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The Deeper Physical Nature of Electric Current

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Abstract. **While it is generally accepted that electric current involves the motion of electric charge through conducting channels, there is observable evidence in the field of pulse transmission, that electric current exhibits wave-like behaviour, and that two electric pulses can pass right through each other in opposite directions along the same wire. An attempt will be made to reconcile these two seemingly contradictory natures of electric current.**

The Electric Fluid

I. In order to reconcile Ampère's Circuital Law with the wave-like behaviour that is observed in electric pulse transmission, we would ideally require a uni-directional electric current which can create a magnetic field while crossing a dielectric gap, and which flows at a speed in the order of the speed of light. It is therefore proposed that electric current is something more fundamental than just the flow of charged particles, and that it consists in a deeper undercurrent of the primary substance of all matter, [1]. This must surely be the *electric fluid*, known to men of old, which fluid is otherwise known as the *aether*, and all particles of matter are either sinks or sources in the aether. The aether, when accelerating, will impart its acceleration to source particles, while sink particles eat their way in the opposite direction, but due to its inviscosity, the fluid will not impart its speed to these particles. Hence, the charged particles that are involved in an electric current, never reach anywhere near the speed of light. It only then remains to establish what exactly it is that constrains the flow of electric current inside a conductor.

Magnetization and Polarization

II. The aethereal undercurrent mentioned in the preceding section is almost certainly what L. F. Woodruff was referring to as the *displacement current* that crosses the dielectric gap in a two-wire transmission line, in the first period of the

transient, before the disturbance has reached the other end, with the crossing of the gap being necessary to maintain the closed circulation prior to the current completely filling the conducting wires. Woodruff dissociated this displacement current from electron flow and he identified it with Maxwell's displacement current in the *ether*, **[2]**.

It is proposed that this aethereal electric current, when flowing in a conducting wire, will be hemmed in by a surrounding dense sea of rotating electron-positron dipoles which pervades all of space and which serves as the medium for the propagation of light. Such a sea of rotating dipoles, as well as serving as a dielectric, doubles for a sea of dipolar vortices in the aethereal electric fluid mentioned in the preceding section, **[3], [4], [5], [6], [7]**. This dielectric vortex sea, referred to by Maxwell as the *luminiferous medium*, can then accommodate dielectric polarization and magnetization, both of which serve as reactive impedances to the flow of electric current. When it comes to hemming electric current inside a conducting wire by limiting the amount of leakage, polarization is a spring-like impedance which ultimately blocks the flow, whereas magnetization is a flywheel-like impedance which allows the flow to continue inside the wire, but which after the first period of the transient, traps aether within a surrounding near magnetic field, hence preventing any further escape from the conducting wire. This aether is returned to the wire again, continuing in its original direction, when the power is disconnected.

Maxwell's displacement current, as used in the derivation of the electromagnetic wave equations, represents escaped aether, and it takes the form of a fine-grained vortex flow as described in the article entitled *"Ether (in physics)"* in the 1937 Encyclopaedia Britannica, **[7]**. On the other hand, the aether which leaks into the gap between the plates of a capacitor during the transient period, when the capacitor is charging or discharging, is associated with polarization in a dielectric. Meanwhile, polarization current itself is broadly identical in principle to the original concept of displacement current proposed by Maxwell in the preamble to Part III of his 1861 paper, ***"On Physical Lines of Force"***, **[4]**, and this fact has caused much confusion, since the mathematical form of displacement current as later used by Maxwell when he first derived the electromagnetic wave equation in 1864 for his next paper ", ***"A Dynamical Theory of the Electromagnetic Field"***, **[8]**, is not compatible with the context of polarization in a dielectric. Maxwell never seems to have explicitly brought it to attention that the displacement current, as used in the derivation of the electromagnetic wave equations, is a magnetization-based displacement current as opposed to a polarization-based displacement current. *See the note after the reference to Maxwell's 1865 paper,* **[8]**. The result is that the concept of displacement current transferred into twentieth century textbooks in the context of capacitors and transmission lines. See, ***"Maxwell's Displacement Current in the Two Gauges"***, **[9]**.

At any rate, as regards the aethereal fluid that enters the dielectric gap in a capacitor, this is due to the tendency of such fluid, when in a pressurized state, to expand, hence giving rise to a radial electrostatic field. Aether pressure and aether tension is measured as electric charge, while electric charge is then seen as the source of an electrostatic field, which causes the surrounding dielectric sea to become linearly polarized, and this will induce a back EMF which impedes further expansion. Meanwhile, linear polarization in a rotating dipole manifests itself in the form of precession. The electrostatic field will therefore cause the surrounding rotating electron-positron dipoles to precess about the lines of force.

As regards magnetization in the context of an electric pulse, if a region of pressurized aether actually moves through the electron-positron sea, a magnetic field will also be induced in the surrounding space. This will be due to the rotating dipoles aligning along their mutual rotation axes, as per Ampère's Circuital Law, with these rotation axes tracing out magnetic lines of force which form concentric solenoidal rings around the path of motion. This magnetization tendency will be antagonistic to the electrostatic alignment mentioned in the previous paragraph, since the former is based on cylindrical symmetry while the latter is based on spherical symmetry, but as the speed of the moving region of charge tends to the speed of light, the magnetic field will totally dominate. This transition is predicted mathematically from the Lorentz transformation of fields, **[10]**. As a moving charge tends to the speed of light, its surrounding electrostatic field will change into a magnetic field, and vice-versa.

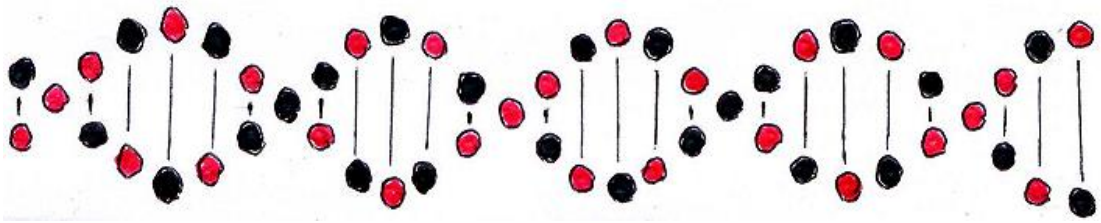

Fig. 1. A single magnetic line of force. The electrons are shown in red, and the positrons are shown in black. The double helix is rotating about its axis with a circumferential speed equal to the speed of light, and the rotation axis represents the magnetic field vector **H**.

Pulse Transmission

III. Discrete electric pulses are like trolley photons trolling a conducting wire. The first tendency of such aethereal pulses is for them to expand outwards into the surrounding space, but this expansion will be swiftly impeded by a back EMF induced by the surrounding dielectric, and any escaping electric fluid will be absorbed into the creation of a magnetic field, as opposed to into the creation of a dielectric polarization field, since the photon is travelling at a speed in the order of the speed of light. The picture will be that of a solenoidal flow of aether, centred on the conducting wire while encasing a toroidal magnetic field which

circulates around the wire. The aether in turn will flow around the outside of the magnetic field from the leading edge of the electric pulse, and then back into the wire again at the rear. Meanwhile the magnetic field will propagate alongside the electric pulse in a wave-like manner, forming at the leading edge and collapsing once again at the trailing edge.

For the sake of simplicity though, we can analyse this case scenario by considering a two-dimensional cross-sectional projection parallel to the conducting wire. This will show up like two caterpillar tracks, each enclosing magnetic field lines directed into and out of the page. The vast bulk of the electric current's momentum will be concentrated in the conducting wire, and we will only need to consider one of these caterpillar track-type circulations for analytical purposes. See **Appendix I** before the reference section.

Reflection of an Electric Pulse at the End of a Wire

IV. When a pulse of aether reaches the open end of a conducting wire, its path will now be blocked. Two things then simultaneously occur at the dead end. Since the aether in the wire at this point is no longer moving, the surrounding magnetic field, immediately adjacent to this point, collapses into a linear polarization field. A similar thing happens when a parallel plate capacitor is charging up. The current across the dielectric gap collapses, as does the magnetic field, while this is replaced in the gap by an electrostatic field. The dielectric will then be in a state of linear polarization.

The second thing that happens when the pulse reaches the open end is that the element of aether at the front of the pulse, that would have continued onwards had its path not been blocked, now flows sideways into the adjacent dielectric, hence doubling up on the polarization caused by the collapsing magnetic field at this point.

The next element of aether coming behind will likewise divert into the next layer of the dielectric further back, and this layer will likewise be doubly polarized. This effect repeats in a wave-like manner as it backtracks through the pulse, until a moment is reached when the photon is now half of its original length. This is the mid-point of a reflection process. It's like as if a magnetic field has reflected back over itself, converting into a polarization field in the process. At the half-way point in the reflection, the measured voltage has doubled, and the length of the pulse has halved, [11]. After the mid-point of the reflection process, the situation reverses and the pulse emerges again at its original length, but with the electric circulation reversed, meaning of course that the magnetic field has also reversed.

If we were to cut the transmission line midway through the reflection process, at the exact point where the leading edge and trailing edge of the pulse become coincident, when the length of the pulse has halved, and the voltage has

doubled, the trapped pulse will be just like a statically charged capacitor. If we then reconnect the line again a few moments later, it won't make any difference to the process described above. The capacitor will simply discharge until all the dielectric polarization has reconverted into a magnetic field. A rough mechanical analogy would be that of a free-wheeling cart with a spring attached to each end as a bumper. When the cart bumps into a wall, the spring compresses and we have potential energy. This is equivalent to dielectric polarization. When the cart recoils, the potential energy reconverts back into kinetic energy again, equivalent to magnetic energy.

It's the recoil context which best exposes the reason why we know that the existing degree of polarization is exactly doubled during the reflection. Consider the compressed pulse at the discharge end as it starts to reverse back along the line again. The individual element of linear polarization at the wavefront cannot empty is load sideways into the adjacent unpolarized element. The load, being aethereal electric current, must first discharge downwards into the conducting wire, from where it moves sideways and then flows up again into the adjacent element. This will continue until equilibrium is reached, like in a U-tube containing water. When equilibrium is reached, exactly half of the load in the leading element will have transferred to its immediate neighbour. This effect then continues to the next element, with the aethereal current in the wire coming incrementally from further back within the doubly polarized region as the emerging half-polarized region expands in both directions. And of course, the linear polarization reconverts into a magnetic field due to this aethereal electric current now flowing around the perimeter of the emerging pulse.

The Poynting Vector and the Telegrapher's Equations

V. The Poynting vector, $\mathbf{S} = \mathbf{E}\times\mathbf{H}$, is derived from Poynting's theorem strictly on the basis that **E** is $\mathbf{E_K}$, where $\mathbf{E_K} = -\partial\mathbf{A}/\partial t$, with $\nabla\times\mathbf{A} = \mu\mathbf{H}$, where μ is the magnetic permeability and **H** is the magnetic field strength, [12]. Maxwell considered the magnetic vector potential, **A**, to be a transverse momentum in the sea of aethereal vortices. The vector field, $\mathbf{E_K}$, is that which is induced by a time-varying magnetic field.

Meanwhile, discrete electric pulses in wires have been disconnected from their power sources and they travel at constant speed on their own momentum, as per Newton's first law of motion. While time-varying magnetic fields will be involved at the leading and trailing edges of such a pulse, the bulk of the travelling energy will be in the electric pulse itself in the wire, and in the steady state magnetic field surrounding the wire. It doesn't therefore look as though the Poynting vector would apply in the space outside the wire in the case of a DC transmission line pulse. The Poynting vector strictly only applies to wireless electromagnetic radiation, where it merely represents the rate of flow of energy

density in such waves. Likewise, the electromagnetic wave equations only apply where the electric field is induced by a time-varying magnetic field. The telegrapher's equations, such as the one derived by Kirchhoff, **[13]**, are simply the wireless EM wave equations applied to the wrong context. They have been wrongly applied to cable telegraphy, because in the derivation, the back EMF due to self-induction in the transient state, has been employed. But this back EMF is not actually driving the propagation mechanism of the magnetic wave that travels alongside the transient, and as such, the derivation cannot be legitimately performed.

The 1855 Weber-Kohlrausch experiment, **[14]**, **[15]**, concerns the transition between an electrostatic field and a magnetic field during the discharge of a Leyden jar (capacitor). Had Weber used electromagnetic units of charge instead of electrodynamic units, he could have reasonably deduced that electric current flows at a speed close to the speed of light. Transients in a conduction current are therefore carried with the flow, which is why they appear to be propagated in a wave-like manner at close to the speed of light.

Head-on Collisions in the Same Wire

VI. If two identical electric pulses collide on the same wire, it will be just as though they have each collided with an open end. It will appear the same as though there had been a mirror at an open end.

More interesting though is the partial reflection that occurs when a longer pulse collides with a shorter pulse. Let's say that the longer pulse comes from the left and the shorter pulse comes from the right. The shorter pulse will complete its reflection first, and when this happens, the aethereal fluid stored in the adjacent polarized zone in the longer pulse, starts to discharge to the right, into the wire, immediately behind the reflected shorter pulse. Meanwhile, back on the left side of the polarized zone, the tail end of the longer pulse will still be feeding into this zone from the left. This polarized zone, now moving backwards towards the left in a wave-like manner, hence gives the illusion of being the shorter pulse passing right through the longer pulse, from right to left. But this is indeed only an illusion. No aether has actually passed through itself, just as no ball in Newton's Cradle ever passes through another ball.

If the shorter pulse coming from the right should also happen to be the stronger pulse by virtue of having a greater momentum density than the longer pulse, the same thing will happen again, except this time the collision front will be pushed along a bit towards the left by the stronger pulse. As such, a process similar in principle to the Doppler effect will occur. The weaker pulse will be compressed such that it rebounds with a greater momentum density, while the stronger pulse will recoil with a lesser momentum density, since the collision

front is moving away from its recoil front. Once again, it will appear as though the shorter pulse has moved through the longer pulse, but this is just an illusion.

In the special case of a two-wire transmission line however, two pulses can of course pass each other, providing that the live part of each pulse is on opposite wires.

Conclusion

VII. Ampère's circuital law can be reconciled with the apparent wave behaviour that is observed in the field of pulse transmission, in the context of reflections and collisions, if we acknowledge that electric current is fundamentally an aethereal fluid, the substance of all matter, which travels in conducting wires at close to the speed of light, and which can leak out into the dielectric space beside a conducting wire during the transient periods, **[16]**.

Two electric currents cannot pass through each other, but collisions result in the aethereal fluid being forced sideways into the adjacent dielectric space, and this effect, resulting in linear polarization, back feeds through the dielectric in a wave-like manner. The partial reflection which results when a longer pulse collides with a shorter pulse, gives the illusion that the shorter pulse has passed right through the longer pulse. But it is only an illusion, no different in principle than that which we observe in Newton's Cradle when an incoming ball stops and an identical ball emerges at the far end, moving at the same speed, as though it were the same ball having passed through the other balls in the row.

Appendix I

In the case of a steady state DC electric current circulation, where the current is confined entirely within conducting channels, and where equilibrium has been reached with the ohmic resistance, the current measured at the outgoing terminal is the same as that measured at the return terminal. Although more aether actually enters the circuit at the outgoing terminal than exits at the return terminal, the difference is explained on account of the fact that some aether is absorbed into heat and/or light radiation by the ohmic resistance.

It is proposed, that in the transient state, before the current has completely occupied the conducting channels, that it is only travelling in one direction, that being the outward direction. Now, consider the case of a two-parallel wire transmission line where the return wire is employed in the capacitance before the disturbance reaches the far end. If we disconnect the power supply before the far end is reached, we will have an electric circulation akin to a caterpillar track, guided between the two wires. The current pulse in the live wire will be equivalent to the upper part of the caterpillar track, as in the part of the track

that is actually moving, while the part of the circulation on the return wire will be like the stationary part of the caterpillar track, as in the part of the track that is in contact with the ground.

The magnetic field will therefore only circulate around the electric current in the live wire, **[17]**, while interlocking with the full electric caterpillar track-type circulation. These two closed circulations will be perpendicular to each other.

References

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"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".

[2] Woodruff, L.F., ***"Principles of Electric Power Transmission"*** (1938)
Chapter VII, page 145
https://archive.org/details/in.ernet.dli.2015.288436/page/45/mode/2up?view=theater

[3] Whittaker, E.T., ***"A History of the Theories of Aether and Electricity"*** (1910)
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"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."

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Maxwell proposes the sea of aethereal vortices in the preamble to Part I, while he proposes displacement current as akin to a polarization current in the preamble to Part III.
http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf

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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"*

[8] 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).
https://royalsocietypublishing.org/doi/pdf/10.1098/rstl.1865.0008
The derivation of the electromagnetic wave equation in the magnetic field begins on page 497. Note how the electrostatic component of the displacement current is eliminated after equation (68), hence leaving the elastic displacement mechanism in the wave as an effect that is connected exclusively with time-varying electromagnetic induction. Maxwell originally conceived the idea of displacement current in connection with dielectric polarization, and hence with electrostatics, but in this derivation, it is no longer applicable to polarization, but instead applies to magnetization. This swap has never been highlighted, and as such, Maxwell's displacement current transferred into the early twentieth century literation as a concept related to capacitors and transmission lines, but in order to derive the electromagnetic wave equations, we need to use the inductive form that is compatible with Faraday's law.

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https://www.researchgate.net/publication/355361120_Maxwell%27s_Displacement_Current_in_the_Two_Gauges

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