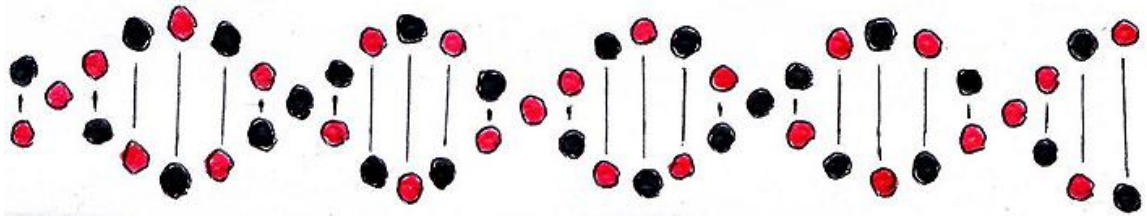
the general science journal

Electricity and the Speed of Light

Frederick David Tombe,
Northern Ireland, United Kingdom,
sirius184@hotmail.com
24th April 2025

Abstract. **Even though Scottish physicist James Clerk Maxwell is credited with having united optics and electromagnetism in the 1860s, the Germans had already linked the speed of light to electricity in the 1850s. Those with a negative opinion about Maxwell often like to point out that Gustav Kirchhoff derived the Telegrapher's Equations in 1857 without any need for Maxwell's displacement current. This article will take a closer look at the respective roles of both Kirchhoff and Maxwell in this matter.**



Introduction

I. While German physicist Gustav Kirchhoff, in 1857, had no knowledge of Maxwell's displacement current, he is nevertheless credited with the Telegrapher's equations which are mathematically equivalent to Maxwell's electromagnetic wave equations which appeared a few years later, [1]. They differ only in the physical context in which they apply. Kirchhoff believed that they applied to the propagation of electric signals along a conducting wire, whereas Maxwell believed that they applied to wireless radiation in space, which he believed was densely packed with tiny aethereal vortices, [2].

Capacitance and Displacement Current

II. In the absence of displacement current, Kirchhoff relied on the concept of capacitance, and he had already identified the speed of light in his calculations through a ratio established in the 1855 Weber-Kohlrausch experiment, [3], [4]. The equation for electric current in a charging or discharging capacitor is mathematically identical to Maxwell's displacement current. Maxwell, meanwhile, also relied on the Weber-Kohlrausch experiment in order to involve the speed of light in his calculations. He then simply applied the capacitance concept to linear polarization in a dielectric, and in doing so he changed the

context of the telegrapher's equations from that of laboratory electric circuits to that of wireless radiation in space. Maxwell considered his sea of tiny vortices to be dielectric.

Electric Inductance

III. Kirchhoff's error seems to have been, that when he was deriving the wave equations, he merged capacitance and inductance on the laboratory scale. While doing substitutions in his equations, he failed to distinguish between electric field terms that were capacitance-induced from those arising due to time-varying electromagnetic induction. Maxwell, on the other hand, in his 1865 paper, **[5]**, switched from a capacitance-based displacement current to an inductance-based displacement current. The wave equations became entirely based on the time-varying electromagnetic induction process being relayed through space by the elasticity of the wave-carrying medium.

Conclusion

IV. The 1855 Weber-Kohlrausch experiment, if properly interpreted, **[4]**, with the velocity term in Weber's 1846 force equation being treated as a reducing velocity, suggests that the speed of light is primarily the speed of electric current, and that electric current at the most fundamental level is a unidirectional aethereal flow, and that the accompanying motion of charged particles is merely a side effect. While in 1857, Gustav Kirchhoff established that electric signals propagate along a wire at the speed of light, he failed to clarify that this is just because changes in the voltage are carried along with the flow, similar to how a change in the pressure of the water in a hosepipe is carried along with the flow, and that we are not dealing with a wave in the sense of it being a propagated disturbance through an elastic medium.

So, while the electromagnetic wave equations can only be derived in the context of time-varying electromagnetic induction, these same equations could still nevertheless be applied mathematically to AC pulses propagating along a transmission line, due to the fact that electric current at the most fundamental level is an aethereal fluid flowing at a speed in the order of the speed of light. The speed of light is primarily the speed of electricity, and Maxwell meanwhile, by applying the wave equations to wireless radiation in space, was in effect showing that these waves are primarily a relay of tiny aethereal electric currents, swirling from vortex to vortex through a dense all-pervading sea of tiny aethereal vortices that fills all of space, **[2], [6], [7], [8], [9], [10].**

.

References

[1] Kirchhoff, G.R., ***"On the Motion of Electricity in Wires"***, Philosophical Magazine, vol. XIII, Fourth Series, pp. 393-412, (1857)
English translation by Professor A.K.T. Assis, vol. 3, chapter 8
https://www.ifi.unicamp.br/~assis/Weber-in-English-Vol-3.pdf
See page 212 for Kirchhoff's periodic equations in linear charge density and electric current. Page 213 is where he suggests an analogy between the electric charge equation and the equation for the propagation of longitudinal waves and see page 214 regarding the connection between Weber's constant and the speed of light.
Meanwhile, a summary by Professor A.K.T. Assis can be found on pp. 280-282 in this link,
https://www.ifi.unicamp.br/~assis/Weber-Kohlrausch(2003).pdf

[2] Maxwell, J.C., ***"On Physical Lines of Force"***, Philosophical Magazine, Volume XXI, Fourth Series, Part II, eqn. 55, London, (1861)
http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf

[3] Weber, W., and Kohlrausch, R., ***"Elektrodynamische Maassbestimmungen insbesondere Zurueckfuehrung der Stroemintensitaetsmessungen auf mechanisches Maass"***, Treatises of the Royal Saxon Scientific Society, Volume 5, Leipzig, S. Hirzel, (1856)
See chapters 5, 6, and 7 in this link,
https://www.ifi.unicamp.br/~assis/Weber-in-English-Vol-3.pdf
Prof. A.K.T Assis has written an excellent summary of this work in an article entitled ***"On the First Electromagnetic Measurement of the Velocity of Light by Wilhelm Weber and Rudolf Kohlrausch"***.
https://www.ifi.unicamp.br/~assis/Weber-Kohlrausch(2003).pdf
Weber and Kohlrausch wrote a short precis of their paper, and this can be found in Poggendorf's Annalen, vol. XCIX, pp. 10-25. An English translation of this precis is presented in the appendix at the end of Prof. Assis's paper.

[4] Tombe, F.D., ***"The 1855 Weber-Kohlrausch Experiment (The Speed of Light)"***, (2019)
https://www.researchgate.net/publication/332411168_The_1855_Weber-Kohlrausch_Experiment_The_Speed_of_Light

[5] Maxwell, J.C., ***"A Dynamical Theory of the Electromagnetic Field"***, Philos. Trans. Roy. Soc. London **155**, pp 459-512 (1865). Abstract: Proceedings of the Royal Society of London 13, pp. 531—536, (1864).
The derivation of the electromagnetic wave equation in **H** begins on page 497 in the first link.
http://www.zpenergy.com/downloads/Maxwell_1864_4.pdf
http://www.zpenergy.com/downloads/Maxwell_1864_5.pdf

[6] Tombe, F.D., ***"The Double Helix Theory of the Magnetic Field"***, (2006)
Galilean Electrodynamics, Volume 24, Number 2, p.34, (March/April 2013)
https://www.researchgate.net/publication/295010637_The_Double_Helix_Theory_of_the_Magnetic_Field

[7] Tombe, F.D., ***"The Double Helix and the Electron-Positron Aether***", (2017)
https://www.researchgate.net/publication/319914395_The_Double_Helix_and_the_Electron-Positron_Aether

[8] Lodge, Sir Oliver, ***"Ether (in physics)"***, Encyclopaedia Britannica, Fourteenth Edition, Volume 8, Pages 751-755, (1937)
The quote below is 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"
The article then goes on to cite Lord Kelvin, **"The Vortex Theory of Ether,"** *Phil. Mag.* (1887) and *Math. and Phys. Papers*, vol. iv. and passim; also G. F. FitzGerald, *Proc. Roy. Dub. Soc.* (1899), or *Collected Papers*, pp. 154, 238, 472.
http://gsjournal.net/Science-Journals/Historical%20PapersMechanics%20/%20Electrodynamics/Download/4105

[9] O'Neill, John J., ***"PRODIGAL GENIUS, Biography of Nikola Tesla"***, Long Island, New York, 15th July 1944, Fourth Part, paragraph 23, 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, filling all space, the Ākāśa 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

[10] 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. It will be seen that Bernoulli is a thorough Cartesian in spirit; not only does he reject action at a distance, but he insists that even the elasticity of his aether shall be explicable in terms of matter and motion. This aggregate of small vortices, or " fine-grained turbulent motion," as it came to be called a century and a half later,* is interspersed with solid corpuscles, whose dimensions are small compared with their distances apart. These are pushed about by the whirlpools whenever the aether is disturbed, but never travel far from their original positions. A source of light communicates to its surroundings a disturbance which condenses the nearest whirlpools; these by their condensation displace the contiguous corpuscles from their equilibrium position; and these in turn produce condensations in the whirlpools next beyond them, so that vibrations are propagated in every direction from the luminous point. It is curious that Bernoulli speaks of these vibrations as longitudinal, and actually contrasts them with those of a stretched cord, which, "when it is slightly displaced from its rectilinear form, and then let go, performs transverse vibrations in a direction at right angles to the direction of the cord." When it is remembered that the objection to longitudinal vibrations, on the score of polarization, had already been clearly stated by Newton, and that Bernoulli's aether closely resembles that which Maxwell invented in 1861-2 for the express purpose of securing transversality of vibration, one feels that

perhaps no man ever so narrowly missed a great discovery. Bernoulli explained refraction by combining these ideas with those of his father. Within the pores of ponderable bodies the whirlpools are compressed, so the centrifugal force must vary in intensity from one medium to another. Thus a corpuscle situated in the interface between two media is acted on by a greater elastic force from one medium than from the other; and by applying the triangle of forces to find the- conditions of its equilibrium, the law of Snell and Descartes may be obtained. * Cf . Lord Kelvin's vortex-sponge aether, described later in this work."