, without physical experimentation in the laboratory for proof, at the end of it.

However, a proposal for a laboratory experiment will be presented below, for those of interest, to prove the veracity of the proposed theory, or to disprove it.

For the calculation of a magnetic field *H*, generated exclusively from a conduction current density

$\mathbf{J}_C$, using equality (see formula 16), the Biot-Savart Law (see formula 27) could be described as in (see formula 28).

$$\boldsymbol{H} = \iiint \frac{\boldsymbol{J} \wedge \boldsymbol{u}_R}{4\pi R^2} dv \qquad (27)$$

$$\boldsymbol{H} = \iiint \frac{-\frac{\partial}{\partial t}(\boldsymbol{D}_c) \times \boldsymbol{a}_R}{4\pi R^2} dv \qquad (28)$$

Then, it is proposed to write the modified Biot-Savart Law (see formula 28), symmetrically for the calculation of the electric field, as in (see formula 29).

$$\boldsymbol{E} = \iiint \frac{-\frac{\partial}{\partial t}(\boldsymbol{B}_c) \times \boldsymbol{a}_R}{4\pi R^2} dv \qquad (29)$$

In order to verify the veracity of the theory that the fields, electrical and magnetic, can be generated, respectively, by the speed of displacement of the lines of the fields (magnetic and electrical), the following experiment is proposed.

It is an electrical circuit formed by an isolated conductive wire, coiled in a distributed and continuous way around a ferromagnetic material of toroidal topology, area *A* constant of the cross section, fed by a direct current source, with a current adjusted such that it does not magnetically saturate the ferromagnetic material. There will be a magnetic field density B confined to all toroidal ferromagnetic material (HALLIDAY; RESNICK; WALKER *et. al*., 2013), Figure 4.

$$\boldsymbol{B} = \frac{\mu N i}{l}$$

Where µ is the magnetic permeability of the ferromagnetic material, N the number of turns, and *l* the perimeter traversed by the cross section of the toroide throughout its revolution.

Then, an isolated conductive wire measuring turn is used around the cross section of the toroide, connected to a VDC voltmeter, in such a way that it is possible to shift the measuring coil along the toroidal perimeter, Figure 4.

It is known that the magnetic field generated by any ideal toroidal electrical circuit, external to it, is zero (HALLIDAY; RESNICK; WALKER *et. al*., 2013).

By the theory presented, when the measuring coil moves with a velocity *V* along the toroidal perimeter, even if the number of magnetic field density lines internal to the turn is not changed, these lines will pass through the Gaussian surface formed by the circumference of the measuring coil, with -*V* velocity.

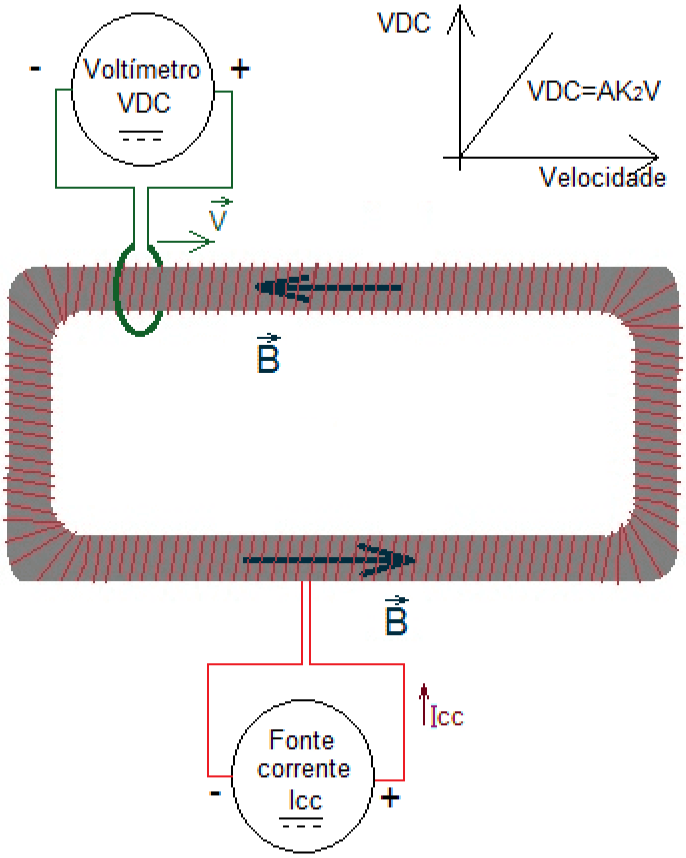
Applying the proposed equation (see formula 22) to the Faraday-Lenz-Maxwell Law (see formula 23), the voltage measured in the voltmeter should be:

$$VDC = -A\frac{d}{dt}(\boldsymbol{B}_c) = -AK_2(\boldsymbol{v}_{mL} \cdot \boldsymbol{a}_S)\boldsymbol{a}_S$$

Where is the area of the cross section of the toroide.

Thus, it is proposed to raise a curve of Measurements *VDC x V,* being *VDC the* voltage measured in the voltmeter, *and V* the velocity vector of the measurement turn, along the toroidal perimeter, Figure 4. According to the proposed theory, this curve should be a straight line with an AK_2 slope, Figure 4.

Figure 4. Suggested experiment to prove the proposed theory



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If the experiment is carried out with a result that corroborates the proposed theory, it is also proposed to consider the existence of the following conduction magnetic

$$\boldsymbol{J}_{mc}$$

current density.

$$-\frac{d}{dt}(\boldsymbol{B}_c) = \boldsymbol{J}_{mc} \quad (30)$$

6. CONCLUSION

In order to better understand the nature of the displacement and conduction currents, the hypothesis was raised that, in a fully closed Gaussian surface, the temporal variation of total electric field flow, in it, could always be equal to zero (see formula 9) and (see formula 10), not contradicting the continuity equation (see formula 3).

An example of an ideal hypothetical situation was created, which would allow mathematical analysis of the hypothesis created.

The result of this analysis, equality (see formula 16), corroborates the idea that the vector temporal variation of total density of electric field (see formula 19) can exist from the following two distinct physical phenomena.

1 –

$$\frac{\partial}{\partial \mathrm{t}}(\mathbf{D}_{\mathrm{d}})$$

→ Temporal variation of the vector density of electric field, in an area element, as a function of the temporal variation of the number of electric field lines that cross it. This is the classic understanding of the di*splacement current density pheno*menon, first recognized by J.C.Maxwell. (HAYT; BUCK *et. al*. 2013; SHADIKU, 2004)

2 –

$$\frac{\mathrm{d}}{\mathrm{dt}}(\mathbf{D}_{\mathrm{c}})$$

→ Temporal variation of the vector density of electric field, in an area element, as a function of the longitudinal velocity of the electric field lines that cross it (see formula 20), due to a conduction current density (see formula 16);

By the premise of symmetry between the behavior of the electric and magnetic fields, similarly the equations (see formula 19) and (see formula 20), the possibility of the magnetic field behaving in the same way in (see formula 21) and (see formula 22) were considered.

Thus, it is proposed a theory that all interactions between fields, electrical or magnetic, and electrically charged particles, are, first of all, interactions between fields only. For example, when applying a potential difference in an electrical circuit, the electric field generated by the potential difference will interact with the electric field of the free loads, forcing them to move. The displacement of the loads implies the displacement of their electric field lines. The longitudinal velocity at which these lines traverse an area differential element would be proportional to the vector

$$\frac{d}{dt}(\mathbf{D}_c)$$

in it.

Considering the possibility of the veracity of equations (see formula 9) and (see formula 10), derived from the dynamics of Gauss's Law, the Ampere-Maxwell Law (see formula 5) is written, in the format (see formula 24), with greater symmetry to the Faraday-Lenz-Maxwell Law (see formula 25).

Finally, a laboratory experiment is proposed to confirm or discredit the proposed theory and its equations.

The following are the equations proposed in this article.

$$\oint \frac{d}{dt}(\boldsymbol{D}_T).\,d\boldsymbol{S} = 0 \tag{9}$$

$$\nabla \cdot \frac{d}{dt}(\boldsymbol{D}_T) = 0 \tag{10}$$

$$\frac{d}{dt}(\boldsymbol{D}_c) = \boldsymbol{J}_c \tag{16}$$

$$-\frac{d}{dt}(\boldsymbol{B}_c) = \boldsymbol{J}_{mc} \tag{30}$$

$$\frac{d}{dt}(\boldsymbol{D}_T) = -\left(\frac{d}{dt}\boldsymbol{D}_c + \frac{d}{dt}\boldsymbol{D}_d\right) \tag{19}$$

$$\frac{d}{dt}(\boldsymbol{D}_c) = K1(\boldsymbol{v}_L \cdot \boldsymbol{a}_S)\boldsymbol{a}_S \tag{20}$$

$$\frac{d}{dt}(\boldsymbol{B}_T) = \frac{d}{dt}\boldsymbol{B}_c + \frac{d}{dt}\boldsymbol{B}_d \tag{21}$$

$$\frac{d}{dt}(\boldsymbol{B}_c) = K_2(\boldsymbol{v}_{mL} \cdot \boldsymbol{a}_S)\boldsymbol{a}_S \tag{22}$$

$$\oint \boldsymbol{H} \cdot d\boldsymbol{L} = -\int \frac{\partial}{\partial t}(\boldsymbol{D}_T) \cdot d\boldsymbol{S} \quad \leftrightarrow \quad \nabla \times \boldsymbol{H} = -\frac{\partial}{\partial t}(\boldsymbol{D}_T) \tag{24}$$

$$\oint \boldsymbol{E} \cdot d\boldsymbol{L} = -\int \frac{\partial}{\partial t}(\boldsymbol{B}_T) \cdot d\boldsymbol{S} \quad \leftrightarrow \quad \nabla \times \boldsymbol{E} = -\frac{\partial}{\partial t}(\boldsymbol{B}_T) \tag{25}$$

$$\boldsymbol{H} = \iiint \frac{-\frac{\partial}{\partial t}(\boldsymbol{D}_c) \times \boldsymbol{a}_R}{4\pi R^2}\, dv \tag{28}$$

$$\boldsymbol{E} = \iiint \frac{-\frac{\partial}{\partial t}(\boldsymbol{B}_c) \times \boldsymbol{a}_R}{4\pi R^2}\, dv \tag{29}$$

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