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ABOUT THE CLASSICAL ELECTRODYNAMICS AND PRACTICAL APPLICATIONS INFLUENCED BY THE DISCOVERY OF MAGNETIC MONOPOLES

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ABSTRACT

Even though one usually calculates capacitor losses with a complex Epsilon it still offends the principle of a constant speed of light. Maxwell's term $c^2 = 1/\varepsilon\cdot\mu$ would even entail a physically unexplicable complex speed! By such an offence against basic principles every physicist is asked to search and to repair the mistake in the textbooks.

In the present treatise vortex losses get in the place of a postulated and fictive imaginary part of the material constant ε when the function of a microwave oven, welding of PVC foils or capacitor losses are to be explained. The responsible potential vortices can be derived without postulate from approved physical laws and their existence can even be proved experimentally.

Key words: Magnetic Monopoles, Electrodynamics, Maxwell Equations, Field Theory, Dielectric Losses, Poynting Vector, Vector Potential, Potential Vortex.

1. INTRODUCTION

The error search leads over Poynting's theorem to the vector potential **A**. At this point a new abyss opens. It shows quickly how and where the whole electrodynamics get entangled in contradictions.

The vector potential **A** assumes, as everybody knows that no magnetic monopoles exist. Mathematically expressed it should be

$$\text{div}\,\mathbf{B} = \text{div}\,\text{curl}\,\mathbf{A} = 0\,. \qquad (1)$$

(Called the 3rd equation of Maxwell).

On the 16th of October, 2009 sixteen authors reported in the magazine "*Science*" about the discovery of magnetic monopoles [1]. For the vector potential and all derivations constructing it, this new discovery means the final death blow from the mathematical-physical view.

However, those who pursue responsible science, know that a new way must be found. A way to electrodynamics free of contradictions, without vector potential **A** and without complex ε!

Vortex physics offers such a way free from contradictions, with the derivation of potential vortices by a potential density vector **b** which adequately substitutes for the outdated vector potential. Also the dielectrically losses, from now on as vortex losses of disintegrating potential vortices can be calculated in the electrodynamics free of contradiction without complex ε.

Besides, **b** is by no means postulated but is derived from approved physical legitimacies according to textbooks.

2. DISCOVERY OF THE LAW OF INDUCTION

In the choice of the approach the physicist is free as long as the approach is reasonable and well founded. In the case of **Maxwell's field equations** two experimentally determined regularities served as basis: On the one hand, **Ampère's law** and on the other hand the **law of induction of Faraday**.

Maxwell, the mathematician, thereby gave the finishing touches for the formulations of both laws. He introduced the displacement current **D** and completed Ampère's law accordingly, and doing so without a chance of being able to measure and prove the measure. Only after his death this was possible experimentally, what afterwards makes clear the abilities of this man.

In the formulation of the law of induction, **Maxwell** was completely free because the **discoverer Michael Faraday** had done so without specifications. As a man of practice and of experiment the mathematical notation was less important for Faraday. For him the attempts with which he could show his discovery of the induction to everybody (i.e. his unipolar generator), stood in the foreground.

However, his 40 years younger friend and professor of mathematics Maxwell had something completely different in mind. He wanted to describe the light as an electromagnetic wave and doing so certainly the wave description of Laplace went through his mind, which in turn needs a second time derivation of the field factor.

Because Maxwell for this purpose needed two equations with each time a first derivation, he had to introduce the displacement current in Ampère's law and had to choose an appropriate notation for the formulation of the law of induction to get to the wave equation.

His light theory initially was very controversial. Maxwell faster found acknowledgement for bringing together the teachings of electricity and magnetism and the representation as something unified and belonging together [2] than for mathematically giving reasons for the principle discovered by Faraday.

Nevertheless, questions should be asked. If Maxwell has found the suitable formulation, if he has understood 100 percent correct his friend Michael Faraday's discovery. If the discovery (1831) and the mathematical formulation (1862) stem from two different scientists, who in addition belong to different disciplines, thus it is not unusual for misunderstandings to occur. It will be helpful to work out the differences.

3. THE UNIPOLAR GENERATOR

If one turns an axially polarized magnet or a copper disc situated in a magnetic field, then perpendicular to the direction of motion and perpendicular to the magnetic field pointer a pointer of the electric field will occur, which everywhere points axially to the outside. In the case of this by **Michael Faraday**, he developed a **unipolar generator** - by means of a brush between the rotation axis and the circumference a voltage is picked off.

The mathematically correct relation $\mathbf{E} = \mathbf{v} \times \mathbf{B}$ (2) I call this the "*Faraday-law*", despite the fact that it appears in this form in textbooks later in time [3]. The formulation usually is attributed to the mathematician **Hendrik Lorentz**, since it appears in the **Lorentz force** in exactly this form. Much more important than the mathematical formalism are the experimental results and the discovery by Faraday, for which the law concerning unipolar induction is named after him the "**Faraday-law**".

Of course we must realize that the charge carriers at the time of the discovery hadn't been discovered yet and the field concept couldn't correspond to that of today. The field concept is an abstracter one, free of any quantization.

That of course is also valid for the field concept advocated by Maxwell, which we now contrast with the „*Faraday-law*" (fig. 1). The second Maxwell equation, the law of induction (3), also is a mathematical description between the electric field strength **E** and the magnetic induction **B**. But this time the two aren't linked by a relative velocity **v**.

In place stands the time derivation of **B**, with which a change in flux is necessary for an electric field strength to occur. As a consequence the Maxwell equation doesn't provide a result in the static or quasi-stationary case. In such cases it is usual to fall back upon the unipolar induction according to Faraday (e.g. in the case of the Hall-probe, the picture tube, etc.). The falling back should only remain restricted to such cases, so the normally idea is used. The question then asked: "*Which restriction of the "Faraday-law" to stationary processes is made*?"

The vectors **E** and **B** can be subject to both spatial and temporal fluctuations. In that way the two formulations suddenly are in competition with each other and we are asked to explain the difference, as far as such a difference should be present.

4. DIFFERENT INDUCTION LAWS

For instance, such a difference it is common practice to neglect the coupling between the fields at low frequencies. At high frequencies in the range of the electromagnetic field the **E**- and the **H**-field are mutually dependent.

While at lower frequency and small field change the process of induction drops correspondingly according to Maxwell so that a neglect seems to be allowed. Under these conditions electric or magnetic field can be measured independently of each other. Usually it is proceeded as if the other field is not present at all.

That is not correct. A look at the "*Faraday-law*" and immediately it shows that even down to frequency zero both fields are always present. The field pointers however stand perpendicular to each other, so that the magnetic field pointer wraps around the pointer of the electric field in the form of a vortex ring. In this case the electric field strength is being measured and vice versa. The closed-loop field lines are acting neutral to the outside; so is the normal used idea. However they need no attention.

It should be examined more closely if this is sufficient as an explanation for the neglect of the not measurable closed-loop field lines or, if not after all, an effect arises from fields which are present in reality.

Another difference concerns the commutability of **E**- and **H**-field, as is shown by the Faraday-generator, how a magnetic field becomes an electric field and vice versa as a result of a relative velocity v. This directly influences the physical-philosophic question: "*What is meant by the electromagnetic* ***field*****?"**

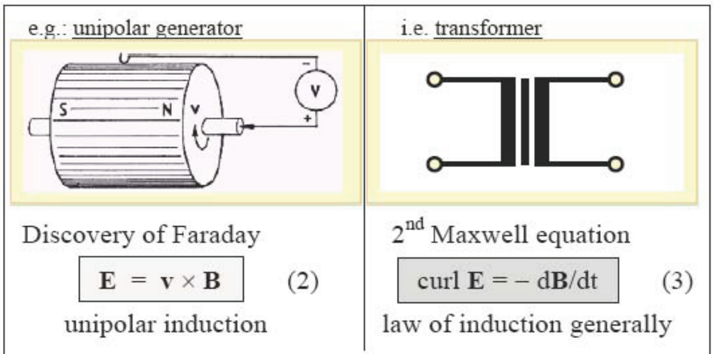

Fig. 1: Two formulations for one law
As a mathematical relation between the vectors of the electric field strength ***E*** *and the magnetic flux density* ***B***

5. THE ELECTROMAGNETIC FIELD

The textbook opinion, based on the *Maxwell equations*, names the static field of the charge carriers as cause for the electric field, whereas moving ones cause the magnetic field [4 i.e.]. But that could not have been the idea of **Faraday**, to whom the existence of charge carriers was completely unknown.

For his contemporaries, completely revolutionary abstract field concept, based on the works of the **Croatian Jesuit priest Boscovic** (1711-1778). In the case of the field it should less concern a physical quantity in the usual sense, than rather the "*experimental experience*" of an interaction according to his field description.

We should interpret the "*Faraday-law*" to the effect that we experience an electric field if we are moving with regard to a magnetic field with a relative velocity and vice versa. In the commutability of electric and magnetic field a duality between the two is expressed, which in the Maxwell formulation is lost as soon as charge carriers are brought into play. The question then becomes, "*Is the Maxwell field the special case of a particle free field*?"

Much evidence points to the answer as "*yes*", because, after all, a light ray can run through a particle free vacuum. As we see, fields can exist without particles but particles without fields are impossible! In conclusion, the field should have been there first as the cause for the particles. The Faraday description should form the basis from which all other regularities can be derived.

What do the textbooks say to that?

6. CONTRADICTORY OPINIONS IN TEXTBOOKS

Obviously there exist two formulations for the law of induction (2 and 3), which more or less have equal rights. Science stands for the questions: "*Which mathematical description is the more efficient one? If one case is a special case of the other case, which description then is the more universal one*?"

What Maxwell's field equations tell us is sufficiently known so that derivations are unnecessary. Numerous textbooks are standing by, if results should be cited. Let us hence turn to the "*Faraday-law*" (2). Often one searches in vain for this law in schoolbooks. Only in more pretentious books one makes a find under the keyword unipolar induction. If one compares the number of pages which are spent on the law of induction according to Maxwell with the few pages for the unipolar induction, then one gets the impression that the later is only a unimportant special case for low frequencies.

Prof. **Küpfmüller** (TU Darmstadt) speaks of a "*special form of the law of induction*" [4, p.228, eq.22], and cites as practical examples the induction in a brake disc and the Hall-effect. Afterwards Küpfmüller derives from the "*special form*" the "*general form*" of the law of induction according to Maxwell, a postulated generalization, which needs an explanation. But a reason is not given.

Prof. **Bosse** (as successor of Küpfmüller at the TU Darmstadt) gives the same derivation, but for him the Maxwell-result is the special case and not the Faraday approach [5, p.58]! In addition he addresses the "*Faraday-law*" as an equation of transformation, points out the meaning, and the special interpretation.

On the other hand he derives the law from the "*Lorentz force*", completely in the style of Küpfmüller [4] and with that again takes part of its autonomy.

Prof. **Pohl** (University of Göttingen, Germany) looks at that differently. He inversely derives the "*Lorentz force*" from the "*Faraday-law*" [3, p.77]. We should follow this very convincing representation.

7. THE EQUATION OF CONVECTION

If Bosse [5] prompted term "*equation of transformation*" is justified or not is unimportant at first. That is a matter for discussion.

If there should be talk about "*equations of transformation*", then the dual formulation (to equation 2) belongs to it, and then it concerns a **pair of complementary equations** which describes the relations between the electric and the magnetic field.

The **new and dual field approach**
consists of **equations of transformation**
of the electric and of the magnetic field

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \quad (2) \qquad \text{and} \qquad \mathbf{H} = -\mathbf{v} \times \mathbf{D} \quad (4)$$

unipolar induction | ***equation of convection***

Written down according to the rules of duality there results an equation (4), which occasionally is mentioned in some textbooks.

While both equations in the books of **Pohl** [3, p.76 and 130] and of **Simonyi** [6, p.924] are written down side by side having equal rights and are compared with each other, **Grimsehl** [7, p.130] derives the dual regularity (4) with the help of the example of a thin, positively charged, and rotating metal ring. He speaks of "*equation of convection*" as moving charges produce a magnetic field and so-called convection currents. Doing so he refers to workings of **Röntgen** 1885, **Himstedt**, **Rowland** 1876, **Eichenwald** and many others. In his textbook **Pohl** also gives practical examples for both equations of transformation. He points out that one equation changes into the other one, if as a relative velocity v the speed of light c should occur [3, p.77].

8. DERIVATION FROM TEXT BOOK PHYSICS

We now have found a field-theoretical approach with the equations of transformation, which in its dual formulation is clearly distinguished from the Maxwell approach. The reassuring conclusion is added: **The new field approach roots entirely in textbook physics**, and are the results from literature research.

We can completely do **without postulates**!

As a starting-point and as approach serve the *equations of transformation* of the electromagnetic field, the "*Faraday-law*" of *unipolar induction* (2) and the according to the rules of duality formulated law called *equation of convection* (4).

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \quad (2) \qquad \text{and} \qquad \mathbf{H} = -\mathbf{v} \times \mathbf{D} \quad (4)$$

If we apply the curl to both sides of the equations:

$$\text{curl}\,\mathbf{E} = \text{curl}\,(\mathbf{v} \times \mathbf{B}) \quad (5), \qquad \text{curl}\,\mathbf{H} = -\,\text{curl}\,(\mathbf{v} \times \mathbf{D}) \quad (6)$$

then according to known algorithms of vector analysis the curl of the cross product each time delivers the sum of four single terms [8]:

$$\text{curl}\,\mathbf{E} = (\mathbf{B}\,\text{grad})\mathbf{v} - (\mathbf{v}\,\text{grad})\mathbf{B} + \mathbf{v}\,\text{div}\,\mathbf{B} - \mathbf{B}\,\text{div}\,\mathbf{v} \quad (7)$$

$$\text{curl}\,\mathbf{H} = -[(\mathbf{D}\,\text{grad})\mathbf{v} - (\mathbf{v}\,\text{grad})\mathbf{D} + \mathbf{v}\,\text{div}\,\mathbf{D} - \mathbf{D}\,\text{div}\,\mathbf{v}] \quad (8)$$

Two of these again are zero for a non-accelerated relative motion in the x-direction with $\mathbf{v} = d\mathbf{r}/dt$ (9)

$$\text{grad}\,\mathbf{v} = 0 \quad (9^*) \qquad \text{and} \qquad \text{div}\,\mathbf{v} = 0 \quad (9^{**})$$

One term concerns the vector gradient $(\mathbf{v}\,\text{grad})\mathbf{B}$, which can be represented as a tensor. By writing down and solving the accompanying derivative matrix and giving consideration to the above determination of the **v**-vector, the vector gradient becomes the simple time derivation of the field vector $\mathbf{B}(\mathbf{r}(t))$,

$$(\mathbf{v}\,\text{grad})\,\mathbf{B} = \frac{d\mathbf{B}}{dt} \qquad \text{and} \qquad (\mathbf{v}\,\text{grad})\,\mathbf{D} = \frac{d\mathbf{D}}{dt}, \quad (10)$$

according to the rule:

$$\frac{d\mathbf{B}(\mathbf{r}(t))}{dt} = \frac{\partial\,\mathbf{B}(\mathbf{r}=\mathbf{r}(t))}{\partial\,\mathbf{r}} \cdot \frac{d\mathbf{r}(t)}{dt} = (\mathbf{v}\,\text{grad})\,\mathbf{B} \quad (11)$$

For the final not yet explained terms are written down the vectors **b** and **j** as abbreviation.

$$\text{curl}\,\mathbf{E} = -\,d\mathbf{B}/dt + \mathbf{v}\,\text{div}\,\mathbf{B} = -\,d\mathbf{B}/dt - \mathbf{b} \quad (12)$$

$$\text{curl}\,\mathbf{H} = d\mathbf{D}/dt - \mathbf{v}\,\text{div}\,\mathbf{D} = d\mathbf{D}/dt + \mathbf{j} \quad (13)$$

With equation 13 we in this way immediately look at the well-known law of Ampère (1st Maxwell eq.).

9. THE MAXWELL EQUATIONS AS A SPECIAL CASE

In addition the comparison of coefficients (15) delivers a useful explanation to the question, "*What is meant by the current density* **j**"? It is a space charge density ρ_{el} consisting of negative charge carriers, which moves with the velocity **v**, for instance through a conductor in the x-direction.

The result will be the **Maxwell equations**, if:

- the potential density $\mathbf{b} = -\,\mathbf{v}\,\text{div}\,\mathbf{B} = 0$, (14)

(eq. 12 ≡ law of induction, if **b** = 0 resp. div **B** = 0)!

- the current density $\mathbf{j} = -\,\mathbf{v}\,\text{div}\,\mathbf{D} = -\,\mathbf{v}\cdot\rho_{el}$, (15)

(eq. 13 ≡ Ampère's law, if **j** ≡ with **v** moved neg. charge carriers; ρ_{el} = electric space charge density).

The current density **j** and the dual potential density **b** mathematically seen at first are nothing but alternative vectors for an abbreviated notation. While for the current density **j** the physical meaning already could be clarified from the comparison with the *law of Ampère*, the interpretation of the potential density **b** is still due:

$$\mathbf{b} = -\,\mathbf{v}\,\text{div}\,\mathbf{B} \quad (= 0) \qquad , \quad (14)$$

From the comparison of eq. 12 with the *law of induction* (eq. 3) we merely infer, that according to the *Maxwell theory* that this term is assumed to be zero. But that is exactly the **Maxwell approximation** and the restriction with regard to the new and dual field approach, which takes root in Faraday.

10. THE MAXWELL APPROXIMATION

Also the duality gets lost with the argument that magnetic monopoles (div **B**) in contrast to electric monopoles (div **D**) do not exist and until today could evade every proof. It has not yet been searched for the vortices dual to eddy currents, which are expressed in the neglected term.

Assuming a monopole concerns a special form of a field vortex, then immediately it is clear why the search for magnetic poles in the past had to be a dead end and their failure isn't good for a counterargument. The missing electric conductivity in a vacuum prevents current densities, eddy currents, and the formation of magnetic monopoles. Potential densities and potential-vortices however can occur. As a result, without exception, only electrically charged particles can be found in the vacuum.

Let us record: **Maxwell's field equations can directly be derived from the new dual field approach under a restrictive condition**.

Under this condition the two approaches are equivalent and with that also error free. Both follow the textbooks and can, so to speak, be the textbook opinion. The restriction (**b** = 0) surely is meaningful and reasonable in all those cases in which the Maxwell theory is successful. It only has an effect in the domain of electrodynamics. Here usually a vector potential **A** is introduced and by means of the ***calculation of a complex dielectric constant*** a loss angle is determined. Mathematically the approach is correct and dielectric losses may be calculated.

Physically the result is extremely questionable since as a consequence of a complex ε a *complex speed of light* would result,

according to the definition: $c = 1/\sqrt{\varepsilon \cdot \mu}$ (16)

With that electrodynamics offends against all specifications of the textbooks, according to which c is constant and not variable and less then ever complex!

But if the result of the derivation physically is wrong, then something with the approach is wrong, therefore we ask if the fields in the dielectric perhaps have an **entirely other nature** and then **dielectric losses** perhaps are **vortex losses** of the **potential-vortex decay**?

11. MAGNETIC FIELD AS A VORTEX FIELD

Is the introduction of a vector potential **A** in electrodynamics a substitute of neglecting the potential density **b**? Do two ways mathematically lead to the same result? And what about the physical relevance?

After classic electrodynamics, being dependent on working with a complex constant of material is buried an insurmountable inner contradiction. The answer begs for the **freedom of contradictions of the new approach**.

The abbreviations **j** and **b** are further transformed, at first the current density in *Ampère's law*

$$\mathbf{j} = -\mathbf{v} \cdot \rho_{el} \qquad (15)$$

as the movement of negative electric charges.

By means of Ohm's law $\mathbf{j} = \sigma \cdot \mathbf{E}$ (17)

and the relation of material $\mathbf{D} = \varepsilon \cdot \mathbf{E}$ (18)

the current density $\boxed{\mathbf{j} = \mathbf{D}/\tau_1}$ (19)

also can be written down as dielectric displacement current with the characteristic relaxation time constant for the eddy currents $\tau_1 = \varepsilon/\sigma$ (20).

In this representation of the law of Ampère:

$$\boxed{\text{curl}\,\mathbf{H} = d\mathbf{D}/dt + \mathbf{D}/\tau_1 = \varepsilon \cdot (d\mathbf{E}/dt + \mathbf{E}/\tau_1)} \qquad (21)$$

clearly is brought to light why the magnetic field is a vortex field, and how the eddy currents produce heat losses depending on the specific electric conductivity σ. As one sees, with regard to the magnetic field description, we move around completely in the framework of textbook physics.

12. DERIVATION OF POTENTIAL-VORTEX

Let us now consider the dual conditions. The comparison of coefficients looked at purely formal, results in a *potential density* $\boxed{\mathbf{b} = \mathbf{B}/\tau_2}$ (22)

in duality to the current density **j** (eq. 19), which with the help of an appropriate time constant τ_2 founds vortices of the electric field. I call these ***"potential-vortices"***

$$\boxed{\text{curl}\,\mathbf{E} = -\,d\mathbf{B}/dt - \mathbf{B}/\tau_2 = -\,\mu \cdot (d\mathbf{H}/dt + \mathbf{H}/\tau_2)} \qquad (23)$$

In contrast to that the Maxwell theory it requires an **irrotationality of the electric field**, which is expressed by taking the potential density **b** and the divergence **B** equal to zero. The time constant τ_2 thereby tends towards infinity.

There isn't a way past the potential-vortices and the new dual approach,

- as the new approach gets along **without a postulate**, as well as
- consists of **accepted physical laws**,
- why also **all error free derivations** are to be accepted,
- no scientist can afford to already exclude a possibly **relevant phenomenon** at the approach,
- the **Maxwell approximation** for it's negligibleness is to examine,
- to which a **potential density measuring instrument** is necessary, which may not exist according to the Maxwell theory.

Supported by the discovery of magnetic monopoles by the Helmholtz center [1] in Berlin and Dresden we are forced to accept a div **B** different from zero which forbids the usual use of the vector potential **A** in the new physics.

In its place come the potential density **b** and the potential-vortices with the characteristic time constant τ_2. Therefore, the Maxwell approximation is history.

Nevertheless, we should check the new field approach for plausibility. At this point particularly the question of the calculation of dielectric losses in capacitors and insulators interests us.

13. THE EXTENDED POYNTING VECTOR

The Poynting vector $\mathbf{S} = \mathbf{E} \times \mathbf{H}$ (24)

stands for the energy flux density of the electromagnetic field. With this usual abbreviation the calculation of the entire energy balance is possible. First the power flux density is determined:

$$\text{div}\,\mathbf{S} = \text{div}\,(\mathbf{E} \times \mathbf{H}) = \mathbf{H} \cdot \text{curl}\,\mathbf{E} - \mathbf{E} \cdot \text{curl}\,\mathbf{H} \qquad (25)$$

Then the enlarged field equations are used for [12 or 23 (curl **E**) and for 13 or 21 (curl **H**)]:

$$\text{div}\,\mathbf{S} = -\,\mathbf{H} \cdot d\mathbf{B}/dt - \mathbf{H} \cdot \mathbf{b} - \mathbf{E} \cdot d\mathbf{D}/dt - \mathbf{E} \cdot \mathbf{j} \qquad (26)$$

By consideration of the material equations and the relation, that

$$\varepsilon \cdot \int_0^{\mathbf{E}} \mathbf{E} \cdot d\mathbf{E} = \tfrac{1}{2}\varepsilon \cdot \mathbf{E}^2 \qquad (27)$$

resp. $\mathbf{E} \cdot d\mathbf{D}/dt = d/dt(\tfrac{1}{2}\varepsilon \cdot \mathbf{E}^2)$ (27*)

and accordingly: $\mathbf{H} \cdot d\mathbf{B}/dt = d/dt(\tfrac{1}{2}\mu \cdot \mathbf{H}^2)$ (28)

the energy balance for an infinitesimal volume element (Poynting theorem) in enlarged form is:

$$\text{div}\,\mathbf{S} + d/dt(\tfrac{1}{2}\varepsilon \cdot \mathbf{E}^2 + \tfrac{1}{2}\mu \cdot \mathbf{H}^2) + \mathbf{E} \cdot \mathbf{j} + \mathbf{H} \cdot \mathbf{b} = 0 \qquad (29)$$

Four of the five appearing terms in the entire balance are described and discussed in numerous textbooks [9, p.68].

Thus div **S** stands for the input power,

$\varepsilon \cdot \mathbf{E}^2/2$ describe the stored electric

and $\mu \cdot \mathbf{H}^2/2$ the magnetic energy density, while the expression $\mathbf{E \cdot j}$ explains the losses.

The electric energy stored in a condenser amounts:

$$W_{el} = \iiint_V (\tfrac{1}{2}\varepsilon \cdot E^2) dV = \frac{\varepsilon U^2}{2 d^2} d \cdot A = \frac{1}{2} U^2 \frac{\varepsilon A}{d} = \frac{1}{2} C \cdot U^2 \quad (30)$$

with the capacity of the condenser $C = \varepsilon \cdot A/d$ (31)

Analogously the magnetic energy stored in an inductance amounts to:

$$W_{mag} = \iiint_V (\tfrac{1}{2}\mu \cdot H^2) dV = \frac{\mu I^2}{2 s^2} s \cdot A = \frac{1}{2} I^2 \frac{\mu A}{s} = \frac{1}{2} L \cdot I^2 \quad (32)$$

with the inductance
of a conductor loop $L = \mu \cdot A/s$ (33)

A certain duality between the electric and the magnetic field can't be neglected.

If the stored power is subtracted from the supplied input power only the losses are left in the energy balance. Besides, there also appear two terms of losses $\mathbf{E \cdot j}$ and $\mathbf{H \cdot b}$, which require a more exact investigation.

14. JOULE EFFECT LOSSES IN THE ENERGY BALANCE

All textbooks about electrodynamics agree to the fact that only **one** term of loss should appear. This being the heat in an electrically conducting medium on the basis of currents or eddy-currents. For calculating the energy transformed into heat one puts the volume integral over the power density $\mathbf{E \cdot j}$ (with the Ohm´s law $E = j/\sigma$ after eq. (17)):

$$P = \iiint_V E \cdot j \, dV = \iiint_V (j^2/\sigma) \, dV = (j^2/\sigma) \cdot A \cdot d = I^2 \cdot R \quad , \quad (34)$$

Because the current density j defines the current

$$I = j \cdot A \quad (35)$$

and together with the specific conductance σ the resistance R: $R = d/\sigma \cdot A$. (36)

The relaxation-time constant $\tau_1 = \varepsilon/\sigma$ represents the eddy-currents and describes the vortex decay as we had mentioned in eq. 20. If we substitute the conductivity and attach the surface A as disks of a capacitor and d as their distance to each other (after eq. 31) the loss resistance gets a slightly different meaning:

$$R = \frac{d}{A \cdot \sigma} = \frac{d}{A} \frac{\tau_1}{\varepsilon} = \frac{\tau_1}{C} \quad (37)$$

Thus the time constant of the eddy-currents suggests a **R-C-circuit** with the time constant

$$\tau_1 = R \cdot C \quad (38)$$

One might calculate the loss factor of a capacitor run on alternating currents in this manner [10, p.135]

$$\tan \delta = 1/\omega \cdot R \cdot C \quad (39)$$

but what remains unnoticed is the fact that here exclusively the *Joule effect* is calculated, while an electric conductivity σ forms the basic condition for the realization of the currents and eddy-currents. A good insulator does not fulfill this basic condition any better than standard capacitors. And this is only one **point of critique** among many.

If we run the capacitor, for example with AC currents and exchange the dielectric with one of less conductivity, then the time constant will grow and also the losses are supposed to grow to infinity. This is nonsense!

A derivation which still works fine in the case of conducting materials is completely useless for calculating dielectric losses. In formulary and application books show the measured loss factors listed as a substitute for the offered model and have a limited validity as they only work as guidelines [e.g. 4, p.157].

Of course there is always a complex ε and the implied offence against the constancy of the speed of light hidden behind these loss factors! Thus one mistake causes the other. In the end the whole electrodynamics subject is under heavy critique. Fortunately, there is a solution to all our problems, as the extended *Poynting vector* (29) offers a **new loss term** in addition to the known ones.

15. POTENTIAL-VORTEX LOSSES IN THE ENERGY BALANCE

The potential density **b**, introduced in the Maxwell equations stands for the origin of potential-vortices like they are expected to be found in poorly conducting materials and particularly in capacitors and insulators. In contrast to eddy-currents with their "*skin effect*" the potential-vortices move towards the *vortex center* to decay there and to generate *heat*.

Again we calculate the power by using the volume integral over the power density $\mathbf{H \cdot b}$ (in eq. 26);

(with $H = B/\mu = b \cdot \tau_2/\mu$ after eq. (22)):

$$P = \iiint_V H \cdot b \, dV = \iiint_V (b^2 \tau_2/\mu) \, dV = (b^2 \tau_2/\mu) \cdot A \cdot s$$

$$= b^2 \cdot A^2 \cdot \tau_2 \cdot s/\mu \cdot A = U^2 \cdot \tau_2/L = U^2/R_2 \, , \quad (40)$$

because the *potential-density* b gives the voltage $U = b \cdot A$ (41)

and the inductivity of a conductor loop L is given by equation 33.

The *time constant* τ_2 being responsible for **heat generation by vortex decay of the potential-vortices** suggests an R-L-behavior:

$$\tau_2 = L/R_2 \quad (42)$$

whereas the parameters R_2 and L are also in this case to be understood as parameters of an alternitive model. However, this time the resistance is in the denominator which corresponds to reality even better.

If we converted this into current losses with R (after eq. 36) for better comparability:

$$R_2 = \frac{\mu \cdot A}{\tau_2 \cdot s} \cdot \frac{\sigma}{\sigma} = \frac{\mu}{\tau_2 \cdot \sigma \cdot R} = \frac{\tau_1}{\tau_2} \cdot \mu^2 \cdot \frac{1}{R} \quad , \qquad (43)$$

then the losses ascertained in textbooks would have to be corrected according to the time constants τ_2/τ_1 (i.e. for the purposes of the potential-vortices in the dielectric and to the loads of the counter-rotating eddy-currents).

However, the actual efficiency of the new approach only shows when calculating a concrete case. When looking through technical literature, take Prof. **Simonyi** as an example [6, p.698]. Simonyi first calculates the special case of a frame antenna as a current loop by the harmlessly wrong assumption of a *vector potential* **A**.

The mathematically won result for the emitted power is very similar to that of a dipole antenna. This makes Simonyi understand his loop as a magnetic dipole and create the duality to the electric dipole. He writes, "*We can imagine it like this: just as there are electric charges flowing in an electric dipole there are virtual magnetic currents flowing in the form of virtual magnetic charges here.*"

In this explanation the lack of duality is to be taken into account because a current is never dual to a current! The variable dual to the current density **j** is the *potential density* **b**, which Simonyi calls *magnetic current density* $\mathbf{j}_m$.

Mathematically, the new approach fits perfectly, according to Simonyi, "*The magnetic loads introduced here are of course virtual, however, the radiation field can be calculated as if they were real.*" Furthermore, he calls the introduction of $\mathbf{j}_m$ (= **b**) suitable, "*because one can thereby convert more complicated radiation fields back to the known dipole fields.*"

16. TABLE OF FORMULA SYMBOLS

	Electric field			Magnetic field	
E	V/m	Electric field strength	**H**	A/m	Magnetic field strength
D	As/m^2	Electric displacement	**B**	Vs/m^2	flux density
U	V	Tension voltage	I	A	Current
b	V/m^2	potential density	**j**	A/m^2	Current density
ε	As/Vm	Dielectricity	μ	Vs/Am	Permeability
τ_2	s	Relaxation time constant of the potential vortices	τ_1	s	Relaxation time constant of the eddy currents
			$\tau_1 = \varepsilon/\sigma$		
σ	Vm/A	Specific electric conductivity			
ρ_{el}	As/m^3	Electric space charge density			

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18. ADDRESS

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19. APPENDIX

About the erroneous Proca equations:

Simonyi certifies the mathematical applicability to the new approach and, in addition, points to its superiority compared to the outdated approach. But with his view he remains a special physicist among the electrodynamicists who all still calculate with **B** = 0 and with the vector potential **A** whereas the approach is used

$$\mathbf{B} = \text{curl}\, \mathbf{A} \quad . \tag{1}$$

This approach is not allowed anymore due to the **discovery of magnetic monopoles in 2009**. At the same time all attempts to insert the vector potential into the Maxwell equations are to be cancelled. These are known as *Proca equations* [11, p.521].

These equations clearly indicate the contradictions of the old or *classical electrodynamics*. If one sets the electric conductivity close to zero, all the additional terms disappear and the *Maxwell equations* are left. The failure is hardwired if it is about the calculation of insulators.

Also, in the case of the *Proca equations* taking another look for the *Poynting theorem*, the energy balance does not deliver any additional loss term with which the *dielectric losses* could be explained.

This extension is somewhat helpful, although we agree that an extension is necessary in the Maxwell equations. However, this has to occur mathematically and has to be physically correct.

For the rehabilitation of the *Proca equations* it should be mentioned that in isolated cases the extension by potential also generate correct results. Thus *Lehner* derives ***longitudinal waves*** [11, page 528], which I call "***scalar waves***" [12].

However, he limits his result by pointing out the fact that there are no "*longitudinal waves of this form in the classical theory. They are only possible if space charges exist.*" Hence he limits the validity of his derivation to the special case of a ***plasma wave***.

The general derivation of *scalar waves*, proven already 100 years ago by **Nikola Tesla** experimentally and still existing today within every **near field of an antenna**, is found in my book "*Scalar wave transponder*" [12, p.39]. With which instead of the *vector potential* **A** the *potential density* **b** is used.

In direct comparison, the results once more confirm that several ways can lead to the aim but that an extension is however, necessary in any case. In the question which expansion is to be recommended everything points at the potential density **b** - not only because of broader validity of the *calculated scalar waves* but also the possibility of a correct *calculation of losses* within capacitors and microwave ovens.

The discovery of the potential-vortices and the new approach lead far beyond it to a unified world of physics and a big unification of all interactions and the removal of all unsettled physical constants [13 (Material collection) and 14].