Poynting theorem for the vacuum electric field.

by

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Abstract.

Considerations of the Lamb shift show the presence of what is termed the vacuum electric field. The latter is used to construct a Poynting theorem for the electric power in watts taken up by a straight wire from spacetime. It is shown that there should be an excess power present in the wire over and above the power created by the applied electromotive force. Experimental evidence in favour of this theory is discussed.

Keywords: Lamb shift, Poynting theorem for the vacuum electric field, power from spacetime in a straight wire, experimental evidence for power from spacetime.

1. Introduction

In the development of ECE theory several papers have been dedicated to the acquisition of electric power from spacetime [1–10]. The difficulty is to obtain reliable data in this sector of physics, data which are well accepted and uncontroversial. The clearest evidence for the existence of a vacuum electric field is the Lamb shift, a small spectral effect which is nevertheless unequivocal. It is an example of a radiative correction [11] as is well known. The vacuum electric field can therefore be used, in theory, to produce electric power from spacetime. In Section 2 it is shown that this type of power is ubiquitous in any circuit, in the simplest instance a straight wire. Similarly the Lamb shift is ubiquitous in atomic and molecular spectra, i.e. the Lamb shift is always present and always observable. Furthermore the existence of the Lamb shift does not violate any conservation law of physics, because it is due to energy ever present in spacetime. Similarly, the ability to take electric power from spacetime (the same source as that of the Lamb shift) does not violate any conservation law of physics. This fact is proven in Section 2 with a straightforward method based on the Poynting theorem, the law of conservation of energy in electrodynamics. An estimate is given of the magnitude of the vacuum electric field. The use of quantum electrodynamics is avoided in this context because of renormalization. Feynman described this process as "hocus pocus" and the claims of quantum electrodynamics to ever increasing accuracy can be discarded because of the use of adjustable parameters from renormalization. The criticisms of quantum electrodynamics are summarized in UFT 85 on www.aias.us

In Section 3, an experimental claim is discussed for the ability of a circuit to take electric power from spacetime and the ECE theory of the background developed by Eckardt and Lindstrom.. The theory of Section 2 is simple and straightforward, and shows that there should be excess power present in any circuit. The experimental challenge is to find how to measure this power and how to amplify and use it for the electric power industry.

2. Poynting theorem due to the vacuum electric field.

Consider a circuit, in the simplest instance a wire, in which flows the electric current density $\boldsymbol{J}$ in units of amps per metre squared, or C $s^{-1}m^{-2}$. This current is created by a conventional electromotive force within the circuit. In ECE theory the current density is denoted by $\boldsymbol{J}^a$, where a denotes polarization. The following theory is for all a, so a is omitted by convention. Denote the ubiquitous vacuum electric field by $\boldsymbol{E}_{vac}$. The vacuum electric field is well accepted to be the source of the Lamb shift, so the existence of $\boldsymbol{E}_{vac}$ is well accepted in physics. The power per unit volume due to $\boldsymbol{J}$ and $\boldsymbol{E}_{vac}$ is $\boldsymbol{J}.\ \boldsymbol{E}_{vac}$ in watts per cubic metre, or J s^{-1} m^{-2}. Within the circuit the current $\boldsymbol{J}$ is governed by the Ampère Maxwell law:

$$\nabla \times \boldsymbol{H} - \frac{\partial \boldsymbol{D}}{\partial t} = \boldsymbol{J} \tag{1}$$

where $\boldsymbol{H}$ is the magnetic field strength and $\boldsymbol{D}$ the displacement. These are related to the electric field strength $\boldsymbol{E}$ and magnetic flux density $\boldsymbol{B}$ within the circuit by:

$$\boldsymbol{D} = \epsilon_0 \boldsymbol{E} + \boldsymbol{P} \quad , \quad \boldsymbol{B} = \mu_0 \ (\boldsymbol{H} + \boldsymbol{M}) \tag{2}$$

where $\boldsymbol{P}$ is the polarization and $\boldsymbol{M}$ is the magnetization. The interaction of the vacuum electric field and the circuit is therefore given by the Poynting theorem:

$$\boldsymbol{J}.\ \boldsymbol{E}_{\mathrm{vac}} = (\nabla \times \boldsymbol{H} - \frac{\partial \boldsymbol{D}}{\partial t}) . \boldsymbol{E}_{\mathrm{vac}} \tag{3}$$

The vacuum electric field strength sets up a fluctuation $\delta\boldsymbol{r}$ in the position of an electron within the circuit, in the simplest instance a straight wire. If m and $-e$ are the mass and charge of the electron then:

$$m \frac{d^2}{dt^2} (\delta\boldsymbol{r}) = -e\ \boldsymbol{E}_{\mathrm{vac}} \tag{4}$$

which is a simple balance of the Newton force law and Lorentz force law. The change in potential energy in joules due to the fluctuation of the electron $\delta\boldsymbol{r}$, is:

$$\Delta \mathrm{V} = \mathrm{V}(\boldsymbol{r} + \boldsymbol{r}) - \mathrm{V}(\boldsymbol{r}) \tag{5}$$

which can be expanded as [12]:

$$\Delta \mathrm{V} = \delta\boldsymbol{r} . \Delta \mathrm{V} + \frac{1}{2} (\delta\boldsymbol{r} . \nabla)^2 \mathrm{V}(\boldsymbol{r}) + \ldots \tag{6}$$

If the fluctuation is isotropic its mean vanishes:

$$< \delta\boldsymbol{r} > = \mathbf{0} \tag{7}$$

but its mean square does not. Therefore:

$$< (\delta\boldsymbol{r} . \nabla)^2 > = \frac{1}{3} < (\delta\boldsymbol{r})^2 > \nabla^2 \tag{8}$$

where the Laplacian acts on a circuital property. The mean change in potential in joules is therefore:

$$< \Delta \mathrm{V} > = \frac{1}{6} < (\delta\boldsymbol{r})^2 > \nabla^2 \mathrm{V}_0 \tag{9}$$

For example, if the Coulomb law is used then:

$$< \Delta \mathrm{V} > = \frac{1}{6} < (\delta\boldsymbol{r})^2 > < \nabla^2 (\frac{-e^2}{4\pi r \epsilon_0}) > = \frac{e^2}{6\epsilon_0} < (\delta\boldsymbol{r})^2 > \delta(\boldsymbol{r}) \tag{10}$$

where ϵ_0 is the vacuum permittivity and $\boldsymbol{r}$ the distance between charges or negative and positive terminals of a battery.

The Poynting theorem (3) can be developed if it is assumed that the Faraday law of induction is true for the vacuum $\boldsymbol{E}_{\mathrm{vac}}$ and the vacuum $\boldsymbol{B}_{\mathrm{vac}}$, i.e.:

$$\nabla \times \boldsymbol{E}_{\mathrm{vac}} + \frac{\partial \boldsymbol{B}\mathrm{vac}}{\partial t} = \mathbf{0} \tag{11}$$

The Faraday law of induction holds for any electromagnetic field, so Eq. (11) is solidly based. Using Eq. (11) then:

$$\boldsymbol{E}_{\mathrm{vac}} . \nabla \times \boldsymbol{H} = -\nabla. (\boldsymbol{E}_{\mathrm{vac}} \times \boldsymbol{H}) - \boldsymbol{H} . \frac{\partial \boldsymbol{B}\mathrm{vac}}{\partial t} \tag{12}$$

and the Poynting theorem (3) can be rewritten as:

$$- \int_V \boldsymbol{J} \,.\, \boldsymbol{E}_{\text{vac}} \; d^3x = \int_V \; \frac{dU}{dt} + \boldsymbol{\nabla}.\, (\, \boldsymbol{E}_{\text{vac}} \times \boldsymbol{H}\,)\; d^3x \tag{13}$$

where:

$$U = \frac{1}{2}\left(\boldsymbol{E}_{\text{vac}} \,.\, \boldsymbol{D} + \boldsymbol{B}_{\text{vac}} \,.\, \boldsymbol{H}\right) \tag{14}$$

and

$$\boldsymbol{S} = \boldsymbol{E}_{\text{vac}} \times \boldsymbol{H} \;\; . \tag{15}$$

The total work done by the vacuum $\boldsymbol{E}_{\text{vac}}$ within the volume V is $\int_V \boldsymbol{J} \,.\, \boldsymbol{E}_{\text{vac}} \; d^3x$ in units of watts, the units of power. One watt is one joule per second, or energy per unit time. This power is always being transferred from spacetime to a circuit, because $\boldsymbol{E}_{\text{vac}}$ is ubiquitous and ever present, an unlimited reservoir of electric power. The current density $\boldsymbol{J}$ is a circuit property or “source” property, and $\boldsymbol{E}_{\text{vac}}$ is a property of spacetime.

For example consider a straight wire of radius r_0 along the Z axis carrying a current I in amps or coulombs per second. Determine the power in watts entering the wire due to $\boldsymbol{E}_{\text{vac}}$ [13]. Use the cylindrical polar coordinates defined by:

$$\left.\begin{aligned} X &= r \cos \phi \,, \\ Y &= r \sin \phi \,, \\ Z &= Z \end{aligned}\right\} \tag{16}$$

with unit vectors:

$$\left.\begin{aligned} \boldsymbol{e}_r &= \boldsymbol{i} \cos \phi + \boldsymbol{j} \sin \phi \;\;, \\ \boldsymbol{e}_\phi &= -\boldsymbol{i} \sin \phi + \boldsymbol{j} \cos \phi \;\;, \\ \boldsymbol{e}_Z &= \boldsymbol{k} \;\;. \end{aligned}\right\} \tag{17}$$

The magnetic field strength at the surface of the wire is:

$$\boldsymbol{H} = \frac{I}{2\pi r_0}\, \boldsymbol{e}_\phi \;\; . \tag{18}$$

The intrinsic electric field strength inside the wire is:

$$\boldsymbol{E} = \frac{1}{\sigma}\, \boldsymbol{J} = \frac{\mathrm{J}}{\sigma}\, \boldsymbol{k} \;\; , \tag{19}$$

where σ is its conductivity. The intrinsic electric field strength is the one produced by the electromotive force applied to the wire, and $\boldsymbol{E}$ is defined by $\boldsymbol{J}$, the current density inside the wire. So the intrinsic Poynting vector at the surface of the wire is:

$$\boldsymbol{S}(\text{intrinsic}) = \boldsymbol{E} \times \boldsymbol{H} = -\frac{I}{2\sigma\pi^2 {r_0}^3}\, \boldsymbol{e}_r \tag{20}$$

The power in watts entering a unit length of wire is:

$$P = \oint \boldsymbol{S} . d\mathbf{A} = \oint \boldsymbol{S} . \boldsymbol{e}_r d\mathrm{A} = \int_V \boldsymbol{\nabla} . \boldsymbol{S} \, d^3x \, . \tag{21}$$

Therefore:

$$P \text{ (intrinsic)} = \frac{2\pi r_0 I^2}{2\sigma\pi^2 {r_0}^3} = \frac{I^2}{\sigma\pi {r_0}^2} = I^2\mathrm{R} \tag{22}$$

where R is the resistance of the wire. The inputted power is $I^2\mathrm{R}$, and this is lost as $-\,I^2\mathrm{R}$ of heat.

Now repeat the calculation with the vacuum electric field strength $\boldsymbol{E}_{\text{vac}}$.

Without loss of generality consider:

$$\boldsymbol{E}_{\text{vac}} = \frac{I_{\text{vac}}}{\pi {r_0}^2} \boldsymbol{e}_{\mathrm{Z}} \tag{23}$$

so:

$$\boldsymbol{S} = \boldsymbol{E}_{\text{vac}} \times \boldsymbol{H} = -\frac{I_{\text{vac}}\, I}{2\sigma\pi^2 {r_0}^3} \boldsymbol{e}_r \tag{24}$$

where I_{vac} is a current in amps (coulombs per second) generated in the wire by the vacuum electric field strength $\boldsymbol{E}_{\text{vac}}$ in volts per metre or J $\mathrm{C}^{-1}\mathrm{m}^{-1}$. The current density due to the current I_{vac} is:

$$\boldsymbol{J}_{\text{vac}} = \frac{I_{\text{vac}}}{\pi {r_0}^2} \boldsymbol{e}_{\mathrm{Z}} \tag{25}$$

in C s^{-1} m^{-1}. The Poynting vector from the cross product of the vacuum electric field strength and the circuital magnetic field strength is:

$$\boldsymbol{S} \text{ (vac)} = -\frac{I}{2\pi r_0} \boldsymbol{J}_{\text{vac}} \tag{26}$$

and so the vacuum electric field strength provides an extra source of power:

$$P \text{ (vac)} = \oint \boldsymbol{S}\text{(vac)}. \, d\mathbf{A} = I I_{\text{vac}} \, \mathrm{R} \tag{27}$$

which is always present in the wire.

The heat generated in a wire of radius r_0 aligned along Z should be slightly greater than the intrinsic heat I^2 R. The engineering problem discussed in Section 3 consists of amplifying the effect of $\boldsymbol{E}_{\text{vac}}$ by circuit design to the point where the power provided by $\boldsymbol{E}_{\text{vac}}$ is of practical utility.

The Lamb shift is well known [14] to occur in atoms and molecules, and its theory can be worked out [12] without use of quantum electrodynamics. The mean square fluctuation picked up by an atom is [12]:

$$< (\delta \boldsymbol{r})^2 > = \frac{1}{2\pi\epsilon_0} (\frac{e^2}{\hbar c})(\frac{\hbar}{mc})^2 \log_e (\frac{4\epsilon_0 \hbar c}{e^2}) \tag{28}$$

where ħ is the reduced Planck constant, and ϵ_0 the vacuum permittivity. Eq. (28) can be written as:

$$< (\delta \boldsymbol{r})^2 > = \mathrm{A}\, \lambda_c^2 \quad , \quad \mathrm{A} = \frac{2\alpha}{\pi} \log_e \frac{1}{\pi\alpha} \quad , \quad \lambda_c = \frac{\hbar}{mc} \tag{29}$$

where

$$\alpha = \frac{e^2}{4\pi\hbar c \epsilon_0} = 0.007297351 \tag{30}$$

is the fine structure constant. Inside an atom or molecule [12]:

$$< \boldsymbol{\nabla}^2 (\frac{-e^2}{4\pi r \epsilon_0}) > = \frac{e^2}{\epsilon_0} < \delta(\boldsymbol{r}) > \; = \; \frac{e^2}{\epsilon_0} \mid \psi(0) \mid^2 \quad . \tag{31}$$

For certain orbitals such as the 2s orbital of the H atom Eq. (31) is non-zero:

$$\mid \psi_{2s}(0) \mid^2 \; = \frac{1}{8\pi {a_0}^3} \tag{32}$$

where the Bohr radius is:

$$a_0 = \frac{4\pi\epsilon_0 \hbar^2}{me^2} \quad . \tag{33}$$

Therefore from Eq. (10) the change in potential energy is:

$$< \Delta \mathrm{V} > = \frac{4}{3} \frac{e^2}{4\pi\epsilon_0} \alpha\, \lambda_c^2 \,.\, \frac{1}{8\pi {a_0}^3} \log_e (\frac{4\epsilon_0 \hbar c}{e^2}) \tag{34}$$

which is in excellent agreement [12] with experiment without use of quantum electrodynamics.

The vacuum electric field is defined by the zero point energy of a harmonic oscillator, as is well known [1–10]:

$$\mathrm{En}_0 = \epsilon_0\, E_{0\kappa}^2\, \mathrm{V} = \frac{1}{2} \hbar\, \omega = \frac{1}{2} \hbar\, c\kappa \tag{35}$$

so for each mode denoted κ :

$$\boldsymbol{E}_{0\kappa}^2 = (\frac{\hbar c}{2\mathrm{V}\epsilon_0})\, \kappa \tag{36}$$

where V is the volume of radiation. Therefore:

$$<E_{0\kappa}^2 > \; = \; (\frac{\hbar c}{2\mathrm{V}\epsilon_0}) < \kappa > \quad . \tag{37}$$

The complete electric field is described by a Fourier series expansion:

$$\boldsymbol{E}_\kappa = \boldsymbol{E}_{0\kappa}\, (a_\kappa \exp(-\, i\, \phi) \, + \, a_\kappa{}^* \exp(\, i\, \phi)) \tag{38}$$

where ϕ is an electromagnetic phase [12]. It follows that the fluctuation is defined by:

$$\delta\boldsymbol{r} = \frac{e}{mc^2\kappa^2}\boldsymbol{E}_\kappa \tag{39}$$

and averages to zero according to Eq. (7). However, the mean square fluctuation is the sum over all modes:

$$< (\delta\boldsymbol{r})^2 > = \sum_\kappa \left(\frac{e}{mc^2\kappa^2}\right)^2 E_{0\kappa}^2 \tag{40}$$

and is non-zero. From Eq. (38):

$$<E_\kappa^2>^{½} = <E_{0\kappa}^2>^{½} \tag{41}$$

From Eqs. (39) and (41):

$$<E_\kappa^2>^{½} = \frac{mc^2}{e}\,\kappa^2 < (\delta\boldsymbol{r})^2 >^{½} . \tag{42}$$

From Eqs. (29) and (42):

$$<E_\kappa^2>^{½} = \left(\frac{mc^2}{e}\,\mathrm{A}^{½}\,\lambda_c\right)\kappa^2 \tag{43}$$

and from Eq. (36):

$$\kappa^2 = \left(\frac{2\mathrm{V}\epsilon_0}{\hbar c}\right) <E_\kappa^2> . \tag{44}$$

So from Eqs. (43) and (44):

$$<E_\kappa^2>^{½} = B^{-1/3} \tag{45}$$

where

$$B = \frac{mc^2}{e}\,\mathrm{A}^{½}\,\lambda_c \left(\frac{2\mathrm{V}\epsilon_0}{\hbar c}\right)^2 . \tag{46}$$

From Eqs. (29) and (30) the root mean square fluctuation picked up in an atom or molecule is:

$$< (\delta\boldsymbol{r})^2 >^{½} = \mathrm{A}^{½}\,\lambda_c = 5.113 \times 10^{-14} \text{ m}. \tag{47}$$

This compares with the Bohr radius:

$$a_0 = 5.29177 \times 10^{-11} \text{ m} \tag{48}$$

which is the radius of the lowest energy orbit of the H atom. Therefore the root mean square vacuum field in volts per metre is:

$$\begin{aligned} <E_\kappa^2>^{½} &= 4.238 \times 10^{-8} \text{ volt m}^{-1} \\ &= <E_{\mathrm{vac}}^2>^{½} \end{aligned} \tag{49}$$

for a radiation volume V of one cubic metre.

To adapt this theory for a circuit the change of potential energy in joules is

$$\Delta V = \frac{1}{6} < (\delta \boldsymbol{r})^2 > \nabla^2 \left(\frac{-e^2}{4\pi r \epsilon_0} \right) \tag{50}$$

which may be expressed as:

$$\Delta V = \frac{1}{6} < (\delta \boldsymbol{r})^2 > e \; \nabla . \boldsymbol{E} \tag{51}$$

In order to calculate the mean square fluctuation $< (\delta \boldsymbol{r})^2 >$ consideration must be given to an electron in a wire, not an electron bound in an orbital as in the above Lamb shift calculation. However to a rough order of approximation it can be assumed that:

$$< (\delta \boldsymbol{r})^2 >^{1/2} \backsim 10^{-14} \text{ m.} \tag{52}$$

3. Experimental data and Eckardt Lindstrom theory

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