

## Displacement Current and the Electrotonic State

*Frederick David Tombe  
Belfast, Northern Ireland, United Kingdom,  
[sirius184@hotmail.com](mailto:sirius184@hotmail.com)  
11th October 2008*

**Abstract.** When the electromagnetic wave equation is derived in modern textbooks, Maxwell's displacement current is used. While investigating the physical meaning of displacement current, this article will take a closer look at the magnetic vector potential  $\mathbf{A}$ , which Maxwell considered to be a momentum lurking in behind the magnetic field.

### Electric Current and Gravity

I. Electric current is aether momentum. In an electric circuit, we normally use the symbol  $\mathbf{J}$  for the current, which is a pressurized flow of aether that behaves according to Bernoulli's principle. The pressure is the charge, and the flow is the kinetic energy. Gravity is an all pervasive radial electric current which constitutes a rarefied flow of aether that gives rise to a tension, and hence to a pull force. Positively charged particles are aether sources and will be accelerated by their pressure. Negatively charged particles are aether sinks, and the surrounding tension will cause them to be pulled in the opposite direction to that of positive particles. Although particles share the acceleration of the aether due to pressure and tension, due to the inviscidity of the aether they will not automatically share the aether's flow velocity, and they will generally move very much slower.

In the special case of Maxwell's displacement current,  $\partial\mathbf{D}/\partial t$  or  $\epsilon\partial\mathbf{E}/\partial t$ , which is observed experimentally in the case of an electric current that is induced in a secondary circuit due to the changing magnetic field of a primary circuit (Faraday's Law), there is a problem regarding how to account for its existence in conjunction with electromagnetic radiation in deep space far from any electrical apparatus. In Part II of his 1861 paper "*On Physical Lines of Force*", Maxwell introduced the electromagnetic momentum  $\mathbf{A}$ , which accounts for Faraday's electrotonic state [1]. It will be proposed that this vector  $\mathbf{A}$  actually is Maxwell's displacement current, because when we derive the electromagnetic wave equation, we

are working on the premises that  $\mathbf{E}$  will equal  $-\partial\mathbf{A}/\partial t$  as per Faraday's law. The vector  $\mathbf{A}$  would then simply be a special case of  $\mathbf{J}$  for the circumstances that exist in wireless electromagnetic radiation in deep space. Those circumstances would of course require the existence of an actual electric current everywhere in space where electromagnetic radiation exists, which is more or less what Maxwell proposed in his 1861 paper in the form of his sea of molecular vortices. Maxwell's proposal regarding the sea of vortices was however rejected, yet ironically his displacement current has been retained in modern physics with its meaning altered so as to render it into a virtual current. This rejection of Maxwell's sea of molecular vortices will now be shown to be in error. From Faraday's law, it follows that,

$$\partial\mathbf{E}/\partial t = -\partial^2\mathbf{A}/\partial t^2 \quad (1)$$

and accepting the vector  $\mathbf{A}$  to be displacement current as per,

$$\mathbf{A} = \varepsilon\partial\mathbf{E}/\partial t \quad (\text{Displacement Current}) \quad (2)$$

it then follows from (1) and (2), that in this context,

$$\mathbf{A} = -\varepsilon\partial^2\mathbf{A}/\partial t^2 \quad (3)$$

This is a simple harmonic motion equation in which  $\varepsilon$  is the inverse of the elastic constant.

Displacement current can therefore be justified on grounds of the existence of some kind of oscillatory disturbance in the aether, with the electric permittivity  $\varepsilon$  being related to the elasticity. It further follows that since,

$$\text{curl } \mathbf{A} = \mathbf{B} \quad (\text{Maxwell's Second Equation}) \quad (4)$$

and since,

$$\text{curl } \mathbf{B} = \mu\mathbf{A} \quad (\text{Ampère's Circuital Law}) \quad (5)$$

that we are dealing with interlocking solenoidal lines of electric current and magnetic force at every point in space. This state of affairs could only come about if the aether exists and were to be rendered into a state of tiny vortices.

Modern textbooks always attempt to justify the existence of Maxwell's displacement current in connection with capacitors, and worse still, in connection with conservation of charge. But from the above

considerations we can conclude that capacitors have been a red herring as regards the understanding of Maxwell's displacement current if it is indeed actually a fine-grained vortex flow of aether which can occur in deep space. In fact, without a sea of tiny aethereal vortices, it is impossible to justify Maxwell's displacement current at all. The articles "*Displacement Current*" [2], and "*Maxwell's Original Equations*" [3], explain how the modern textbook derivations are heavily flawed.

## The Electromagnetic Wave Equation

**II.** In order to confirm that the magnetic vector potential  $\mathbf{A}$  is a special case of current density  $\mathbf{J}$  more generally, we will treat it as such and derive the electromagnetic wave equation accordingly. Combining equations (3), (4), and (5), we obtain,

$$\text{curl}(\text{curl } \mathbf{A}) = -\mu\epsilon\partial^2\mathbf{A}/\partial t^2 \quad (6)$$

This expands to,

$$\nabla(\nabla\cdot\mathbf{A}) - \nabla^2\mathbf{A} = -\mu\epsilon\partial^2\mathbf{A}/\partial t^2 \quad (7)$$

If we take the divergence of  $\mathbf{A}$  to be zero ( $\nabla\cdot\mathbf{A} = 0$ ), this will reduce to a wave equation for disturbances in the aether such that the propagation speed will be exactly equal to the speed of light [4]. This would be the state of affairs that would occur when we are considering a fine-grained vortex flow through a sea of tiny aether whirlpools. In such a case, the motion of the aether would be tangential to the vortices, and hence the divergence of the aether momentum (or the divergence of the displacement current  $\mathbf{A}$ ) would always be zero.

## Conclusion

**III.** Wireless electromagnetic radiation can exist in deep space far from any electrical apparatus, and so Maxwell's displacement current has got nothing to do with capacitors or linear polarization. The linkage between displacement current and capacitors in modern physics has been a red herring of enormous proportions. It's true though that Maxwell first introduced displacement current in Part III of his 1861 paper [1] as a

special kind of transient electric current that occurs when an external electric field is applied across a non-conducting solid, and where the elasticity of the solid causes the induced current to quickly grind to a halt. Maxwell however failed to make it explicitly clear that when the displacement current is used with Ampère's Circuital Law when deriving the electromagnetic wave equation, that cause and effect have been reversed, in that rather than the elasticity impeding the current, the elasticity is actually causing the current as per Faraday's Law of electromagnetic induction. This omission led to the erroneous belief that a changing electric field causes a magnetic field.

Maxwell's displacement current is in fact none other than the magnetic vector potential  $\mathbf{A}$  itself, which is a circulating aether momentum giving rise to a magnetic moment. Wireless radiation should not be confused with the transverse electric waves which propagate in the space between the two wires of a transmission line. Linear polarization between the two wires will impede the flow of aether across the gap, and so as the aether flows sideways between the wires, it will be advancing parallel to them in order to circumvent the induced impedance. Cable transmissions do not constitute electromagnetic radiation as is often wrongly believed.

There are some who reject Maxwell's displacement current outright on the grounds that it doesn't correctly fit with capacitor and transmission line theory, or that it can't possibly exist in empty space, and that there is no experimental evidence for its existence either in deep space or between the plates of a capacitor. These arguments are all correct as regards the displacement current associated with wireless electromagnetic radiation. But then they go further and deny the mathematical argument that displacement current is necessary for the symmetry of the electromagnetic equations and the derivation of the electromagnetic wave equation, while claiming that all of modern electromagnetic theory is wrong.

Maxwell's sea of molecular vortices solves all of these problems, but if this idea is rejected, then the only alternative is indeed to do away with displacement current altogether. There is however too much experimental evidence confirming all the other equations of electromagnetism, including experimental evidence of displacement current being induced on the large scale in a secondary electric circuit due to the changing magnetic field of a primary. The most likely inference is therefore that Maxwell was correct about the sea of molecular vortices. Nikola Tesla, John Bernoulli the Younger, and Sir Oliver Lodge, have all independently supported a similar approach [5], [6], [7].

## References

- [1] Clerk-Maxwell, J., **“On Physical Lines of Force”**, Philosophical Magazine, Volume XXI, Fourth Series, London, (1861)  
[http://vacuum-physics.com/Maxwell/maxwell\\_oplf.pdf](http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf)
- [2] Tombe, F.D., **“Displacement Current”** (2008)  
<http://gsjournal.net/Science-Journals/Research%20Papers-Mechanics%20/%20Electrodynamics/Download/227>
- [3] Tombe, F.D., **“Maxwell’s Original Equations”** (2011)  
<http://gsjournal.net/Science-Journals/Essays-Mechanics%20/%20Electrodynamics/Download/3889>
- [4] Tombe, F.D., **“The Speed of Light”** (2014)  
<http://gsjournal.net/Science-Journals/Research%20Papers-Mechanics%20/%20Electrodynamics/Download/5373>
- [5] O’Neill, John J., **“PRODIGAL GENIUS, Biography of Nikola Tesla”**, Freeport, Long Island, New York, (15th July 1944)  
Quoting Tesla from an unpublished paper entitled “Man’s Greatest Achievement”  
*“Long ago he (mankind) recognized that all perceptible matter comes from a primary substance, or tenuity beyond conception, filling all space, the Akasha or luminiferous ether, 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>
- [6] Whittaker, E.T., **“A History of the Theories of Aether and Electricity”**, Chapter 4, pages 100-102, (1910)  
*“ - - - All space, according to the young [John] 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 - - - ”.*
- [7] Lodge, Sir Oliver J., **“Ether (in Physics)”**, Encyclopaedia Britannica, Fourteenth Edition, Volume XIII, Pages 751-755, (1937)  
It says in the section entitled, **“POSSIBLE STRUCTURE.**\_\_ *The question arises as to what that velocity can be due to. 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 order of magnitude as the vortex or circulation speed - - - - ”*  
<http://gsjournal.net/Science-Journals/Historical%20Papers-%20Mechanics%20/%20Electrodynamics/Download/4105>