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Cable Telegraphy and Poynting's Theorem

Frederick David Tombe,
Belfast, Northern Ireland,
United Kingdom,
sirius184@hotmail.com
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***Abstract*. Wireless EM radiation relates to magnetization while the electrostatic and magnetic fields that travel alongside the conducting wires in transmission lines are associated with capacitance and linear polarization. This article will examine how these two phenomena may or may not be treated using the same electromagnetic wave equations.**

The Electromagnetic Wave Equations

I. The original electromagnetic wave equation for wireless radiation,

$$\nabla^2\mathbf{H} = \mu_o\varepsilon_o\partial^2\mathbf{H}/\partial t^2 \qquad \textbf{(1)}$$

was derived in 1864 for the magnetic intensity vector **H** by Scottish physicist James Clerk Maxwell. It appeared in his 1865 paper ***"A Dynamical Theory of the Electromagnetic Field"***, and it was derived in connection with the electromagnetic momentum vector **A**, where $\nabla\times\mathbf{A} = \mu_o\mathbf{H}$ **[1]**. Since **H** is a vorticity in the momentum field, equation **(1)** must be describing the propagation of angular acceleration through a sea of tiny aethereal vortices that pervades all of space **[2]**.

This is further confirmed by the fact that another EM wave equation can be derived for the electric field vector **E**, where $\mathbf{E} = -\partial\mathbf{A}/\partial t$, providing that $\nabla\cdot\mathbf{E} = 0$. This could be the case for a radial **E** providing that it obeys an inverse square law in distance, but then this would mean that $\nabla\times\mathbf{E} = 0$, whereas the derivation requires that $\nabla\times\mathbf{E} = -\mu_o\partial\mathbf{H}/\partial t$ (Faraday's Law). The only alternative is that **E** represents a force that accelerates **A** transversely to the polar origin, as would be the case in the context of a vortex that is undergoing angular acceleration. We'll call the force $\mathbf{E_K}$ in order to distinguish it from the radial electrostatic $\mathbf{E_S}$. In a steady state magnetic field, the momentum density, **A**, will represent the aether circulation within the individual vortices and no transfer will be taking place between neighbouring vortices, but in the dynamic state where angular acceleration takes place, there will be an overflow of aether from the vortices into their immediate neighbours. This is known as time varying electromagnetic induction and it is the basis of electromagnetic waves.

The speed of these waves is c, where $c^2 = 1/\mu_o\varepsilon_o$, with μ_o representing magnetic permeability and ε_o representing electric permittivity, and where c is the speed of light. The magnetic permeability is related to the magnetic flux density while the electric permittivity is inversely related to the elasticity and the dielectric constant. The equation $c^2 = 1/\mu_o\varepsilon_o$ is then essentially Newton's equation for the speed of a wave in an elastic solid, equivalent to $\mathbf{E} = mc^2$ in the context [3].

The Telegrapher's Equations

II. A telegrapher's equation linking electric signals in a conducting wire to the speed of light was first derived by German physicist Gustav Kirchhoff in 1857 [4]. This was four years before Maxwell linked the speed of light to electric and magnetic phenomena in space, and seven years before Maxwell derived the electromagnetic wave equation. The commonality between Kirchhoff's telegrapher's equation and Maxwell's EM wave equation is the fact that both used the result of the 1855 Weber-Kohlrausch experiment in order to import the speed of light into the proceedings. The 1855 experiment was the first historical linkage between optics and electromagnetism [5]. It involved establishing the ratio between electrodynamic and electrostatic units of electric charge by discharging a Leyden jar (a capacitor).

Some years later in 1883, English physicist John Henry Poynting made a proposal regarding the transfer of energy in electric circuits. While it was traditionally accepted that electric energy is transferred through the conducting wires in a circuit, Poynting proposed that at least some of the energy is actually transferred through the space outside the conducting wires [6]. This idea was also taken up by English electrical engineer Oliver Heaviside [7]. From then on, it has been assumed that the telegrapher's equations apply to the electric and magnetic fields that propagate alongside the electric current in a wire in the dynamic and transient states, and that this is what Kirchhoff had been originally driving at.

The telegrapher's equations are in all essential details the same as the electromagnetic wave equations only they traditionally derive from the capacitance and the self-inductance within a laboratory electric circuit, with $Q = CV$ replacing the electric elasticity equation $\mathbf{D} = \varepsilon\mathbf{E}$ (Maxwell's Fifth Equation) in the wireless equivalent. But since capacitance involves the electrostatic force, $\mathbf{E_S}$, while inductance involves the electromagnetic force, $\mathbf{E_K}$, then we should not ideally be able to combine the capacitative and the inductive parts in the same analysis. Besides, $\mathbf{E_S}$ acts perpendicularly to the conducting surfaces while $\mathbf{E_K}$ acts parallel to the conducting wires. Furthermore, the propagation of the electric current in the wire is being driven by the external power source and not by the induced back EMF. It would therefore seem that Kirchhoff has actually derived the electromagnetic wave equation for wireless waves, while wrongly applying the electric permittivity to capacitance rather than to the inductive displacement current, $\mu_o\varepsilon_o\partial\mathbf{E_K}/\partial t$, which he knew nothing about at the time **[8]**. It looks like Kirchhoff assumed that he had derived a wave equation in connection with an electric signal in a wire where in fact he had really just derived the electromagnetic wave equation for waves travelling through space, similar to what Maxwell would later derive.

The question still remains though as to how the speed of signals in a wire is so closely related to the speed of light. It has previously been suggested in ***"The Telegrapher's Equations"*** **[9]**, that the reason why a signal propagates along a wire at the speed of light is because electric current is in fact more fundamentally an under-current of aethereal electric fluid which flows from positively charged particles (sources) to negatively charged particles (sinks) at an average speed in this same order of magnitude. In the special case of transmission lines where the two conducting wires are parallel and close together, the first tendency when the power is connected will be for a pilot under-current to move into the outgoing wire and immediately cut across the dielectric gap towards the return wire. This will linearly polarize the dielectric space between them and set up a back EMF which will impede further current flow across the gap. The pilot current will therefore carry on along the outgoing wire while continually splitting and branching off at right angles into the dielectric gap. As regards electric circuits in general, in the first moments after the power is connected (the transient state), the principles will be the same as in the case of the transmission line, but there will be no significant current flow until the pilot current has completed the circuit and the full conducting path is opened up.

Magnetization and Polarization

III. Electromagnetic waves radiate into space perpendicularly from the conducting wire and they are based around the time varying electromagnetic induction relationship, $\mathbf{E_K} = -\partial\mathbf{A}/\partial t$, where $\nabla\times\mathbf{A} = \mu_o\mathbf{H}$. This is a magnetization effect. The magnetic field that travels alongside a charged pulse of electric current in a transmission line, on the other hand, is a convective effect involving an electrostatic field superimposed upon a magnetic field. It is not a wave and its motion is sourced in the electric current in the wire, which is in the transient state. This is a linear polarization effect, and the $\mathbf{E_S}$ field is sourced in Coulomb's Law of Electrostatics.

Electric current is fundamentally a flow of the primordial electric fluid known as the aether. It's the stuff that everything is made of. It is denoted by **A** and it is known variously as the *electrotonic state*, the *electromagnetic momentum*, the *displacement current*, or the *magnetic vector potential*. As it flows through conducting wires, it has a tangential interaction with the surrounding dielectric space, and this induces a leakage at right-angles to the wire, which results in the creation of a magnetic field. The electrostatic pressure in the current, known as the electric charge, also results in a leakage which in turn results in linear polarization of the surrounding space, providing that space is dielectric. If indeed, space is dielectric and the individual constituent dipoles are rotating, then we have a basis upon which to distinguish between magnetization on the one hand and linear polarization on the other hand. See ***"The Double Helix Theory of the Magnetic Field"*** **[10]**, **[11]**.

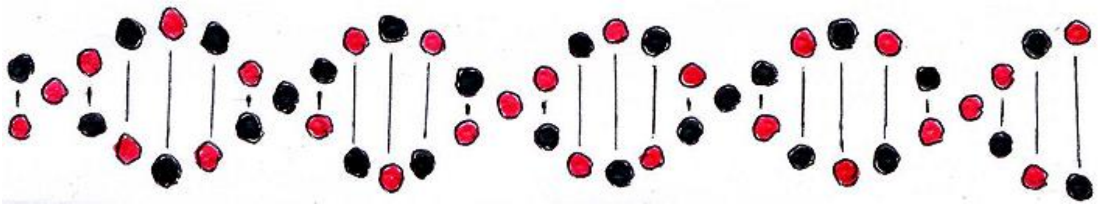

Fig. 1. A single magnetic tube of force. The electrons are shown in red and the positrons are shown in black. The double helix is rotating about its axis with a circumferential speed equal to the speed of light, and the rotation axis represents the magnetic field vector **H**.

Magnetization is the alignment of the rotating dipoles along their mutual rotation axes as this occurs naturally in conjunction with Ampère's Circuital Law, which is closely related to the fundamental Coriolis force. The rotation axes determine the direction of the magnetic field lines **H**. Polarization on the other hand is the separation of charges due to the application of an external electric field. When an electrostatic field is applied parallel to a magnetic field, linear polarization of the magnetic field amounts to a torque which induces a precession in the tiny rotating dipoles.

Poynting's Theorem

IV. Poynting's theorem follows from the equation of continuity as used in the context of energy density,

$$\nabla\cdot\mathbf{S} - \partial w/\partial t = 0 \qquad \mathbf{(2)}$$

where **S** is the rate of flow of energy per unit area across a surface and *w* is the energy density. It is applied to regions of space where the energy density is the sum of the electric energy density $½\varepsilon_o\mathbf{E}^2$ and the magnetic energy density $½\mu_o\mathbf{H}^2$ as per,

$$w = ½[\varepsilon_o\mathbf{E}^2 + \mu_o\mathbf{H}^2] \qquad \mathbf{(3)}$$

So long as we can link **E** and **H** through Faraday's Law, $\nabla\times\mathbf{E_K} = -\mu_o\partial\mathbf{H}/\partial t$, and Ampère's Circuital Law, $\nabla\times\mathbf{H} = \varepsilon_o\partial\mathbf{E_K}/\partial t$, then we can use the vector identity $\nabla\cdot(\mathbf{E_K}\times\mathbf{H}) = (\nabla\times\mathbf{E_K})\cdot\mathbf{H} - \mathbf{E_K}\cdot(\nabla\times\mathbf{H})$ to show that $\mathbf{S} = \mathbf{E_K}\times\mathbf{H}$. The vector $\mathbf{E_K}\times\mathbf{H}$ is known as the Poynting vector.

As regards trying to apply Poynting's theorem to wireless EM radiation beyond the near field of an electric circuit, there is the problem of isolating distinct values for **E** and **H**. This would be difficult in the case of starlight in deep space because the disturbance is passing through the already existing background magnetic field rather than carrying its own magnetic field with it. Nevertheless, wireless waves in space still operate under the principle of electromagnetic induction which means that energy is being continually transferred between electric circuits. This implies that space needs to be densely filled with tiny electric circuits. This is where Maxwell's sea of molecular vortices plays a role **[2], [3], [13], [14]**. The sea of vortices is of course the sea of dipolar electron-positron vortices.

Light is often treated using the packaging theory know as *quantum mechanics* where relationships are dealt with in terms of the energies associated with emissions and absorptions from different sources. This in no way detracts from the underlying fundamental electromagnetic wave nature of light.

Although Poynting's Theorem only applies to the dynamic state, we can nevertheless extrapolate the Poynting vector itself to the convective/transient state. The Poynting vector is a measure of the rate of flow of electric and magnetic energy per unit area per unit time. In the case of a DC transmission line pulse, the electric energy is of the electrostatic kind and so the Poynting vector takes the form $\mathbf{E_S}\times\mathbf{H}$.

Reflection of a DC Transmission Line Pulse

V. When a DC pulse reaches the end of the line in an open-ended transmission, it reflects back upon itself and reduces to exactly half of its original length, when it then continues to reverse back down the line again. It is the fact that it reduces to exactly half of its original length that tells us that we need more than just standard electron current theory in order to explain this phenomenon. We need the aethereal undercurrent too. This is because, in order for the pulse to compress to exactly half its length, the compression effect at the reflecting boundary must be incremental. This would not be so if we were depending on the compression of an electron cloud.

When the pulse reaches the reflecting boundary, the aethereal undercurrent at the point of contact, flows into the dielectric space beside the wire, increasing the dielectric polarization until impeded by the back EMF. This effect repeats incrementally as it backtracks through the pulse, until the pulse has compressed to exactly half its original length, but twice the original voltage (pressure).

Then the recoil begins in the exact opposite fashion. The dielectric incrementally unpolarizes to its original state and the aethereal electric current starts to flow back down the same wire again. The original electrostatic field direction across the gap is maintained but the magnetic field has now reversed its direction. The pulse then continues on its own momentum as per Newton’s first law of motion, while bringing its magnetic field with it. The aethereal electric current circulating around the perimeter of the pulse is akin to a free-wheeling caterpillar track riding on the other wire.

Conclusion

VI. A wave is a propagated disturbance in a particulate medium and its associated elasticity is related to the inter-particle bonding forces. These bonding forces in turn are determined by the speed of flow of the fundamental aethereal medium that exists in the interstitial spaces between the particles and which mediates the bonding forces. This fundamental medium is the primordial electric fluid from which everything is made. It is the aether. It flows between positive particles (sources) and negative particles (sinks) at an average speed in the order of the speed of light. In a conducting circuit, the electric fluid enters under pressure from the positive terminal and it pushes positive charges along with it. Meanwhile negative particles eat their way in the opposite direction towards the positive source at the terminal. Due to resistance in a conducting wire, these particles are never accelerated to anything like the speed of the aether itself. Electromagnetic radiation is a complex flow of electric fluid through a sea of tiny vortices that pervades all of space. This flow radiates outwards from the side of a conducting wire when the conduction current is in the dynamic state. The telegrapher's equations do not therefore technically apply to transmission line pulses, but due to the underlying commonality connected to aether flow, it's as if the telegrapher's equations do apply.

References

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http://gsjournal.net/Science-Journals/Historical%20PapersMechanics%20/%20Electrodynamics/Download/4105
In relation to the speed of light, *"The most probable surmise or guess at present is that **the ether is a perfectly incompressible continuous fluid, in a state of fine-grained vortex motion,** circulating with that same enormous speed. For it has been partly, though as yet incompletely, shown that such a vortex fluid would transmit waves of the same general nature as light waves— i.e., periodic disturbances across the line of propagation—and would transmit them at a rate of the same order of magnitude as the vortex or circulation speed"*

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[12] Tombe, F.D., ***"The Significance of the Poynting Vector"*** (2020)
https://www.researchgate.net/publication/338898407_The_Significance_of_the_Poynting_Vector

[13] Whittaker, E.T., ***"A History of the Theories of Aether and Electricity"***, Chapter 4, pages 100-102, (1910)
"All space, according to the younger Bernoulli, is permeated by a fluid aether, containing an immense number of excessively small whirlpools. The elasticity which the aether appears to possess, and in virtue of which it is able to transmit vibrations, is really due to the presence of these whirlpools; for, owing to centrifugal force, each whirlpool is continually striving to dilate, and so presses against the neighbouring whirlpools."

[14] O'Neill, John J., ***"PRODIGAL GENIUS, Biography of Nikola Tesla"***, Long Island, New York, 15th July 1944, quoting Tesla from his 1907 paper ***"Man's Greatest Achievement"*** which was published in 1930 in the Milwaukee Sentinel,
"Long ago he (mankind) recognized that all perceptible matter comes from a primary substance, of a tenuity beyond conception and filling all space - the Akasha or luminiferous ether - which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. The primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter; the force subsiding, the motion ceases and matter disappears, reverting to the primary substance".
http://www.rastko.rs/istorija/tesla/oniell-tesla.html
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Appendix I
(Cause and Effect in Faraday's Law and Ampère's Circuital Law)

It's well known that a changing magnetic field causes an electric field. This is expressed in Faraday's law of electromagnetic induction,

$$\nabla\times\mathbf{E_K} = -\mu_0\partial\mathbf{H}/\partial t \qquad \textbf{(1A)}$$

It is also claimed that Ampère's Circuital Law in connection with Maxwell's displacement, as in,

$$\nabla\times\mathbf{H} = \varepsilon_0\partial\mathbf{E_K}/\partial t \qquad \textbf{(2A)}$$

means that a changing electric field causes a magnetic field. This is not in fact true. An electric current causes a magnetic field, and the electric field which drives this electric current does not have to be changing. Both of these two equations cover the situation where a changing magnetic field is causing an electric field. The induced electric field in question will necessarily be changing too, but that is incidental and nothing to do with any cause. The correct general rule, ***applying equally to both equations***, is that,

(1) A ***changing magnetic*** field causes an ***electric*** field.
(2) An ***electric*** field causes a ***changing magnetic*** field.

7^{th} June 2021 amendment