



## Displacement Current Dilemma



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### Abstract:

Again the question arises: Does displacement current generate a magnetic field as required by Maxwell's Equations?

This paper will show two arguments against the magnetic field contribution of the displacement current. To be clear, we do not dispute the displacement current since displacement current is simply a euphemism for capacitive coupling. We only contend that the displacement current itself can not contribute a magnetic field component.

The first argument turns inside-out the "Thought experiment" that Maxwell used to infer the magnetic contribution of displacement-current. This argument utilizes conceptual/logical reasoning (no mathematics) to show that the "thought experiment" can be construed to suggest that a dipole antenna operating at resonance has no net magnetic field.

The second argument is a mathematically rigorous derivation which shows that Maxwell's equation  $\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$  predicts twice as much magnetic field strength for a current distribution than what is normally measured.

Ultimately, it is shown that the uniform plane wave as proposed by Maxwell is not a tenable solution to explaining electromagnetic radiation through free space. We have included the New Electromagnetism transverse dipole equations in Appendix A of this article.

Displacement Current Dilemma



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# 1 Maxwell's Dilemma

The two arguments contained in this article are separated into two sections

Section 1.1 Maxwell's thought experiment

Section 1.2 "Two much" flux

## 1.1 Maxwell's thought experiment

Though this is not as rigorous as the second argument, it does demonstrate the fragility of thought experiments. It shows that it is possible to make the outcome say what ever you want it to say. Maxwell used a "Thought Experiment" to infer that displacement current can induce a magnetic field. We use the same thought experiment to suggest that this can not be so.

Maxwell derived the displacement current term from a simple circuit "thought experiment" as shown in Figure 1-1.

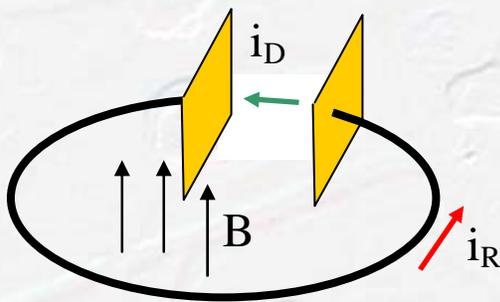


Figure 1-1: The simple LC circuit

The circuit is a single loop of wire (like a single turn loop inductor) split with a capacitor (two capacitive plates).

From basic circuit analysis we know that when a "real" current ( $i_R$ ) is induced in the loop, it will cause charges to effectively "displace" across the plates. This is where the term displacement current comes from. Thus, the term displacement current is simply a euphemism for capacitive coupling.

Because the current coupled through the capacitor must equal the current in the loop, then the displacement current must equal the real current or:

$$1) i_D = i_R$$



In Figure 1-1, and the rest of this document, the displacement current is shown as a single arrow for simplicity. In reality, the current entering the plates distributes across the plates as shown (in a bit more detail) in Figure 1-2. It is important to remember that current is conserved; the amount of real current entering a plate must equal the displacement current across the plates.

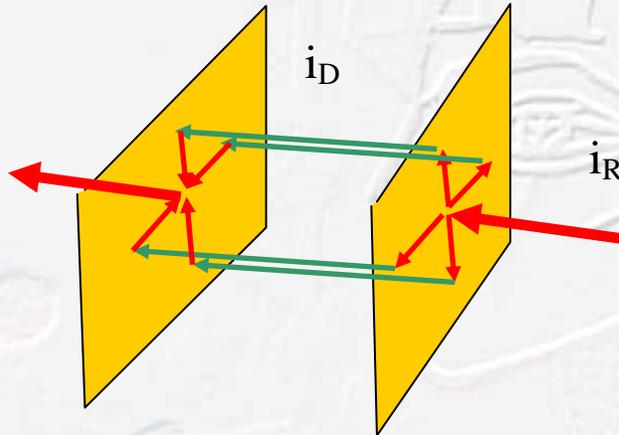


Figure 1-2: Close up of displacement current in capacitor

The nice result of this displacement current idea is that no matter how you bisect the loop (see Figure 1-3) with a plane, the net amount of current (real or displacement) passing through the plane is zero ( $i_D + i_R = 0$ ). This conservation of current holds even if the loop is being excited by a time varying current with a wavelength much smaller than the loop.

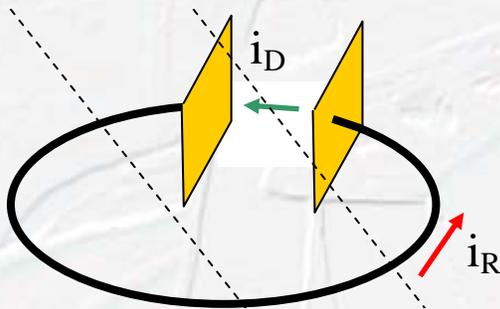


Figure 1-3: Bisections

So the displacement current concept is excellent, and consistent with nodal analysis of ac circuits.

Let us return to the question at hand. Does the displacement current itself generate a magnetic field?



Maxwell reasoned that if the real current contributes magnetic field, then so must the displacement current. Furthermore, the displacement current and real current contribute equally (on a per unit length basis) to the magnetic field about the loop.

Maxwell then takes this concept and correctly forms it into the point equation that we know and love which is:

$$2) \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

Someone may ask why the displacement current term ( $\frac{\partial \mathbf{D}}{\partial t}$ ) is a differential and not a zero order term like the J term. This is simply due to the fact that the current through a capacitor is a time derivative of the voltage across the plates ( $i_D = -C \frac{dv}{dt}$ ); for those who want more details on how Figure 1-1 is transformed into step 2, please see any good text book on the subject.

### 1.1.1 Along comes Distinti

Continuing from Figure 1-1; suppose we were to straiten out the loop as follows:

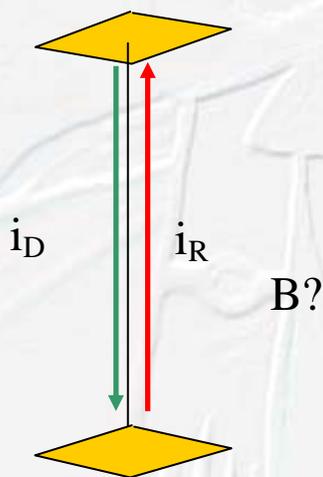


Figure 1-4: unrolled loop



Before you say anything, let us also reshape the capacitive plates into long thin cones (like radio elements). The elements are driven at the base of the cones (not at the apex).

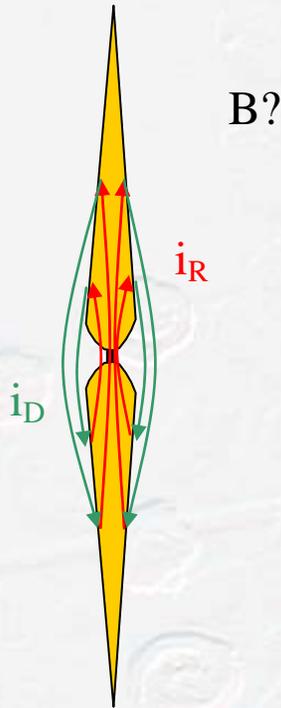


Figure 1-5: Dipole with current flows

When radiating, we alternately pull charges from one side of the dipole and deposit them on the other side. This is only possible because of the capacitive coupling between the two halves of the dipole. If there were no capacitive coupling between the two halves, it would not be possible to induce charge motion between the radiators. This benefit of capacitive coupling is well known to radio engineers.

The displacement current (through the capacitive coupling) must be equal and opposite to the real current induced in the elements as shown diagrammatically in Figure 1-5. Therefore, no matter how we slice the dipole with a plane, the total amount of current (real + displacement) passing through the plane at any instant must equal zero.

Since the real current is moving in one direction and the displacement current is moving in the other at any given instant, then shouldn't the total magnetic field equal zero at any given instant?



If a changing electric field (the displacement current) generates a magnetic field, then antennas should fail to radiate according to Maxwell's equations; since for every real current, there is a retrograding displacement current. To see how New Electromagnetism resolves this paradox see Appendix A.

If you want more "Thought Experiment Olympics" then see what we do to Einstein's Principle of Equivalence in the free paper New Gravity.

## 1.2 "Two much" flux

In this section we derive the total magnetic flux about a moving charge to show that Maxwell's equations predict too much flux by a factor of two; or "two much".

Consider a charge moving through space as shown in Figure 1-6

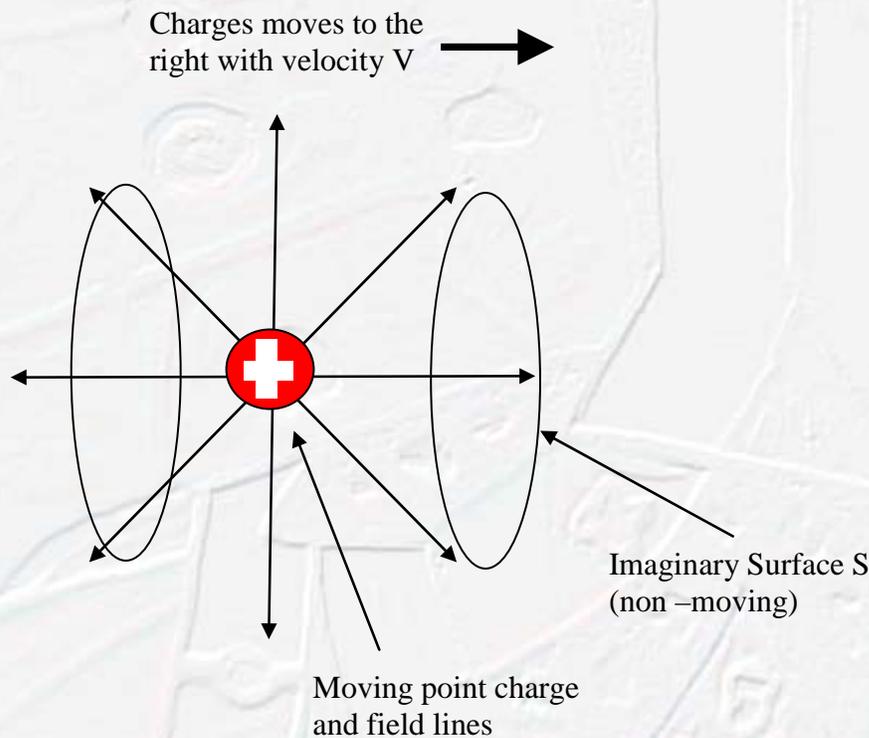


Figure 1-6: Moving charge

We already know that a moving charge will generate a magnetic field about itself due to the real charge. What about the displacement current? According to Maxwell's Equation, the magnetic field strength at the



perimeter of an imaginary area is the summation of both the charge passing through the area and the displacement current effects. This is stated clearly in the following well known equation:

$$1) \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

Since the  $\mathbf{J}$  term is easily calculated from Biot-Savart (see section 1.2.2 for more details) then what about the displacement current term?

From a conceptual standpoint we conclude that the displacement current term must also contribute a quantity of flux. If we were to place an imaginary surface ( $S$ ) in front of the moving charge, then as the charge moves toward it, the concentration of the electric-flux passing through the surface increases. Since the  $d\mathbf{D}/dt$  is positive and the direction of  $\mathbf{D}$  is to the right, then an  $\mathbf{H}$  field is created that will curl as shown in the following diagram. Next, if we were to place another imaginary surface behind the charge, then as the charge moves away from it, the concentration of electric flux lines through the surface decreases. The result is a negative  $d\mathbf{D}/dt$ ; however, since the direction of  $\mathbf{D}$  is to the left then the direction of magnetic curl turns out to be in the same direction as the previous case.

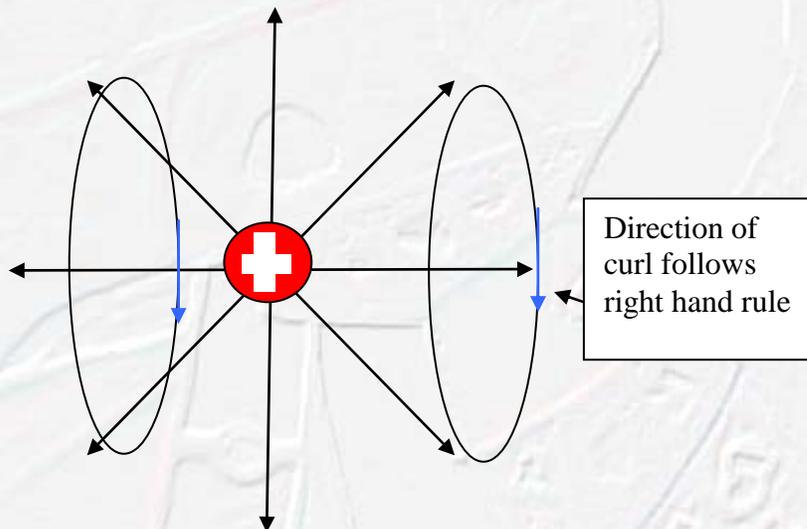


Figure 1-7: The Displacement magnetic field

With this in mind we next derive the general expression for displacement current induced magnetic field about a point charge moving through space.



## 1.2.1 Derivation of Displacement magnetic field about a point charge

In this section we derive the general expression for the magnetic field ( $B$ ) of a charge ( $Q$ ) due to the displacement current term of Maxwell's equation. We start with:

$$2) \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}$$

The following diagram shows the parameters used in the derivation.

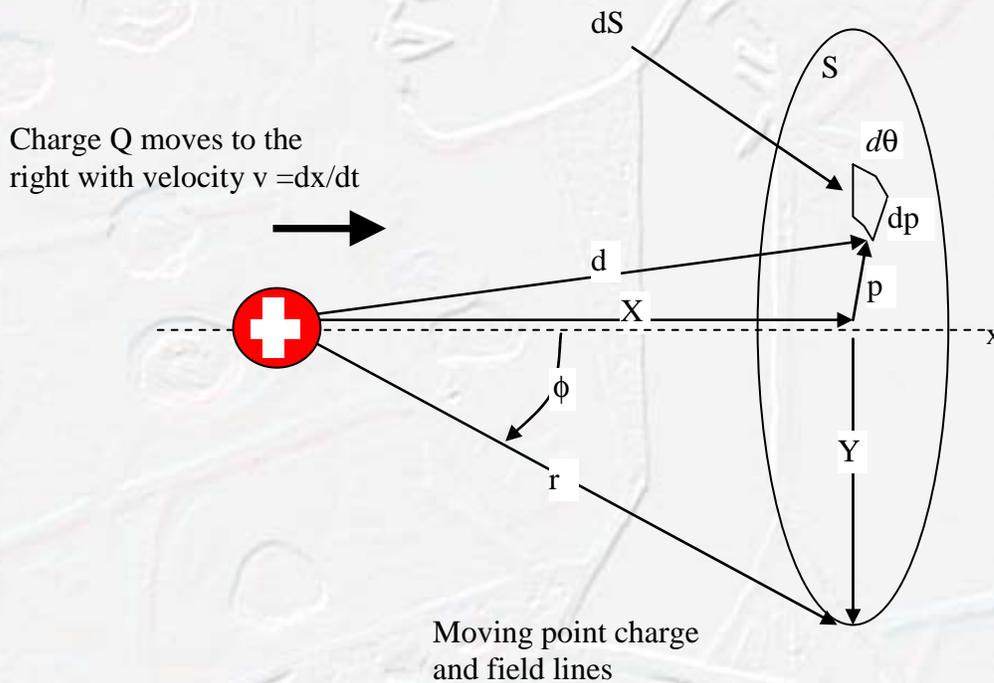


Figure 1-8: The variables used to parameterize the problem

Note: Lower case  $x$  is the  $x$ -axis and upper case  $X$  is the  $X$  component of distance from the charge to  $S$ .  $Y$  is the radius of  $S$ . The variables  $d$  and  $p$  parameterize  $dS$ .

Start by integrating both sides of step 2 over the surface of  $S$ .

$$3) \int_s (\nabla \times \mathbf{H}) \cdot d\mathbf{S} = \int_s \frac{\partial \mathbf{D}}{\partial t} \cdot d\mathbf{S}$$

Then applying Stoke's Theorem



$$4) \oint_L \mathbf{H} \cdot d\mathbf{L} = \int_S \frac{\partial \mathbf{D}}{\partial t} \cdot d\mathbf{S} \quad (\text{L is the perimeter of S})$$

Since  $\frac{d\Phi_E}{dt} = \int_S \frac{\partial \mathbf{D}}{\partial t} \cdot d\mathbf{S}$  then

$$5) \frac{d\Phi_E}{dt} = \oint_L \mathbf{H} \cdot d\mathbf{L}$$

Since H is perfectly uniform around L then

$$6) \frac{d\Phi_E}{dt} = HL \quad \text{Then}$$

$$7) B = \frac{\mu}{L} \frac{d\Phi_E}{dt} \quad \text{Since } L = 2\pi Y \quad \text{Then}$$

$$8) B = \frac{\mu}{2\pi Y} \frac{d\Phi_E}{dt}$$

Put step 8 aside for the moment. Next, develop an expression for the electric flux lines passing through S as a function of time.

Start with the well known Coulomb's Law in E form

$$9) \mathbf{E} = \frac{Q\hat{\mathbf{d}}}{2\pi\epsilon|\mathbf{d}|^2} \quad \text{Then}$$

$$10) \mathbf{D} = \frac{Q\hat{\mathbf{d}}}{2\pi|\mathbf{d}|^2} \quad \text{Since } \Phi_E = \int_S \mathbf{D} \cdot d\mathbf{S} \quad \text{then}$$

$$11) \Phi_E = \frac{Q}{4\pi} \int_{p=0}^Y \int_{\theta=0}^{2\pi} \frac{pd\theta dp}{(X^2 + p^2)} \hat{\mathbf{d}} \cdot \hat{\mathbf{x}}$$



$\hat{d} \cdot \hat{x}$  is the cosine of the angle between  $d$  and  $x$  which is identical to  $\frac{X}{d}$  or

$$\hat{d} \cdot \hat{x} = \frac{X}{\sqrt{X^2 + p^2}} \quad \text{thus}$$

$$12) \Phi_E = \frac{Q}{4\pi} \int_{p=0}^Y \int_{\theta=0}^{2\pi} \frac{Xpd\theta dp}{(X^2 + p^2)^{3/2}}$$

Integrate with respect to theta

$$13) \Phi_E = \frac{QX}{2} \int_{p=0}^Y \frac{pdp}{(X^2 + p^2)^{3/2}} \quad \text{Then integrate with respect to } p$$

$$14) \Phi_E = \frac{Q}{2} \left[ 1 - \frac{X}{\sqrt{X^2 + Y^2}} \right]$$

Now find the electric flux change as a function of  $X$ . This is done by differentiating both sides with respect to  $X$ .

$$15) \frac{d\Phi_E}{dX} = \frac{Q}{2} \left[ \frac{X^2}{\sqrt{(X^2 + Y^2)^3}} - \frac{1}{\sqrt{X^2 + Y^2}} \right]$$

The above equation is the electric flux change as a function of the distance ( $X$ ) between the charge and  $S$ . If the charge were moving to the right with velocity  $v$ , then the distance between the charge and  $S$  will be decreasing ( $-dX/dt$ ); thus, using the chain rule of differential calculus we get

$$16) \frac{d\Phi_E}{dt} = \frac{d\Phi_E}{dX} \frac{dX}{dt} = \frac{Qv}{2} \left[ \frac{1}{\sqrt{X^2 + Y^2}} - \frac{X^2}{\sqrt{(X^2 + Y^2)^3}} \right]$$

Now substitute step 16 into step 8 and to get

$$17) B = \frac{\mu}{2\pi Y} \frac{Qv}{2} \left[ \frac{1}{\sqrt{X^2 + Y^2}} - \frac{X^2}{\sqrt{(X^2 + Y^2)^3}} \right]$$



Recognizing the following

$$a) |\mathbf{r}| = \sqrt{X^2 + Y^2}$$

$$b) \sin(\phi) = \frac{Y}{\sqrt{X^2 + Y^2}}$$

$$c) \cos(\phi) = \frac{X}{\sqrt{X^2 + Y^2}}$$

$$d) Y = |\mathbf{r}| \sin(\phi)$$

Substitute a-d accordingly into 17

$$18) B = \frac{\mu}{2\pi|\mathbf{r}|} \frac{Qv}{2|\mathbf{r}|} [1 - \cos^2 \phi] \text{ Reducing and converting yields}$$

$$19) B = \frac{\mu Qv}{4\pi|\mathbf{r}|^2} [\sin \phi]$$

From basic vector calculus  $\hat{\mathbf{v}} \times \hat{\mathbf{r}} = \hat{\mathbf{n}} \sin \phi$  (where  $\hat{\mathbf{n}}$  is a normal unit direction vector to  $\mathbf{v}$  and  $\mathbf{r}$ ). Substitute to get

$$20) B\hat{\mathbf{n}} = \frac{\mu Q\mathbf{v} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

Since  $B$ , by definition, is normal to  $(\mathbf{v} \times \mathbf{r})$  then we can simply write

$$21) \mathbf{B} = \frac{\mu Q\mathbf{v} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

To make sure we do not confuse this derivation from others, apply the subscript  $D$  to signify that this magnetic field is from the displacement effects.

$$\mathbf{B}_D = \frac{\mu Q\mathbf{v} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

**Equation 1: Displacement magnetic field of moving charge**

We will discuss the ramifications of this derivation in a moment.



In the next section we perform another quick derivation to give us something to compare to Equation 1.

### 1.2.2 The real magnetic field of a moving charge

The real magnetic field of a moving charge is determined from Biot-Savart

$$1) d\mathbf{B}_R = \frac{\mu d\mathbf{L} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

Realize that

$$Id\mathbf{L} = \frac{dq}{dt} d\mathbf{L} = dq \frac{d\mathbf{L}}{dt} = dq\mathbf{v} \text{ (For } \mathbf{v} \text{ and } d\mathbf{L} \text{ in same direction)}$$

Then substitute to arrive at

$$2) d\mathbf{B}_R = \frac{\mu dq\mathbf{v} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

Integrate both sides with respect to dq to arrive at

$$\mathbf{B}_R = \frac{\mu Q\mathbf{v} \times \hat{\mathbf{r}}}{4\pi|\mathbf{r}|^2}$$

Equation 2: Real Magnetic field of moving charge

### 1.2.3 What does it mean?

According to Maxwell, a magnetic field is created by the summation of the real current and the displacement effects

$$1) \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

This correlates to

$$2) \mathbf{B}_{total} = \mathbf{B}_R + \mathbf{B}_D \text{ (for charges moving through space)}$$



or

$$3) \mathbf{B}_{total} = \frac{\mu Q \mathbf{v} \times \hat{\mathbf{r}}}{4\pi |\mathbf{r}|^2} + \frac{\mu Q \mathbf{v} \times \hat{\mathbf{r}}}{4\pi |\mathbf{r}|^2} = \frac{\mu Q \mathbf{v} \times \hat{\mathbf{r}}}{2\pi |\mathbf{r}|^2}$$

This means that a charge moving through space emits twice the magnetic field strength than is generally accepted.

This also means that current in a wire should produce twice the magnetic field strength than is normally attributed to Biot-Savart. I know there is someone who will claim (from knowledge of basic electricity) that there is no net electric field inside a good conductor and therefore Maxwell is saved; however, just because the NET electric field is zero does not mean that that  $\frac{\partial \mathbf{D}}{\partial t} = 0$ . This is easily proven by the following diagram:

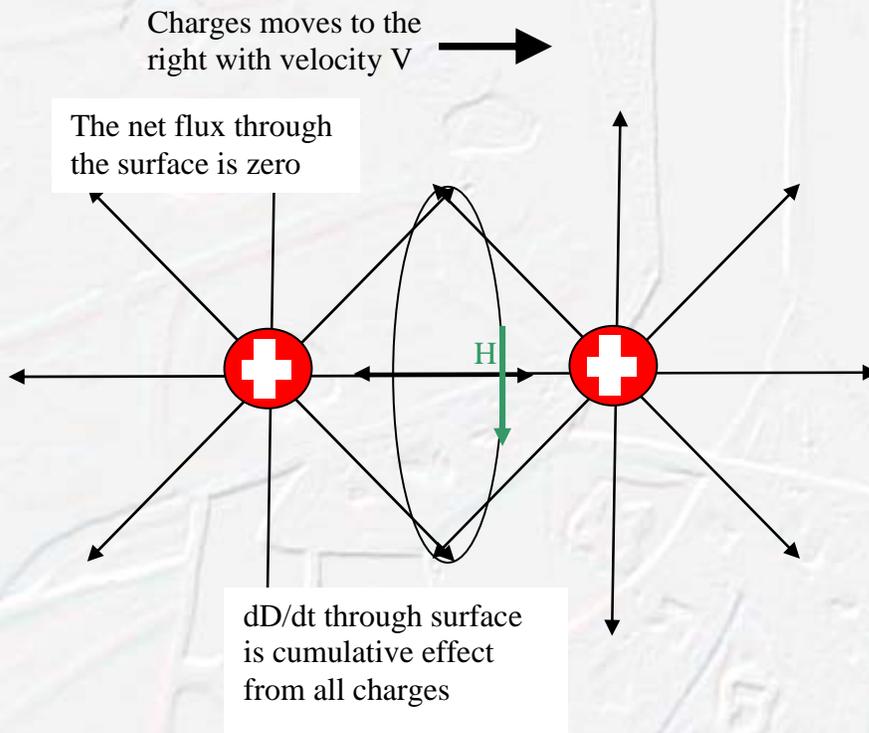


Figure 1-9: dD/dT is not zero even if D is.

If you did not quite follow the above, then take a closer look at the discussion around Figure 1-7.



Since we can not have twice the magnetic field emanating from wires containing real currents, then we must drop the displacement current term from Maxwell's equations. Thus

$$4) \nabla \times \mathbf{H} = \mathbf{J}$$

Or perhaps we compromise and suggest

$$5) \nabla \times \mathbf{H} = \frac{1}{2} \mathbf{J} + \frac{1}{2} \frac{\partial \mathbf{D}}{\partial t}$$

This compromise does not allow us to save Maxwell's Plane wave equation.

The only wave to save the plane wave equation is to suggest that

$$6) \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}$$

The equation in step 6 can only be true if  $\mathbf{D}$  is sourced by a conservative electric field. The only known source of a conservative electric field is a charge.

The  $\mathbf{E}$  field in the other Maxwell Equation (see step 7 below) is not a conservative electric field.

$$7) \nabla \times \mathbf{E}_M = -\frac{\partial \mathbf{B}}{\partial t}$$

If the left side of 7 were a conservative electric field then it would violate Kirchoff's Law ( $\nabla \times \mathbf{E} = 0$ ). The  $\mathbf{E}$  field in step 7 is not compatible to the  $\mathbf{D}$  field of 6 (many free papers on this topic at [www.distinti.com](http://www.distinti.com)).

By specifying a magnetic field in terms of  $\mathbf{D}$  might inadvertently give someone the false idea that charge is not required to convert an electric field to a magnetic field and vice versa. Therefore, we prefer to use the form that reminds us of this fact.

$$8) \nabla \times \mathbf{H} = \mathbf{J}$$

The preferred form?



Unfortunately step 8 is wrong because it says that there is only a magnetic field when the charge actually passes through the surface. We have shown that a circulation ( $\mathbf{H}$ ) about  $S$  will occur as the charge is approaching and as the charge leaves (it is true with  $\mathbf{B}_D$  therefore it must be true with  $\mathbf{B}_R$ ). When we look back into our electromagnetism text books we find that  $\nabla \times \mathbf{H} = \mathbf{J}$  is based on Ampere's circuital law which is inferred from an infinitely long current source. Am I the only engineer that "howls at the moon" when he sees a "point equation" which is only valid for an infinitely long current distribution? Thus, the equation in step 8 is only a good approximation under certain conditions (conditions which are never specified in any text book).

The wise thing to do is to completely toss out  $\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$  and just say that a magnetic field is  $\mathbf{B}_R = \frac{\mu Q \mathbf{v} \times \hat{\mathbf{r}}}{4\pi |\mathbf{r}|^2}$  or  $\mathbf{H} = \frac{Q \mathbf{v} \times \hat{\mathbf{r}}}{4\pi |\mathbf{r}|^2}$ .

According to New Electromagnetism; these equations are only valid for closed loop systems.

These changes start a snowball effect throughout classical electromagnetic theory.



## 2 Conclusion

Electromagnetism begins and ends with charges. This is written into the very definitions of the “fields” that we use:

E is a force per CHARGE field

H is AMPERE per meter field.

B and D are only different from the above by constants.

Each of these fields is created by forcing charges to behave a certain way. Each of these fields is measured by observing the behavior of charges caught within.

How space is disturbed by charges to create these fields and how fast these effects propagate through space is the big question. The only thing that is known for sure is that electric fields store potential energy and magnetic fields store kinetic energy (see New Induction ni.pdf). Without the presence of charge, it is impossible to convert one into the other. This is analogous to shooting a bullet into the sky of an airless planet. At the muzzle, the bullet will have kinetic energy. At a later point in time this kinetic energy is converted into potential energy as the bullet attains maximum altitude before falling back. This conversion between kinetic and potential energy can not occur without the medium of the bullet. Consequently, all wave phenomena rely on the transfer of energy from one form into the other; however, this transformation can not occur without a medium such as string or water. In an electric tank circuit (RLC), energy is alternately converted between kinetic energy (magnetic field) and potential energy (electric field); however, this occurs only because there are charges present to do this. Consequently, Maxwell’s Uniform Plane Wave Equation (UPWE) was inferred from an electric tank circuit in which a medium of charges exists to allow the conversion between fields.

The UPWE is not valid for free space unless we conclude that free space contains a charge distribution. This could be the case; however, let us assume for the moment that it isn’t. If there are no charges in space, then how does light propagate? We know that a charge can affect another distant charge through an electric or magnetic field. So why not suggest that light is either a purely electric or magnetic disturbance. Since New Induction is only an inverse law (not Inverse Square) its effects travel farther than other



New Electromagnetic effects; therefore, it is the most likely candidate for explaining electromagnetic radiation. A dipole derivation based on New Induction is included in appendix A.

It was suggested by someone that New Electromagnetism does not account for the propagation time of field effects; this is true, however, this is not different than the classical models. In both we assume that the propagation of field effects is the speed of light. This propagation is bolted onto the classical model in the form of retarded time techniques and this is the same technique we have adopted for New Electromagnetism. This retarded time technique is the same used in the derivation of the Schrödinger's Wave Equation.

I close by proposing a question to the reader: The Transverse Dipole Equation (Found in Appendix A) can be rigorously derived from  $F=QV \times B$ ; though the derivation is much more complicated than the New Induction method, it yields identical results. Therefore, if it is possible to show dipole to dipole coupling as a purely magnetic occurrence (just like the coupling between primary and secondary of a transformer) using accepted classical equations, then this coupling must exist along with the accepted Uniform Plane Wave Effects (if that is correct). Can anyone propose a simple test to verify if either or both are correct? If there can only be one correct way in which energy can couple between dipoles (far field) then how do we know which one is correct? Can they both be correct? (Me thinks not).

Note: Longitudinal dipole effects can not be derived from  $F=Qv \times B$  since classical theory is based upon a transverse only magnetic field model. We are sure that the transverse only field model is incorrect because it predicts strange effects that are not observed in the lab. These effects and the rigorous mathematical proof are found in chapter 10 of New Magnetism (which you can download for free from our site).



## Appendix A. The New Electromagnetism Dipole equation (transverse only)

The following is an excerpt from the book NIA1 found at Distinti.com. The derivation assumes that magnetic field effects travel at the speed of light.

The Book NIA1 contains a more general version of the Dipole Equation that predicts longitudinal, transverse and phase/distance effects.

Inserted comments are in blue.

\*\*\*\*\* Beginning of excerpt\*\*\*\*\*

In this section we use  $\frac{di}{dt} = -2\pi f I_0 \sin(2\pi ft) \cos\left(\frac{y\pi}{2L}\right)$  for  $L = \frac{\lambda}{4} = \frac{C}{4f}$

(which is a current source model similar to others found in antenna theory texts) to determine the  $V_K$  (emf) receive by another dipole (the target) which is parallel to the source and located along the transverse axis as show in Figure 2-1.

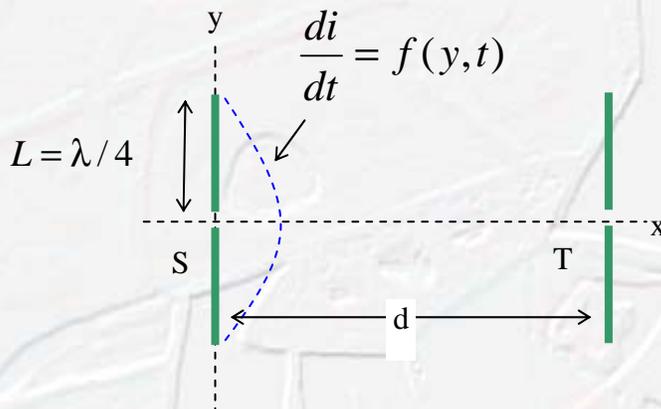


Figure 2-1

We start with the wire fragment form of the IEL:

$$1) V_K = -K_M \int_S \int_T \left( \frac{dI_S}{dt} \right) \frac{d\mathbf{L}_S \cdot d\mathbf{L}_T}{|\mathbf{r}|}$$



Since the target is parallel and sufficiently far away, the effect felt by the target is going to be substantially uniform over its length; therefore, we simplify the problem as follows:

$$2) V_K = \frac{-2K_M L}{d} \int_s \left( \frac{dI_s}{dt} \right) dL_s$$

We can also assume that the propagation delay from each source fragment to each target fragment is substantially the same; therefore we use the version of the source current model without retarded effects to model the current in the source since it does not account for propagation delay.

$$3) V_K = \frac{2K_M L}{d} 2\pi f I_0 \sin(2\pi f t) \int_{y=-L}^{+L} \cos\left(\frac{y\pi}{2L}\right) dy$$

Then perform the integration

$$4) V_K = \frac{8K_M L^2}{d} f I_0 \sin(2\pi f t) \left[ \sin\left(\frac{\pi}{2}\right) - \sin\left(\frac{-\pi}{2}\right) \right]$$

$$5) V_K = \frac{16K_M L^2 f}{d} I_0 \sin(2\pi f t)$$

Since the radiators operate in the quarter wave mode, substitute  $L = \frac{\lambda}{4} = \frac{C}{4f}$

and

$$V_K = \frac{K_M C^2}{fd} I_0 \sin(2\pi f t) \text{ (for half-wave dipoles only)}$$

**Equation 2-1: Traverse Dipole Equation**

\*\*\*\*\* End of excerpt\*\*\*\*\*

Note: The above equation is the emf induced in the receiver antenna. Because the antenna is a tuned circuit, the actual output of the antenna will be affected by the “Q-rise” of the antenna.



Unlike Maxwell's uniform plane wave equation, the New Induction derivation shows that radio waves are inversely affected by both frequency and distance. The Book NIA1 also shows that longitudinal components of propagation also exist. You will also notice that the Equation 2-1 is a purely magnetic phenomenon.

More important is the fact that we did not once use a "FIELD" abstraction. If you think about it, all FIELDS are created by forcing charges to behave a certain way and all FIELDS are measured by observing the behavior of charges contained within. Flux lines are no more real than the borders on a map.

Since we can accurately measure how one charge affects another through the medium of space then why do we waste time with field abstractions? It is OK to say fields exist and that fields are some manifestation or disturbance of space; however, to give this phenomenon a vector variable and pretend that we actually understand it just from the electromagnetic equations alone is really naive. To really understand what space is and what fields really are, we need to decide what the correct models of electromagnetism are (New Electromagnetism or Maxwell's Equations). Then we need to consider all other "FIELD" phenomenon which manifests themselves as "disturbances" of this same medium (such as gravity). Then and only then might we be in a position to venture a reasonable guess. Our publication New Gravity proposes a new model for the old concept of the Ether which yields some very interesting results.

The NIA1 publication goes into great detail about parasitic elements and inductive reflection from conductive surfaces. It also has experimental data to verify the predictions along with software and other supplements.