The homogeneous and inhomogeneous ECE current, Part II

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Abstract

We discuss the special forms of the homogeneous current of ECE theory, which can also explain certain parts of the technology of Nicola Tesla. The polarization of the vacuum is the key element in this explanation. Starting from a classical view of polarization, we extend this model by ECE theory to obtain a resonant version of the Ampère-Maxwell law. We demonstrate that this mechanism is able to induce non-classical behavior in electromagnetism, which is then able to transfer energy from the vacuum.

Keywords: ECE theory, ECE2 theory, electrodynamics, homogeneous current, Tesla technology, vacuum polarization.

1 Introduction

In Part I [5] of this article series, we have analyzed the homogeneous and inhomogeneous currents of ECE theory [1–4]. Both currents complement the Maxwell-like equations by providing full duality. The inhomogeneous current is the usual current of charge carriers, while the homogeneous current is interpreted to have a magnetic nature and is generally assumed to be zero in standard theory.

However, this magnetic interpretation is only half of the truth. In the homogeneous current, there are also electric polarization terms that represent a "dual" counterpart to electric current and magnetism. This is what Tesla researched throughout his life. Most of the other researchers did not understand this kind of duality and therefore were not able to appreciate his results. Tesla did not write scientific articles, and his patents were often cryptic. There are very few documents that explain the nature of Tesla's work, and even they sometimes do so in an obscure manner, so the reader often has to extract the key scientific facts by himself. Two authors of explanatory books are Vassilatos [6] (the second chapter therein on Tesla's technology) and Valone [7].

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In this paper, we present approaches for interpreting the homogeneous current as a structure of the classical ECE vacuum. This current is quite different from the usual one, which consists of charge carriers.

The first approach for describing the effects of a "cold current" goes back to 2014, when we separated the classical field terms from the terms of spacetime (spin connections) [10], and the first version of the approach that we are presenting here, which uses the Ampère-Maxwell law, was developed in 2020 [11].

2 Vacuum polarization

We start by investigating several kinds of electromagnetic polarization effects.

2.1 Classical polarization and magnetization

The polarization and magnetization of matter is defined by the following equations:

$$\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}, \tag{1}$$

$$\mathbf{H} = \frac{1}{\mu_0}\mathbf{B} - \mathbf{M}, \tag{2}$$

where $\mathbf{E}$ is the electric field, $\mathbf{D}$ is dielectric displacement, and $\mathbf{P}$ is the electric polarization vector (which changes the total electric field into the dielectric displacement field). In a similar way, the magnetic field $\mathbf{H}$ is defined using the induction $\mathbf{B}$ and magnetization $\mathbf{M}$. It is also possible to rewrite Maxwell's equations to include polarization and magnetization. According to [8], the Faraday law then reads

$$\frac{1}{c^2}\frac{\partial \mathbf{H}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{D} = \mathbf{0}. \tag{3}$$

When polarization and magnetization depend linearly on the electric and magnetic fields, these equations then contain the relative permittivity and permeability [8]. The homogeneous current does not appear in the classical theory.

2.2 Vacuum polarization by the homogeneous current

According to [9], we can incorporate polarization and magnetization into the Faraday law of classical theory in vacuo, Eq. (3). After we insert $\mathbf{D}$ and $\mathbf{H}$, this equation becomes

$$\frac{1}{c^2}\frac{\partial(\frac{1}{\mu_0}\mathbf{B} - \mathbf{M})}{\partial t} + \boldsymbol{\nabla} \times (\epsilon_0 \mathbf{E} + \mathbf{P}) = \mathbf{0}. \tag{4}$$

Rearranging the terms gives

$$\frac{\partial \mathbf{B}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{E} = \mu_0 \left(\frac{\partial \mathbf{M}}{\partial t} - c^2 \boldsymbol{\nabla} \times \mathbf{P} \right). \tag{5}$$

Comparing this equation to Eq. (6) of [5], we see that it is identical to the Faraday law of ECE theory (which contains the homogeneous current $\mathbf{j}$):

$$\frac{\partial \mathbf{B}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{E} = c\mu_0 \mathbf{j} \tag{6}$$

with

$$\mathbf{j} = \frac{1}{c}\frac{\partial \mathbf{M}}{\partial t} - c\boldsymbol{\nabla} \times \mathbf{P}. \tag{7}$$

In this derivation, it can be seen clearly that the homogeneous current, with respect to polarization and magnetization, is equivalent to a spacetime with polarization and magnetization. These properties can be attributed to matter, or to spacetime itself, if no matter is present. The latter case describes polarization and magnetization of the vacuum. The impedance of the vacuum is

$$Z_0 = c\mu_0 = \sqrt{\frac{\mu_0}{\epsilon_0}}, \tag{8}$$

and therefore Eq. (6) can also be written in the following form:

$$\frac{\partial \mathbf{B}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{E} = Z_0 \mathbf{j}. \tag{9}$$

This corroborates that $\mathbf{j}$ is a vacuum current. If magnetic effects are negligible, the above equation simplifies to

$$\boldsymbol{\nabla} \times \mathbf{E} = -cZ_0 \boldsymbol{\nabla} \times \mathbf{P} = -\frac{1}{\epsilon_0}\boldsymbol{\nabla} \times \mathbf{P}. \tag{10}$$

One solution of this equation for $\mathbf{E}$ is

$$\mathbf{E} = -\frac{1}{\epsilon_0}\mathbf{P}. \tag{11}$$

This can be interpreted to mean that the vacuum polarization is connected with an electric field of the vacuum. After this equation is inserted into the definition of polarization (1), it follows that

$$\mathbf{D} = \mathbf{0}, \tag{12}$$

which means that there is no macroscopic electric displacement.

The derivations so far have been based on the magnetization and polarization definitions of standard Maxwell theory, but we will now transition to the definitions of ECE theory. The Faraday law of ECE theory (Eq. (25) of [5]) reads

$$\frac{\partial \mathbf{B}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{E} = 2\left(c\kappa_{(\Lambda)0}\mathbf{B} - \boldsymbol{\kappa}_{(\Lambda)} \times \mathbf{E}\right). \tag{13}$$

Neglecting the $\mathbf{B}$ field, as in Eq. (10) above, we obtain

$$\boldsymbol{\nabla} \times \mathbf{E} = -2\boldsymbol{\kappa}_{(\Lambda)} \times \mathbf{E}, \tag{14}$$

where $\kappa_{(\Lambda)}$ is the wave vector

$$\boldsymbol{\kappa}_{(\Lambda)} = \frac{1}{W^{(0)}}\mathbf{A} - \boldsymbol{\omega}_{(\Lambda)}. \tag{15}$$

$\boldsymbol{\omega}_{(\Lambda)}$ is a spin connection vector of ECE theory, and $W^{(0)}$ is a fixed constant.

We identify the vector potential $\mathbf{A}$ with that of the ECE vacuum (potentials without force fields). A homogeneous current, and consequently, a vacuum polarization, appear when $\mathbf{A}/W^{(0)}$ deviates from $\boldsymbol{\omega}_{(\Lambda)}$.

Eq. (14) is highly similar to Eq. (10), which was derived from classical electromagnetic theory. The difference is that in (14) the polarization effect is controlled by the wave vector $\boldsymbol{\kappa}_{(\Lambda)}$. This is zero if the vacuum polarization field $\mathbf{A}$ behaves in the same way as the spin connection. If they differ, a detectable $\mathbf{E}$ field follows from (14). The questions are whether a $\boldsymbol{\kappa}_{(\Lambda)}$ exists that satisfies this equation, and if it is unique.

As an example, we assume a plane wave for $\mathbf{E}$. This example is quite general, because all kinds of oscillations can be constructed with single plane waves in a Fourier synthesis. We define

$$\mathbf{E} = \begin{bmatrix} E_{01} \\ E_{02} \\ E_{03} \end{bmatrix} \exp\left(i(\omega_t t - \mathbf{k}\cdot\mathbf{r})\right) \tag{16}$$

with a wave vector

$$\mathbf{k} = \begin{bmatrix} k_X \\ k_Y \\ k_Z \end{bmatrix} \tag{17}$$

and a spatial coordinate vector

$$\mathbf{r} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}. \tag{18}$$

ω_t is a time frequency. Computer algebra gives the result that Eq. (14) is of rank 2, i.e., one κ component can be chosen freely.

The solution leads to a complex-valued $\kappa_{(\Lambda)}$. If we use κ_0 as a free parameter, the real part is

$$\mathrm{Re}(\boldsymbol{\kappa}_{(\Lambda)}) = \begin{bmatrix} \frac{E_{01}}{E_{03}}\kappa_0 \\ \frac{E_{02}}{E_{03}}\kappa_0 \\ \kappa_0 \end{bmatrix} = \frac{1}{E_{03}} \begin{bmatrix} E_{01}\kappa_0 \\ E_{02}\kappa_0 \\ E_{03}\kappa_0 \end{bmatrix}, \tag{19}$$

and the imaginary part is

$$\mathrm{Im}(\boldsymbol{\kappa}_{(\Lambda)}) = \frac{1}{2E_{03}} \begin{bmatrix} E_{03}k_X - E_{01}k_Z \\ E_{03}k_Y - E_{02}k_Z \\ 0 \end{bmatrix}. \tag{20}$$

Obviously, the real part is parallel to the electric field (16). This means that, if $\boldsymbol{\kappa}_{(\Lambda)}$ is real-valued, the term $\boldsymbol{\kappa}_{(\Lambda)} \times \mathbf{E}$ vanishes, i.e., there is no energy transfer through vacuum polarization. On the other hand, an imaginary part of a wave vector describes dissipative effects, which in our case can be interpreted as an energy transfer from the vacuum.

2.3 Energy transfer from the vacuum

What is still open is the question of how such an energy transfer can be initiated. From Tesla's experiments, we know that a sharp pulse in the potential is required. According to classical theory, such a pulse in the vector potential evokes an electric field spike

$$\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t}, \tag{21}$$

but nothing else. In ECE theory, there are two equivalent representations of the electric field by potentials[1]:

$$\mathbf{E} = -2(\frac{\partial \mathbf{A}}{\partial t} + c\omega_0 \mathbf{A}) \qquad \text{and} \tag{22}$$

$$\mathbf{E} = -2(\boldsymbol{\nabla}\phi - \boldsymbol{\omega}\phi), \tag{23}$$

with spin connections[2] ω_0 and $\boldsymbol{\omega}$. From equating both expressions for $\mathbf{E}$, it follows that

$$-\frac{\partial \mathbf{A}}{\partial t} + \boldsymbol{\nabla}\phi = -c\omega_0 \mathbf{A} - \boldsymbol{\omega}\phi. \tag{24}$$

The left side is a sum of the classical expressions for the electric field potential[3] (please notice the different signs of these expressions in the classical case). According to Eq. (24), this sum is identical to expressions with spin connections. This means that spin connections are always there in electrodynamics, even though the equations for the classical potentials can formally be obtained by setting the spin connections to zero[4].

If a short pulse is created in the vacuum potential $\mathbf{A}$, a momentarily very high $\mathbf{E}$ field is created in the form of a shock wave, and the vacuum is strongly polarized. The spin connections of an incoming aether stream are not compatible with this pulse, thus the laws of standard electrodynamics do not apply in this situation; only general relativity (ECE theory) can provide a valid description. Since the electric field is not virtual, but is instead a physical (existing) force field, we can use the Ampère-Maxwell equation in the form where the electric and magnetic fields are replaced by their ECE potentials. According to [11] and Example 5.7 in [2], the Ampère-Maxwell law (neglecting scalar potential terms) reads

$$\frac{\partial^2 \mathbf{A}}{\partial t^2} + c\frac{\partial\,(\omega_0 \mathbf{A})}{\partial t} = \frac{1}{\epsilon_0}\,\mathbf{J}, \tag{25}$$

where $\mathbf{J}$ is an electronic current. When we assume that the potential $\mathbf{A}$ and spin connection ω_0 are present, it follows that a real current is created in a conductive medium. This could be the wire of a coil, for example. As discussed in [2, 11], Eq. (25) can be expanded to

$$\frac{\partial^2 \mathbf{A}}{\partial t^2} + c\left(\omega_0 \frac{\partial \mathbf{A}}{\partial t} + \frac{\partial \omega_0}{\partial t}\mathbf{A}\right) = \frac{1}{\epsilon_0}\,\mathbf{J}, \tag{26}$$

[1] This follows from the antisymmetry law [2].

[2] These are the spin connections that are responsible for the curvature and torsion forms that make up the force fields; notice that they are different from $\omega^0_{(\Lambda)}$ and $\boldsymbol{\omega}_{(\Lambda)}$.

[3] The classical electric field is defined by $\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t} - \boldsymbol{\nabla}\phi$.

[4] The general ECE expression for the electric field (without the antisymmetry law being applied) is $\mathbf{E} = -\frac{\partial \mathbf{A}}{\partial t} - \boldsymbol{\nabla}\phi - c\omega_0 \mathbf{A} + \boldsymbol{\omega}\phi$.

and is then formally identical to an equation for Euler-Bernoulli resonance, but with non-constant coefficients. These coefficients change the behavior of the solutions completely, but resonances continue to appear. For certain choices of ω_0 and $\mathbf{J}$, even analytical solutions are possible for $\mathbf{A}$. As an example, we choose an oscillating ω_0 and a constant $\mathbf{J}$:

$$\omega_0 = \kappa_0 \cos(\beta t), \tag{27}$$

$$\mathbf{J} = \mathbf{J}_0, \tag{28}$$

with a time frequency β and constants κ_0 and $\mathbf{J}_0$, and we restrict our consideration to one dimension. Computer algebra gives us a solution for A that consists of some complicated integrals. The leading term is

$$A(t) = \frac{J_0}{\epsilon_0}\, f_1(t)\, f_2(t) \tag{29}$$

with

$$f_1(t) = t \cdot \exp\left(\frac{c\,\kappa_0 \sin(\beta t)}{\beta}\right) \tag{30}$$

and

$$f_2(t) = \int \exp\left(-\frac{c\,\kappa_0 \sin(\beta t)}{\beta}\right) dt. \tag{31}$$

The function f_1 contains a linear factor of t, which leads to a self-reinforcing resonance of A. The electric field follows from A by Eq. (21), for example. The integral of f_2 has to be determined numerically.

We continue this example with a calculation in which all constants are set to unity and the integral in Eq. (31) is evaluated using suitable Maxima code. In Fig. 1, the function f_1, the integrand of f_2, and the evaluated function f_2 are graphed. f_1 shows an oscillating behavior with increasing amplitude, and f_2 behaves similarly, because the integrand is always positive. Consequently, the vector potential A increases in the same way, and so does the derived electric field E (see Fig. 2). Note that we have just shown that this type of structure leads to an unlimited resonance in A and E.

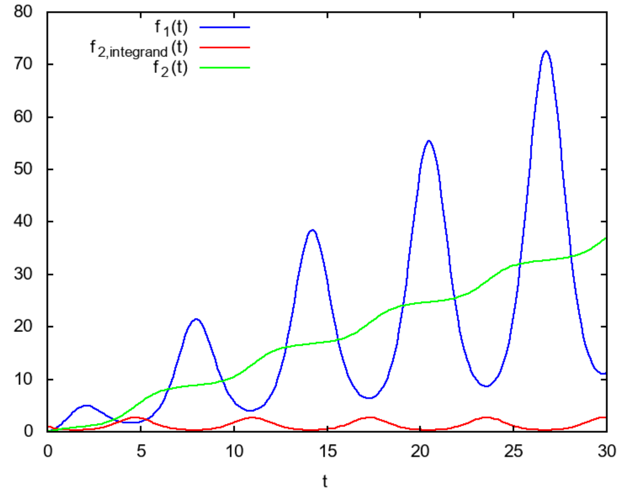

Figure 1: Functions (29) and (30), all constants normalized.

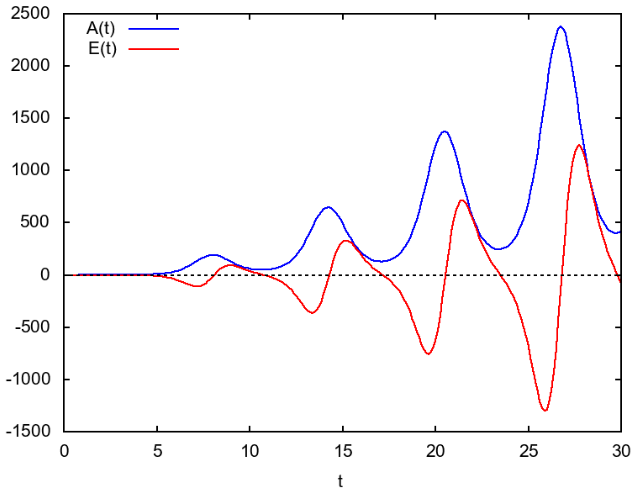

Figure 2: Solution of Eq. (25) and electric field (21), all constants normalized.

In this limited example, the result holds for a constant current **J**. In real systems, we will obtain a feedback effect, i.e., the resonance of the **A** field enlarges the current **J**. To demonstrate this behavior, at least in a theoretical way, we have changed the model current in Eq. (28) to the following form:

$$\mathbf{J} = \mathbf{J}_0 \frac{t}{\tau} \tag{32}$$

with a time constant τ. Then, one part of the general solution, (30), takes the following form:

$$f_1(t) = \frac{1}{2\tau} \cdot t^2 \cdot \exp\left(\frac{c\,\kappa_0 \sin(\beta t)}{\beta}\right). \tag{33}$$

The general solution increases even with a factor of t^2. When $\mathbf{J}$ is multiplied with an additional oscillatory part, the principal increasing character of the solution remains. In addition to this semi-analytic analysis, it is also possible to solve Eq. (25) numerically.

3 Discussion and conclusions

In this paper, we have presented quantitative methods that describe effects of the homogeneous current. These methods were developed in ECE theory under the name *spin connection resonance* as early as 2006 [12].

The homogeneous current has been identified as a "vacuum current", which means that it is a flux of structures of the vacuum, and not of material particles. Therefore, the laws of thermodynamics do not apply to this current, because these laws are valid only for material statistical ensembles. If energy is transferred from the vacuum to material particles, then this energy has to be replenished in the vacuum. This will take place through additional, compensating vacuum currents, and possibly through the extraction of energy from the physical (material) environment. This may cause the "cold current" effects, where temperature decreases. If such effects seem to contradict the laws of thermodynamics (which state that entropy can only increase if there is no active input of energy), then system boundaries have not been defined correctly. The vacuum has to be included in the system under consideration. Then, energy is conserved, as required for any closed system.

Tesla apparently succeeded in initiating energy transfer from the vacuum by using sharp electric pulses. We have shown that this kind of transfer can be maintained by a resonance mechanism derived from the Ampère-Maxwell law of ECE theory. It has been proven, at least qualitatively, that a real current can be enhanced in this way, possibly accompanied by "cold current" effects. More precisely, the current is not "cold", but the temperature of the apparatus decreases due to backflow of energy into the surrounding vacuum.

The effect of drawing energy from the vacuum has already been discussed, without presenting a quantitative mechanism, in [10]. Therein, it has been stated:

To achieve a non-Maxwellian ECE state, none of the potentials can ever be zero, nor can they ever become separable nor continuous. This means that the system has to be placed in a state of potential that is either negative or positive, and remains that way, and that the potentials become discontinuous making their derivative multi-valued, or perhaps "near infinite". A pulsed potential, with extremely fast rise and collapse times, would have this property, for example. A multivalued potential is closely connected with non-conservative fields of field theory. Such fields can be used to extract energy by reaching the same point of definition space on different paths. However, it is not easy to find such fields in Nature.

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