Failure of Electrodynamics Laws and Atomic Model Due to Non-existence of Magnetic Field

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Abstract

This article addresses several key issues with the current laws of electrodynamics, including Lorentz's law, Faraday's law, and the Maxwell-Ampère law, by highlighting various scenarios where these laws fail to describe physical phenomena. It also presents a case where the condition $\nabla \cdot \vec{B} \neq 0$ occurs, challenging the standard belief that magnetic fields always have zero divergence. The article argues that magnetic fields, as traditionally understood, do not actually exist. Instead, effects thought to be caused by magnetic fields are simply due to electric fields (no need to include special theory of relativity). A new concept introduced in the article is the "drag property of the electric field," a previously unknown characteristic that creates the illusion of a magnetic field. Using this drag property, the article derives a set of revised electrodynamic laws that consistently apply across all situations. Additionally, it addresses the failure of the traditional atomic model and suggests a new approach. The article also challenges the idea that space is empty, proposing that space is filled with something rather than being a true vacuum. This research offers a fresh perspective on both electromagnetic theory and the nature of space.

[**General note:** *Please note that I am not a professional in research writing, so there may be some errors. I appreciate your understanding.*
• *If you don't have enough time to read, just read the sec-3.1, 3.2, 4.1 and 6; these are sufficient to justify the article's title and theme of the entire paper.]*

1 Introduction

The relation between electric field and magnetic field is given by Maxwell's third and fourth equation as

$$\nabla \times \vec{E} = -\frac{d\vec{B}}{dt} \tag{1}$$

$$\nabla \times \vec{B} = \mu \vec{J} + \mu\epsilon \frac{d\vec{E}}{dt} \tag{2}$$

But we have another set of equation which also relates the electric and magnetic field known as field transformation equation , given by [1][2]

$$\vec{E} = \vec{B} \times \vec{v}_B \tag{3}$$

$$\vec{B} = \mu\epsilon\,(\vec{v}_E \times \vec{E}) \tag{4}$$

where v_B and v_E represents the velocity of magnetic field and electric field respectively.
Using this equation-4 and principle of superposition of field, we can calculate magnetic field produced due to any shape of current carrying wire.

1.1 Finding magnetic field due to a current carrying straight wire using field transformation equation

The principle of superposition states that at every point, fields due to all different sources live in superposition, and the net field at that point is the vector sum of all the different fields present there. This means that if there is a null point near a system of charge, it doesn't mean that no field is present there i.e., a null point can't be treated as field-free space. It only signifies that the net electric field is zero, but the fields are still present there.
Taking the case of current carrying wire, let (λ_r, E_r, v_r) and (λ_m, E_m, v_m) are the linear charge

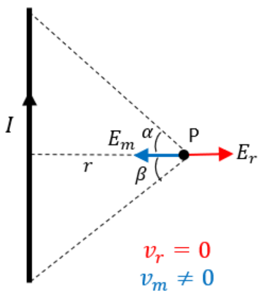


Figure 1: A Current carrying wire

density, electric field and the speed of corresponding rest charge and moving charge respectively. Here, wire is neutral, so $\lambda_r + \lambda_m = 0$ and $\vec{E}_r + \vec{E}_m = 0$.

E_r and E_m live in superposition. When the free electrons move, the field associated with it also moves (with the same speed), while the field of rest charge remains at rest ($v_r = 0$).

Using the field transformation equation 4, we can obtain the magnetic field of surrounding region as

$$
\begin{aligned}
\vec{B}_{net} &= \mu\epsilon \sum \vec{v}_i \times \vec{E}_i \\
&= \mu\epsilon\,(\cancelto{0}{\vec{v}_r} \times \vec{E}_r) + \mu\epsilon\,(\vec{v}_m \times \vec{E}_m) \\
&= \mu\epsilon\,\vec{v}_m \times (\vec{E}_{m\parallel} + \vec{E}_{m\perp})
\end{aligned}
$$

(where $\vec{E}_{m\parallel}$ and $\vec{E}_{m\perp}$ are the parallel and perpendicular components of $\vec{E}_m$ w.r.t. the wire (direction of motion of electron) and $\hat{n}$ is a unit vector along $\vec{v}_m \times \vec{E}_{m\perp}$.)

$$
\begin{aligned}
&= \mu\epsilon\, v_m E_{m\perp}\ \hat{n} \qquad\qquad (\because \vec{v}_m \times \vec{E}_{m\parallel} = 0) \\
&= \mu\epsilon\, v_m \frac{\lambda_m}{4\pi\epsilon r}\,(\sin\alpha + \sin\beta)\ \hat{n} \\
&= \frac{\mu I}{4\pi r}\,(\sin\alpha + \sin\beta)\ \hat{n} \qquad (I = \lambda_m v_m)
\end{aligned}
$$

1.2 Deriving Biot-Savart law using field transformation equation

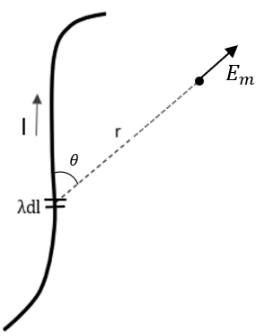


Figure 2: A curved current carrying wire

We can also derive Biot-Savart law using the same concept (principle of superposition and field transformation equation 4).

Suppose dE_m is the electric field due to the moving elemental charge $\lambda_m dl$ (free electrons) at point p at distance r

$$dE_m = \frac{\lambda_m dl}{4\pi\epsilon\, r^2}$$

The magnetic field (dB) produced at point P due to this moving electric field will be

$$
\begin{aligned}
d\vec{B}_P &= \mu\epsilon\,\vec{v}_m \times d\vec{E}_m = \mu\epsilon\, v_m\ dE_m \sin\theta\ \hat{n} \\
&\quad (\text{where } \hat{n} \text{ is unit vector along } \hat{v}_m \times \hat{E}_{m\perp}) \\
&= \mu\epsilon\, v_m \frac{\lambda_m dl}{4\pi\epsilon\, r^2} \sin\theta\ \ \hat{n} \\
&= \frac{\mu}{4\pi}\ \frac{I\ dl}{r^2}\ \sin\theta\ \ \hat{n} \qquad\qquad (I = \lambda_m v_m) \\
&= \frac{\mu}{4\pi}\ \frac{I\ d\vec{l} \times \hat{r}}{r^2}
\end{aligned}
$$

2 Categorization of field

Before proceeding, we need to categorize the field on the basis of their source and their dependence on observer as below

2.1 Primary and secondary fields

On the basis of source of fields, it can be classified into two categories:

1. Primary field

This type of field is created by source charge (electric charge or magnetic charge). It initiates from the source and terminates at infinity. When a charge of opposite nature comes near it, it does not terminate or bend there because fields from different sources live in superposition, without affecting each other. In field line representation, we draw the paths along net electric field or magnetic field, but not along the individual fields and so it seems like that field line is terminating or bending in presence of external charge which is not actually true (as if field lines really bends then any charge $+q_1$ can't apply any force on a charge $+q_2$, if there is any third charge $+q_3$ in between them, which is against the principle of superposition of charge).

It is a conservative type of field and its field line follows a straight path (curl is zero).

Example: Electric field produced by charges $\vec{E} = kq/r^2\hat{r}$, $(\oint \vec{E}_p \cdot d\vec{l} = 0)$

2. Secondary field

This type of field does not incur any source charge. It is always created by some another fields (called parent field or producer field). Its field line can be straight, circular or any type of curve depending upon, how it is produced. It is non-conservative in nature.
Example: Magnetic field produced by moving electric charge or electric field ($\vec{B} = \vec{v} \times \vec{E}$), electric field produced by moving magnet or magnetic field ($\vec{E} = \mu\epsilon\, \vec{B} \times \vec{v}$).

Let us denote primary electric field as $\vec{E}_p$ and secondary electric field as $\vec{E}_s$.

Gauss law: This law states that $\nabla \cdot \vec{E} = \frac{\rho}{\epsilon}$ but the electric field mentioned here can't be secondary electric field as this law deals with the fields of electric charges i.e., primary electric field. Hence, the actual representation of this law will be

$$\nabla \cdot \vec{E}_p = \frac{\rho}{\epsilon} \tag{5}$$

2.2 Absolute and non-absolute field

On the basis of dependence of field on the observer, it can be classified into two types.
(1) Absolute field and (2) non-absolute field

1. Non-absolute field
It is an observer-dependent field. The magnetic field produced by moving charge is a non-absolute magnetic field as it depends on the velocity of charge w.r.t. the observer given by $\vec{B} = \frac{\mu}{4\pi}\frac{q\vec{v} \times \hat{r}}{r^2}$, where $\vec{v}$ is the velocity of q w.r.t. observer [3].

2. Absolute field
This type of field does not depend on the observer. Its magnitude remains the same for each and every observer, whether it is at rest or motion (we are not including special theory of relativity here). The electric field produced by charges or the magnetic field produced by current-carrying wires are the examples of absolute magnetic field.
Note:- The magnetic field produced by moving charge is a non-absolute field, but the magnetic field produced by moving charges of a neutral medium (current-carrying wire, sheet or any conducting neutral medium) is absolute field or observer-independent in nature which can be seen mathematically also as below .
Consider the case of current-carrying wire, where λ_r and λ_m are moving with velocity $\vec{v}_r$ and $\vec{v}_m$ respectively w.r.t. any observer S. The total magnetic field that would be produced by these moving charge system in its surrounding space will be

$$\begin{aligned}
\vec{B} &= \mu\epsilon\,(\vec{v}_m \times \vec{E}_m) + \mu\epsilon\,(\vec{v}_r \times \vec{E}_r) \\
&= \mu\epsilon\,\frac{\lambda_m v_m}{2\pi\epsilon\, r}\,\hat{n} + \mu\epsilon\,\frac{\lambda_r v_r}{2\pi\epsilon\, r}\,\hat{n} \\
&= \frac{\mu(\lambda_m v_m + \lambda_r v_r)}{2\pi\epsilon\, r}\,\hat{n} \\
&= \frac{\mu I}{2\pi r}\,\hat{n}
\end{aligned}$$

($\because I = \lambda_m v_m + \lambda_r v_r = \lambda_m v_m - \lambda_m v_r = \lambda_m(v_m - v_r)$)

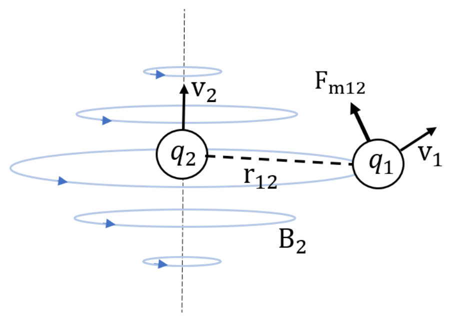
It is not containing any observer-dependent parameter, and hence, it is an absolute field which remains the same for every frame of reference.

3 Failure of Lorentz Law

The magnetic force $\vec{F}_{m12}$ on a charge q_1 due to an another charge q_2, moving with velocity $\vec{v}_1$ and $\vec{v}_2$ respectively (w.r.t. any observer S) is given as [4]

$$\vec{F}_{m12} = q_1\vec{v}_1 \times \vec{B}_2 = \frac{\mu}{4\pi}\frac{q_1 q_2}{r^2}\left[\vec{v}_1 \times (\vec{v}_2 \times \hat{r}_{12})\right] \tag{6}$$

where r is the distance between the charges, $\vec{B}_2$ is the magnetic field field produced by the moving charge q_2 (at the position of q_1) and $\hat{r}_{12}$ is a unit vector from q_2 to q_1.



Proof :

$$\left[\begin{aligned}
\vec{F}_{m12} &= q_1\vec{v}_1 \times \vec{B}_2 = q_1\vec{v}_1 \times \left(\frac{\mu}{4\pi}\frac{q_2\vec{v}_2 \times \hat{r}_{12}}{r^2}\right) \\
&= \frac{\mu}{4\pi}\frac{q_1 q_2}{r^2}\left[\vec{v}_1 \times (\vec{v}_2 \times \hat{r}_{12})\right] \\
\text{OR,} &= \mu\epsilon\, q_1 E_2\left[\vec{v}_1 \times (\vec{v}_2 \times \hat{r}_{12})\right]
\end{aligned}\right]$$

However, there is a problem in this equation as this force is depending on the velocity of charges w.r.t. the observer. This seems paradoxical because it supports that a zero force in one frame can be non-zero in some other frame or vice versa, which is not possible.
An observer cannot know if the system is moving or not, but it can always know about the system's

acceleration (whether the observer is inside or outside the system) because acceleration is absolute. Hence, **if a system experiences zero force in any one frame, it will be zero in all the other frames as well, as it's acceleration will be zero for all the frame**.
However, the above equation doesn't support this. Here are a few situations that clearly prove this equation to be wrong.

3.1 Charges moving with the same velocity don't experience or apply any magnetic force on each other

Suppose two charges (q_1 and q_2) are fixed across a nonconducting rod and two observers S and S' are there. S is at rest, and S' is moving with velocity $-\vec{v}$ at angle θ (w.r.t. the system) as shown in Fig. 3.
In the S frame, this charge system is stable as there is no torque in this system. Its stability is not depending on the observer S' or the value of θ. Also there isn't any magnetic force on the charges q_1 and q_2 as no magnetic field is present in this frame.

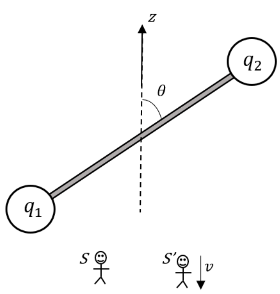


Figure 3: Two charge system (stationary) w.r.t. S

But for S', these charges are moving with velocity $\vec{v}$ (fig-4) and so producing magnetic field. In this figure 4, the magnetic field produced by charges q_1 (at the position of q_2) and q_2 (at the position of q_1) will be respectively

$$\vec{B}_{q_1} = \frac{\mu}{4\pi}\frac{q_1\vec{v}\times\hat{r}_{21}}{r^2} = \frac{\mu}{4\pi}\frac{q_1 v}{r^2}\sin\theta \otimes$$
$$\vec{B}_{q_2} = \frac{\mu}{4\pi}\frac{q_2\vec{v}\times\hat{r}_{12}}{r^2} = \frac{\mu}{4\pi}\frac{q_2 v}{r^2}\sin\theta \odot$$

where r is the distance between the charges, $\hat{r}_{21}$ and $\hat{r}_{12}$ are the unit vectors from q_1 to q_2 and q_2 to q_1 respectively. Nevertheless, charges are moving, the electric field will be in the radial direction [5], and so the electric force on both charges will be along the rod, i.e., $F_{e12} = F_{e21}$ (toward each other, along the rod).
But, because of the magnetic field, the magnetic force on charge q_1 due to q_2 ($\vec{F}_{m12}$) and on q_2 due to q_1 ($\vec{F}_{m21}$) will be (applying Lorentz law):

$$\vec{F}_{m12} = q_1\vec{v}\times\vec{B}_{q_2} = \frac{\mu}{4\pi}\frac{q_1 q_2\, v^2}{r^2}\sin\theta\ \ \hat{a}_x$$
$$\vec{F}_{m21} = q_2\vec{v}\times\vec{B}_{q_1} = \frac{\mu}{4\pi}\frac{q_1 q_2\, v^2}{r^2}\sin\theta\ \ (-\hat{a}_x)$$

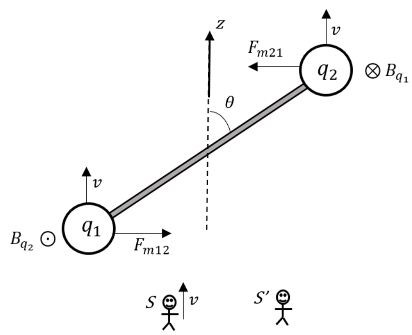


Figure 4: Two charge system (moving) w.r.t. S'

Same result we will get, if we apply equation-6 directly.
So in the frame of S', there is a net torque in this system, and hence it should rotate anticlockwise (clockwise if q_1 and q_2 are of opposite polarity) to align itself along z-axis (or along the $\vec{v}$).
This experiment is sufficient to proves that equation 6 is wrong as it is giving different result for the same experiment when observed from different frames which is not possible as the laws of physics are the same in all inertial frames of reference that are moving at a constant velocity.
The Lorentz law is also failing here as the magnetic force ($\vec{F}_m = q\vec{v}\times\vec{B}$) on the charges q_1 and q_2 in S frame is zero while in the S' frame, it is non-zero.

The question arise here is, (i) will this moving charge-pair (or any two charge moving with same velocity as shown in fig-4) rotate or not due to the presence of a magnetic force? (ii) will there be any magnetic force on these moving charges q_1 and q_2?
If it rotates, then it means that a stationary charge pair should also rotate (fig-3) as it is also moving w.r.t. some other observer, which can't be true as (i) it will violates the law of conservation of energy; (ii) the magnitude of torque and the final stable position of this system will be unpredictable (For S, this charge pair is stable for all value of θ while for S', it is stable only for $\theta = 0^o$ and 90^o) as there can be more than one observer at a time. So, the solution of this experiment is that it will not rotate at all.
This proves that charges moving with the same

velocity do not experience or apply any magnetic force on each other, regardless of the observer or the value of θ (fig-4); otherwise, for some observer (like S), it will be violation of law of physics (rotation without having any rotating force or torque).

One interesting question arise here is: how do two identical current-carrying wires (velocity of electrons in both wires is the same) attract each other if the magnetic force between two moving charges moving with the same velocity is zero? (actual explanation is mentioned in sec 5.3)
Note that its explanation using the concept of stationary magnetic field (present understanding) is not correct as the concept of stationary magnetic field itself is wrong (mentioned in sec-6.4).

Modification in Lorentz force equation

The Lorentz law states that the total force on a charge moving in an electromagnetic field ($\vec{E}+\vec{B}$) is given as

$$\vec{F_q} = q\vec{E} + q\vec{v}_q \times \vec{B} \tag{7}$$

Here, the electric field can be either a primary electric field, a secondary electric field, or both. Similarly, the magnetic field can be both, but the primary magnetic field doesn't exist, and hence it is always the secondary magnetic field ($\vec{B}$). So, it can be written as

$$\begin{aligned}\vec{F_q} &= q(\vec{E}_p + \vec{E}_s) + q\vec{v}_q \times \vec{B} \\ &= q(\vec{E}_p + \vec{B} \times \vec{v}_B) + q\vec{v}_q \times \vec{B} \\ &= q\vec{E}_p - q(\vec{v}_B \times \vec{B}) + q\vec{v}_q \times \vec{B} \\ &= q\vec{E}_p + q(\vec{v}_q - \vec{v}_B) \times \vec{B} \\ &= q\vec{E}_p + q\vec{v}_{q,B} \times \vec{B}\end{aligned} \tag{8}$$

Here, the velocity of charge is not w.r.t the observer, but it is w.r.t the magnetic field.

EMF in a coil, moving with a magnet

A magnet always creates a circular electric field (secondary) around itself, whenever it moves, given by equation 3 i.e., $\vec{E}_s = \vec{B} \times \vec{v}_B$.
Suppose a coil is moving with a magnet as shown in figure 5.
Due to the secondary electric field, there should be a current in the coil because of the induction of EMF in the coil due to $\vec{E}_s$ as

$$\mathcal{E}_{loop} = \oint \vec{E}_s \cdot \vec{dl} = \oint (\vec{B} \times \vec{v}_B) \cdot \vec{dl} \tag{9}$$

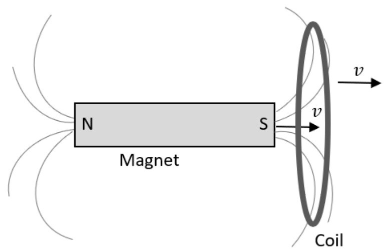


Figure 5: Magnet-coil system

But consider the same case from the magnet frame. In this case, both the coil and magnet are stationary, and so no EMF or current is there (Faraday experiment), violating the previous case. So it proves that the previous equation of EMF is not true.
The actual equation of $\mathcal{E}_{loop}$ can be find using equation 8 (modified Lorentz force equation) as

$$\begin{aligned}\mathcal{E} &= \frac{\int \vec{F_q} \cdot \vec{dl}}{q} = \frac{\int (q\vec{E}_p + q\vec{v}_{q,B} \times \vec{B}) \cdot \vec{dl}}{q} \\ &= \int \vec{E}_p \cdot \vec{dl} + \int (\vec{v}_{q,B} \times \vec{B}) \cdot \vec{dl}\end{aligned}$$

For a closed loop, it will become

$$\begin{aligned}\mathcal{E}_{loop} &= \oint \cancelto{0}{\vec{E}_p \cdot \vec{dl}} + \oint (\vec{v}_{q,B} \times \vec{B}) \cdot \vec{dl} \\ &= \oint (\vec{v}_{q,B} \times \vec{B}) \cdot \vec{dl} \qquad (10) \\ \text{OR ,} \quad &= \oint (\vec{B} \times \vec{v}_{B,q}) \cdot \vec{dl}\end{aligned}$$

So, $\mathcal{E}_{loop}$ is not depending on the velocity of the magnetic field or coil, but depending on the relative velocity between the magnetic field and coil.
In the above case, $v_{q,B} = 0$, and hence, $\mathcal{E}_{loop} = 0$ i,e no matter from which frame, it is observed, it will be same for all.
This explains why the same EMF induces in a coil when
(i) The coil is stationary and a magnet passes through it, OR
(ii) The magnet is stationary and a coil passes through it.
However, according to many physicists, these EMFs are getting induced through a totally different mechanism and came out to be the same because there is some deep connection between these two situations. But the above derived equation of $\mathcal{E}_{loop}$ (equation-10) could be the simplest explanation of this.

A magnetic field always moves along with its producer charge

Section 3.1 proved that the magnetic force between two moving charge having the same velocity is zero. It is possible only if $v_{q,B} = 0$, otherwise not, as in that case $v_{q,B} \neq 0 \Rightarrow F_m \neq 0$. This means that "magnetic fields always move along with the producer charge".
So using this concept and equation 8 , equation 6 can be modified as

$$\vec{F}_{m12} = q_1\vec{v}_{12} \times \vec{B}_2 = \frac{\mu}{4\pi}\frac{q_1q_2}{r^2}\left[\vec{v}_{12} \times (\vec{v}_2 \times \hat{r}_{12})\right] \tag{11}$$

But this equation also fails in multiple cases. Few of then is mentioned below.

3.2 Two charges, approaching each other

We have a system as shown in fig-6, where two non-conducting rod (R_1 and R_2) is there, placed in a line. The first rod have two uncharged beads (b_1 and b_2) while the other have two charged beads (b_3 and b_4) having charge q and $-q$ respectively. Beads are free to slide over the rod.
Here, b_3 and b_4 are moving toward each other under electrostatic attraction (let their velocities are $u\,\hat{a}_x$ and $-u\,\hat{a}_x$ respectively (take the direction from left to right of the page as x-axis and bottom to top as z-axis)) while the uncharged beads b_1 and b_2 are stationary.

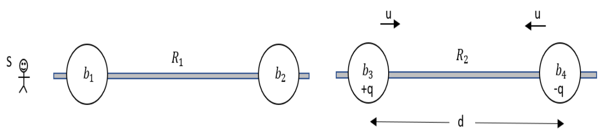


Figure 6: Two approaching charges w.r.t. S

For observer S (system frame), beads b_3 and b_4 will simply collide with each other (let the collision is completely inelastic) and the position of rod R_1 and R_2 will remain same before and after the collision i.e., the motion of charges will not affect the position of rods.
However, does the situation remain the same for S' (moving with velocity $-\vec{v}$ w.r.t the system (we will use this two observer S and S' in this entire paper, so if not mentioned, just assume it))? NO!. For S', charges are moving (with velocity $v\,\hat{z}$) and so magnetic field comes into play and changes the situation.
In this case (fig-7), the magnetic field produced by the charged bead b_3 (at the position of b_4) and b_4 (at the position of b_3) will be respectively

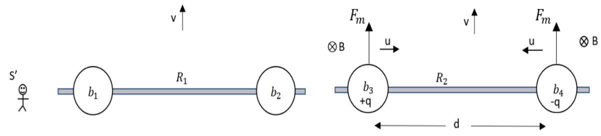


Figure 7: Two approaching charge w.r.t. S'

$$\vec{B}_{b_3} = \frac{\mu}{4\pi}\frac{q(\vec{v}+\vec{u}) \times \hat{r}_{b_4b_3}}{d^2} = \frac{\mu}{4\pi}\frac{qv}{d^2} \otimes$$
$$\vec{B}_{b_4} = \frac{\mu}{4\pi}\frac{-q(\vec{v}-\vec{u}) \times \hat{r}_{b_3b_4}}{d^2} = \frac{\mu}{4\pi}\frac{qv}{d^2} \otimes$$

where $\hat{r}_{b_4b_3}$ and $\hat{r}_{b_3b_4}$ are the unit vectors from b_3 to b_4 and b_4 to b_3 respectively.
On applying the modified Lorentz force equation (equation-8) and the concept that magnetic field always moves along with its producer charge, the magnetic force on the beads b_3 and b_4 will be respectively

$$\begin{aligned}\vec{F}_{m,b_3} &= q\,\vec{v}_{(q,B_{b_4})} \times \vec{B}_{b_4} = q\,(2\vec{u}) \times \vec{B}_{b_4} \\ &= -\frac{\mu}{2\pi}\frac{q^2vu}{d^2}\hat{z} \\ \vec{F}_{m,b_4} &= -q\,\vec{v}_{(-q,B_{b_3})} \times \vec{B}_{b_3} = q\,(-2\vec{u}) \times \vec{B}_{b_3} \\ &= -\frac{\mu}{2\pi}\frac{q^2vu}{d^2}\hat{z}\end{aligned}$$

In another way, we can directly use the equation-11 and we will get the same result i.e., the magnetic forces on the beads b_3 and b_4 will be

$$\vec{F}_{m,b_3} = \vec{F}_{m,b_4} = -\frac{\mu}{2\pi}\frac{q^2vu}{d^2}\hat{z}$$

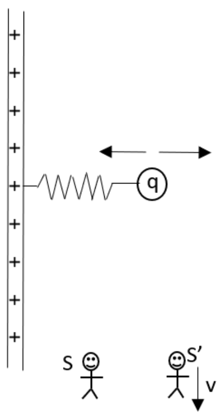
This force on b_3 and b_4 came in the same direction (in the direction of $\vec{v}$). So for S', the rod R_2 will gain some velocity (after the collision) because of the magnetic force, which implies that position of rods will not remain the same after the collision of charges, irrespective of what we observe in the S frame. So, this proves that modified equation (equation 11) also fails as here it is predicting different result for different observer.

Now the same question arises here: which one is true, i.e., will the rod R_2 move or not?
We can clearly say that it will not move at all, as if it moves, then
(i) what will be the direction of motion and the magnitude of final velocity of rod R_2 as there can be more than one observer like S' at a time (having different velocities in different directions)? For each observer, the direction of this magnetic

force will be opposite to $\vec{v}$ (measured w.r.t. that observer), and so the direction of the net magnetic force will become unpredictable (indeterminate). Also the magnitude of this force depends on the observer, i.e., if larger is the velocity of observer w.r.t. the system, larger will be the magnetic force and so the final velocity of rod R_2 (w.r.t the observer or R_1) which is not possible as observers can't affect any system or decide the final velocity of R_2.
(ii) there must be a such responsible force in the S frame also, which isn't;
(iii) it violates Newton's third law as the action and reaction force on charges comes in the same direction ($\vec{F}_{m,b_3} = \vec{F}_{m,b_4}$).
So, the solution of this experiment is that the rod R_2 will move at all (w.r.t R_1), and the conclusion is that two charges moving toward each other, do not experience or apply any magnetic force on each other, no matter from which frame it is getting observed.

A few more cases where equation-11 fails are: -

- A charge is connected to a line charge through a non-conducting spring, as shown in the figure, which is oscillating perpendicularly to it. For S, this oscillation is simple to and fro motion of charge.



But for the S' frame, this charge system is moving (with speed v), and so producing magnetic field in its surrounding region which mean that this oscillation is not as simple as seems in S frame (for S') because now there is an additional force (magnetic force), perpendicular to the direction of oscillation. In addition, the direction of this force changes whenever the charge changes its direction of motion (at extreme positions).
So, this equation-11 is predicting different result for the different observer which is not possible.
- Consider a hydrogen atom having a revolving electron. For S (stationary observer), the orbit of atom is circular. But for the S' frame (moving away from the atom, in the plane of electron's orbits), this orbit becomes elliptical as now there is a magnetic force (use equation 11) due to the magnetic field produced by the moving nucleus. But, it is not possible because the shape of orbit can't be affected by an observer.

It again proves that equation 11 is not always true. It is limited to some fixed cases. Therefore, we need to find a formula that can handle each and every case.

4 Failure of Faraday law

4.1 EMF in a coil, moving toward a current-carrying wire

Suppose we have a wire carrying current I, and a rectangular coil is moving toward it with velocity $v_c\,\hat{i}$ as shown in figure 8(a). The total magnetic fux inside the coil will be

$$\Phi_B = \int \vec{B}\cdot d\vec{A} = \int \frac{\mu I}{2\pi r}\,ldr$$

Due to the motion of the coil, this magnetic flux inside the coil changes and it leads to the induction of an EMF inside it as given by Faraday law

$$\begin{aligned}\mathcal{E} &= -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left(\int \frac{\mu I}{2\pi r}\,ldr\right)\\ &= -\frac{\mu I l}{2\pi}\int_{r_1}^{r_2}\frac{d}{dt}\left(\frac{dr}{r}\right) = \frac{\mu I v_c l}{2\pi}\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\\ &= B_1 v_c l - B_2 v_c l \qquad (12)\end{aligned}$$

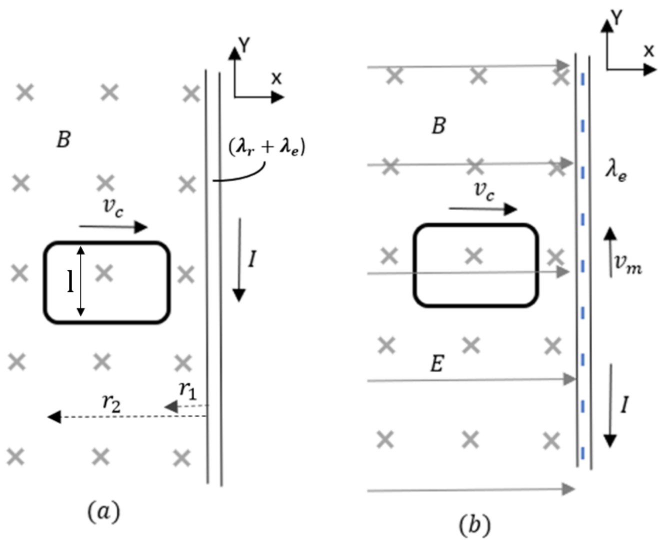


Figure 8: (a) A coil is moving in magnetic field (b) A coil is moving in electric+magnetic field

In this situation (fig-8(a)), λ_r and λ_e of the neutral wire is at rest and motion respectively (velocity of $\lambda_e = v_m\,\hat{j}$, $I = \lambda_e v_m$). The magnetic field that is increasing inside the coil is produced only due to λ_e (as $v_r = 0$). There is no contribution of λ_r in it. So, if we remove λ_r from this system, still the same EMF will induce in the coil as the surrounding magnetic field will still remain the same (primary electric field will not affect this EMF as $\oint \vec{E}_p \cdot \vec{dl} = 0$).

Case-1: Suppose we removed λ_r and left with the system as shown in figure 8(b). EMF induced in the coil will be same as the previous equation 12 i.e.,

$$\mathcal{E} = \frac{\mu \lambda_e v_m v_c l}{2\pi} \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \tag{13}$$

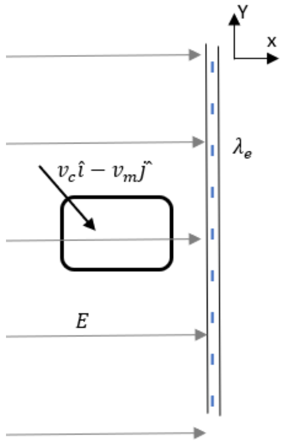


Figure 9: A coil is moving in a stationary electric field

Now study the same case from the λ_e frame (figure 9). In this frame, there is a stationary electric field with zero magnetic field in the space, and a coil is moving in it with velocity $v_c\hat{\imath} - v_m\hat{\jmath}$. If we apply Faraday's law here, then the EMF inside the coil should be zero as no magnetic field is there in this frame, i.e.,

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = 0$$

Even the primary electric field present here can't induce any EMF in the coil as it is a conservative field.
But the EMF is inducing ($\mathcal{E}_{coil} \neq 0$) as this situation is nothing other than figure 8(b), but how? Sometimes, special theory of relativity is used to fix the problems of electrodynamics. But here, this theory also can't explain the above situation. It proves that (i) Faraday law fails in case of non-absolute magnetic field as it gives observer dependent value for the EMF which is not possible
(ii) it is something other than magnetic field which leads to the induction of EMF as there is no magnetic field is λ_e frame (fig-9), but still $\mathcal{E}_{coil} \neq 0$.

Case-2: Now suppose we remove λ_e from the system (figure 8(a)), keeping everything the same as shown in figure 10(a). In this case, the EMF in the coil will be zero as no magnetic field is there. But study the scenario from S' frame (moving with velocity $v\,\hat{\jmath}$). For it, there is a magnetic field $B = \frac{\mu \lambda_r v}{2\pi r}$ in the surrounding region and so, a non-zero EMF should be there in the coil as the magnetic flux is increasing inside the coil. This EMF can be calculated using Faraday law as

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = \frac{\mu \lambda_r v v_c l}{2\pi} \left(\frac{1}{r_1} - \frac{1}{r_2} \right) = B_1 v_c l - B_2 v_c l \tag{14}$$

which again proves the Faraday's law to be inefficient as it is predicting different results for different observer.

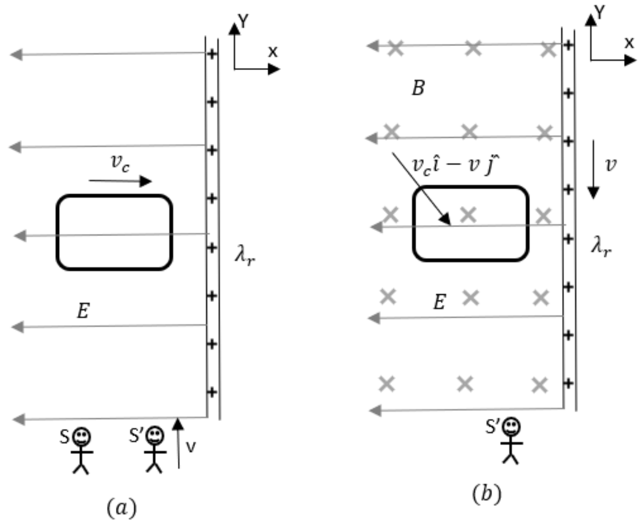


Figure 10: (a) A coil is moving in an electric field (b) A coil is moving in a electric+magnetic field

If we apply the concept of motional EMF with equation $\vec{F}_q = q\vec{v}_q \times \vec{B}$ or $q\vec{v}_{q,B} \times \vec{B}$, it also fails because for S, $\mathcal{E} = 0$ while for S', $\mathcal{E} \neq 0$ (even there is relative motion between the coil and magnetic field, having net increasing magnetic flux inside).

Note that if EMF get induces in S', then (i) there must be a such source of EMF in S frame also which isn't (ii) its magnitude and direction of induction will be unpredictable (indeterminate) as the observer S' can have any velocity i,e if $v = +ve \Rightarrow \mathcal{E} = +ve$, $v = -ve \Rightarrow \mathcal{E} = -ve$ and $v = 0 \Rightarrow \mathcal{E} = 0$ which is not possible as a system can't be affected by an observer's state. So, it proves that no EMF will be induced in the figure 10(b), but how is it possible as there is a net increasing magnetic flux inside the coil in S' frame?

Solution is mentioned in the section-5.5 by introducing a new property of an electric field field which is still untouched from us (Drag property).

4.2 Charge-coil system

Suppose there is a coil (having a bulb) and a charge placed in free space such that the charge is residing outside the coil, as shown in figure 11(a). There is an observer who is observing this system.
Initially, the observer was at rest w.r.t. the system and observed zero current in it because no current source was present. Then, the observer accelerates to velocity $\vec{v}$.

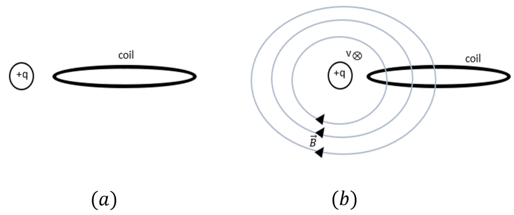


Figure 11: Charge-coil system

After achieving this velocity, he finds that there is a magnetic field inside the coil (fig-11(b)), which is not produced suddenly but increased gradually from zero to B during the acceleration of the observer.
So, the question is, was there current in the coil, or did the bulb glow during the acceleration of the observer because $\dfrac{d\Phi_B}{dt}$ was non-zero during the acceleration?
The answer is no! because acceleration of the observer cannot affect the system. There can be multiple observers at a time where one can be at rest while the other at acceleration, but for all, the system will show the same result as the events are frame-independent. So, Faraday law again failed here.
Note that the production of magnetic field by a charge is a relative phenomenon, which means that to get magnetic field, it is not necessary or the only option is to move the charge, but the observer can also move to obtain the magnetic field. If a charge has some velocity with respect to the observer, it will have a magnetic field, no matter which one is accelerated to create this relative velocity.

4.3 Capacitor and a moving coil

We have a charged parallel-plate capacitor and a coil is moving inside it, as shown in figure 12. In

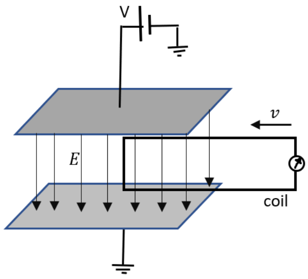


Figure 12: Capacitor - coil system

the coil frame, there is a increasing magnetic flux inside the coil as the electric field of the moving capacitor produces magnetic field $\vec{B} = \mu\epsilon\,\vec{v} \times \vec{E}$ and so a current should induce in the coil, given by

$$I = \frac{\mathcal{E}}{R} = \frac{1}{R}\frac{d\Phi_B}{dt} = \frac{\mu\epsilon\ v^2 El}{R} \tag{15}$$

But study the same case from the capacitor frame and apply the Faraday law. In this case, no magnetic field is present, and so $\dfrac{d\Phi}{dt} = 0$ implies current should not be induced in the coil.
So, which one is true? It also proves that the Faraday law is either wrong or incomplete.
These all experiments proved that our knowledge about electrodynamics is not sufficient to handle every situation, as these laws (Lorentz law and Faraday law) fail in the case of a non-absolute magnetic field. These laws are limited to absolute magnetic only, and the reason is that these laws are experimental laws, i.e., developed from experiments where absolute magnetic field is used (magnetic field due to current-carrying wire, permanent magnet, etc.). Hence, these laws are not the evergreen laws that can handle each and every situation of electrodynamics. But we can find that evergreen law using the concepts of electric drag force, law of conservation of energy, and Newton's third law.

5 Electric drag force [Beyond the Known: Introducing a New Property of Electric Fields in Scientific Research]

In figure 10(b), there is motion of a coil in magnetic field (having increasing magnetic flux) but no EMF induces in it, while in figure 9, no magnetic field is there but still EMF induces in the coil. It happens because the extra force, or non-coulombic force, which we are calling as magnetic force, doesn't arise from a magnetic field but rather arises due to the relative drag of charge in a primary electric field called electric drag force.

Electric drag force: Whenever a charge drags in a primary electric field, i.e., it has some relative velocity w.r.t. the field in its $\perp$ direction, it experiences a force called electric drag force $\vec{F_d}$ (in addition with electric force $q\vec{E}$). This drag force sometimes appears as magnetic force; when observed from some specific frame, and seems like it is generated due to a magnetic field (we will see later).

Let's find the expression of this electric drag force using conservation of energy and Newton's third law.

Expression of electric drag force

Equation 6 is dimensionally correct for the non-coulombic force on charge, i.e., it is directly proportional to the charge q and electric field E, and so in fig-13 (q and q' are moving with velocities $\vec{v}_1$ and $\vec{v}_2$ respectively):

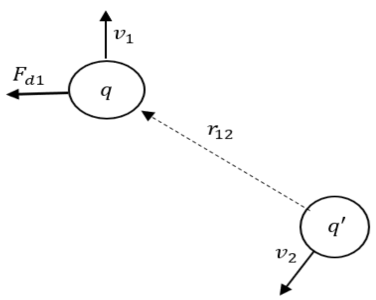


Figure 13: Two charge system

1) Drag force on q which is F_{d1} is proportional to q itself and the electric field $\vec{E}$ (due to q') .

2) Total energy (U) of the system is $U = P.E + K.E = constant$, and it will remain conserved as neither any external force is acting on this system nor any loss is happening (the only energy loss could be EM radiation, which we are neglecting here). So, $\dfrac{dU}{dt} = 0$. The drag forces acting on charges (F_{d1} on q and F_{d2} on q') are the internal forces for this system. Hence, net work done by these forces will be zero, i.e.,

$$W_{F_{d1}} + W_{F_{d2}} = 0$$

Taking derivative w.r.t time on both side, we get

$$\frac{d}{dt}W_{F_{d1}} + \frac{d}{dt}W_{F_{d2}} = 0 \;\Rightarrow\; \vec{F}_{d1}\cdot\vec{v}_1 + \vec{F}_{d2}\cdot\vec{v}_2 = 0$$

Applying Newton's third law, we get $\vec{F}_{d1} = -\vec{F}_{d2}$. So, the above equation can be written as

$$\vec{F}_{d1}\cdot\vec{v}_1 - \vec{F}_{d1}\cdot\vec{v}_2 = \vec{F}_{d1}\cdot(\vec{v}_1 - \vec{v}_2) = \vec{F}_{d1}\cdot\vec{v}_{12} = 0$$
$$\Rightarrow \vec{F}_{d1} \perp \vec{v}_r \ , \quad \text{(where } v_r \text{ is the relative speed)}$$

Similarly, $\vec{F}_{d2} \perp \vec{v}_r$

3) Drag force always lies in the plane of $\vec{v}_r \times \vec{E}$, as if we take any other direction out of this plane, it will violate Newton's third law.

Let the direction of drag force be along $a\,\hat{n} + b\,\hat{p}$ (where $\hat{n}$ is along $\vec{v}_r \times \vec{E}$ and $\hat{p}$ is any random unit vector in the plane $\vec{v}_r \times \vec{E}$ and a, b are the arbitrary constant).

For the situation shown in fig. 13, $\hat{n}$ for both $\vec{F}_{d1}$ and $\vec{F}_{d2}$ comes in the same direction (if q and q' are of the same nature), which proves that drag force can never go out of the plane of $\vec{v}_r \times \vec{E}$; otherwise, it will violate Newton's third law.

So, from (1), (2), and (3): -

A force proportional to q and $\vec{E}$, which is perpendicular to $\vec{v}_r$ and lying in the plane of $\vec{v}_r \times \vec{E}$, can be written as

$$\vec{F}_d = k\,q\,\Big(\vec{v}_r \times (\,\vec{v}_r \times \vec{E}\,)\Big) \tag{16}$$

where k is a constant. Replace this k with $a\,\mu\epsilon$, i.e.., ($k = a\,\mu\epsilon$), where a is another constant, we get

$$\vec{F}_d = a\ q\vec{v}_r \times \mu\epsilon(\,\vec{v}_r \times \vec{E}\,) \tag{17}$$

It is nearly the same as equation 6, but it is frame-independent.

This law is an evergreen law. It can handle all the situations of electrodynamics.

Property of electric field

- When a charge q is stationary in an electric field E, it experiences an electric force given by $\vec{F} = q\vec{E}$.
- But if the charge is not stationary w.r.t. the electric field, i.e., has some relative velocity v_r w.r.t. the electric field, it will experience an extra force along with the electric force, known as electric drag force, given by

$$\vec{F}_d = a\ qE\ \frac{v_r^2}{c^2}\sin\theta\ \hat{p} \tag{18}$$

where θ is the angle between $\vec{E}$ and $\vec{v}_r$ and $\hat{p}$ is a unit vector along $\vec{v}_r \times (\,\vec{v}_r \times \vec{E})$. This property can be called as drag property of electric field .

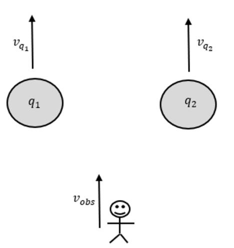
5.1 Explanations of all the failure mentioned before (using the concept of electric drag force)

(1) Sec-4.3 When the system is observed from S' frame, no magnetic field is there but still the EMF is induced because of the drag property of electric field. Due to motion of coil in the electric field, free electrons experiences electric drag force as given by equation-17, which cause generation of the $\mathcal{E}$, given by

$$\mathcal{E} = \frac{\oint \vec{F}_q \cdot \vec{dl}}{q} = a\mu\epsilon\, E v_r^2 l \qquad (19)$$

When it is observed from the S frame, this EMF remains the same as same drag is happening for S also. . But here, it seems like it is generated due to the motion of the coil in the magnetic field $\mu\epsilon\ \vec{v} \times \vec{E}$ as $\mathcal{E} = Bvl = \mu\epsilon\ Ev^2 l \quad , (v_r = v)$ which is not the actually true as it is good to S frame only. For S', concept of magnetic doesn't hold. It proves that magnetic force is nothing but the electric drag force. We will find the value of a later.
(2) Sec-4.2 In this case, the observer is accelerating, but the relative velocity between the electric field of charge and the coil is zero, hence no drag force generated, causing zero EMF. Until unless zero relative velocity is there, no EMF will be generated.
(3) Sec-3.1: There isn't any relative motion between the charges; hence, no magnetic force or electric drag force is there, no matter what the value of θ is.
(4) Sec-3.2 In this case, $\vec{v}_r \times \vec{E} = 0$ i.e., angle between $\vec{v}_r$ and $\vec{E}$ is zero. Hence, $\vec{F}_d$ or $\vec{F}_m = 0$.
(5) Sec-4.1: Mentioned at sec-5.5.

5.2 Two charge with different velocities



Take the situation as shown in the above figure, where q_1 and q_2 (both are of the same nature) and the observer S are moving with $\vec{v}_{q_1}$, $\vec{v}_{q_2}$, and $\vec{v}_{obs}$, respectively, in the same direction ($\vec{v}_{q_1} > \vec{v}_{q_2}$).
According to equation-6:
⇒ If ($v_{obs} < v_{q_2}$) or ($v_{obs} > v_{q_1}$), charges will attract each other magnetically because of their motion in the same direction.
⇒ If ($v_{q_1} < v_{obs} < v_{q_2}$), charges will repel each other magnetically as now they are moving in opposite direction w.r.t. the observer.
But it is not possible, as an observer can't affect any system.
According to equation-11:
⇒ If ($v_{obs} < v_{q_2}$) or ($v_{obs} > v_{q_1}$), the direction of magnetic force of both charges comes in the same direction (action-reaction force)
⇒ If ($v_{q_1} < v_{obs} < v_{q_2}$), the direction of magnetic force comes in the opposite direction.
So, these all proves that equations-6 and 11 are incomplete in themselves, as they are giving frame-dependent result, which is not possible.
According to electric drag force equation, the non-coulombic force (i.e., magnetic force) on the charges will be always equal, opposite and frame independent, which is given by equation-18 as

$$F_{m12} = F_{m21} = a\frac{\mu}{4\pi}\frac{q_1 q_2}{r^2}(v_1 - v_2)^2 \sin\theta \qquad (20)$$

Hence this is the actual equation of magnetic force (or the non-coulombic force) between two moving charges. In fig-4 , $v_r = 0$ while in fig-7 , $\theta = 0$, and hence in both the case, $\vec{F}_m = 0$. These situations can't be handled, if we consider the equations 6 and 11.
We can cross-check it using another thought experiment also as below.

5.2.1 Stationary charge also applies magnetic force to moving charges

In the above case, if $v_{obs} = v_{q_1}$ then according to both equations 6 and 11, $F_{m21} = 0$ and so if we replace this charge with a coil (moving with the same velocity), no EMF should be induced in the coil as there also, all the free electrons of the coil will experience zero magnetic force.
But study the same situation from the coil frame (fig-14(a) or 14(b)). In that case, observer will find that a charge is moving towards the coil, creating a net changing magnetic flux inside it and causing the generation of EMF.
The question here is, which one is true i,e will the EMF induce or not? If not, then it means that, a charge can never generate any EMF in a coil, whether it is at rest or at motion w.r.t the coil which mean that a current carrying also can't generate any EMF in a coil moving toward it (fig-8(b)), which is not true. Hence, it proves that EMF will be generated in that coil.
But, we can't handle this situation (in the charge frame) if we consider equation 6 or 11 i,e $F_{m21} = 0$.

The only solution is the electric drag force i.e., $F_{m21} \neq 0 \Rightarrow$ no matter what the velocity of charges are w.r.t. the observer, if there is relative motion between them, an electric drag force will arise between them (as given by equation-18). This drag force will cause the generation of EMF in the coil of fig-14(a) or 14(b) (see from the charge frame), given by

$$\mathcal{E} = \frac{1}{q} \oint_l \vec{F}_q \cdot d\vec{l} = a \oint_l \frac{v_r^2}{c^2} E \sin\theta \, dl$$

It is observer independent and remain same for every frame. For the observer of coil frame, this equation is equivalent to $\mathcal{E} = a\frac{d\Phi_B}{dt}$ while for charge frame, we don't have any option other than the concept of electric drag force.

So, it proves that a stationary charge also applies magnetic force (or electric drag force) on moving charges.

Modification of Electric drag force equation

Taking the angle between $\vec{v}_r$ and $\vec{E}$ as θ and $\mu\epsilon = 1/c^2$, equation-17 can be modified as

$$\begin{aligned}
\vec{F} &= a\ q\vec{v}_r \times \mu\epsilon(\,\vec{v}_r \times \vec{E}\,) \\
&= a\ qE\ \frac{v_r^2}{c^2}\ \Big(\hat{v}_r \times\ (\hat{v}_r \times \hat{E})\Big) \\
&= a\ qE\ \frac{v_r^2}{c^2}\ \Big((\hat{v}_r \cdot \hat{E})\,\hat{v}_r - (\hat{v}_r \cdot \hat{v}_r)\,\hat{E}\Big) \\
&= a\ qE\ \frac{v_r^2}{c^2}\ \Big(\cos\theta\ \hat{v}_r - \hat{E}\Big) \\
&= a\ qE\ \frac{v_r^2}{c^2}\ \Big(\cos\theta\ (\cos\theta\,\hat{E} + \sin\theta\hat{E}_\perp) - \hat{E}\Big) \\
&= a\ qE\ \frac{v_r^2}{c^2}\ \Big(-\sin^2\theta\,\hat{E}\ +\ \cos\theta\sin\theta\,\hat{E}_\perp\Big) \\
&= -\ aqE\,\frac{(v_r\sin\theta)^2}{c^2}\hat{E} + aqE\,\frac{(v_r\sin\theta\,.\,v_r\cos\theta)}{c^2}\hat{E}_\perp
\end{aligned}$$

$$\vec{F} = -aqE\ \frac{(v_{r\perp})^2}{c^2}\ \hat{E}\ \ +\ \ aqE\ \frac{(v_{r\perp}\ v_{r\parallel})}{c^2}\ \hat{E}_\perp$$

Hence $\vec{F} = a\vec{F}_{\parallel E} + a\vec{F}_{\perp E}$, where

$$\begin{aligned}
\vec{F}_{\parallel E} &= -\,qE\ \frac{(v_{r\perp})^2}{c^2}\ \hat{E}\ \ ,\quad (v_{r\perp} = v_r\sin\theta) \\
\vec{F}_{\perp E} &= \ qE\ \frac{(v_{r\perp}\ v_{r\parallel})}{c^2}\ \hat{E}_\perp\ \ ,\quad (v_{r\parallel} = v_r\cos\theta)
\end{aligned} \tag{21}$$

Here, $\parallel$ and $\perp$ are w.r.t. to electric field $\vec{E}$ i.e., $\vec{F}_{\parallel E}$ and $\vec{F}_{\perp E}$ represents the component of electric drag force along E and perpendicular to E while $v_{r\parallel}$ and $v_{r\perp}$ is the component of v_r (relative velocity) along E and perpendicular to E ($v_{r\parallel} \equiv v_{r,\parallel E}$ and $v_{r\perp} \equiv v_{r,\perp E}$). In the equation (above) of $\vec{F}_{\perp E}$, $\hat{E}_\perp$ represents the direction of $v_{r\perp}$ (or $v_{r,\perp E}$).

Note that the direction of an electric drag force on a charge in the direction of electric field i,e $F_{\parallel E}$ is independent of direction of velocity of charge (w.r.t E). We can also see it in the fig-14(a) and fig-14(b) where in first one, charge is moving toward the coil while in other, it is moving away from the coil, but still the EMF in both coil is induced in same direction (use the concept of motional EMF and $v_{q,B} = 0$) because the free electrons of both the coils are experiencing drag force (or magnetic force) in the same direction. It justify the above equation. These all are the cases of an ideal situation where charges are not under any external force, i.e., energy transfer to the charge-system is zero.

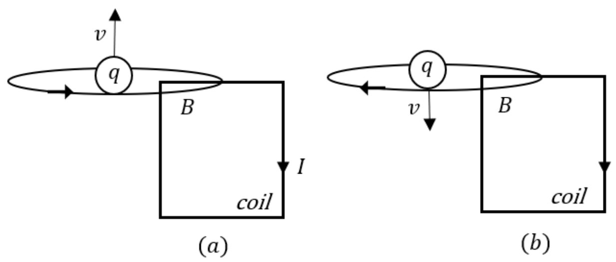


Figure 14: Charge coil system

But, in the case of a current-carrying wire, the situation changes slightly as an external supply of energy (battery) comes into the system, which continuously supplies (or extracts) energy to the circuit/system. So in these cases, equation 21 changes slightly to

$$\vec{F} = a\,\vec{F}_{\parallel E} + b\,\vec{F}_{\perp E} \quad ,\ (a \neq b) \tag{22}$$

because, now energy conservation equation of system can be written as (taking the battery also as the part of system)

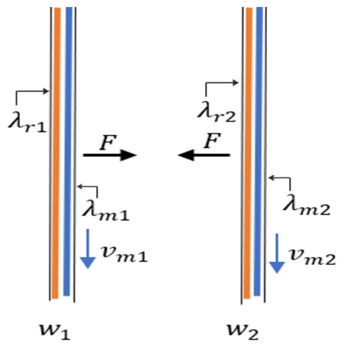
$$\begin{aligned}
&W_{F_{d1}} + W_{F_{d2}} + \Delta U_{battery} = 0 \\
&\Rightarrow\ \vec{F}_{d1}\cdot\vec{v}_1 + \vec{F}_{d2}\cdot\vec{v}_2 + \frac{d(U_{battery})}{dt} = 0
\end{aligned} \tag{23}$$

5.3 Force between two current-carrying wires (calculating using the concept of electric drag force)

Suppose we have two wires, w_1 and w_2, carrying currents I_1 and I_2. Using the concept electric drag force, we can calculate the magnetic force between them. Let λ_{m1}, λ_{m2}, λ_{r1} and λ_{r2} is linear charge density of moving charge (free electron) and rest charge of w_1 and w_2 respectively ($\lambda_{m1} + \lambda_{r1} = 0 = \lambda_{m2} + \lambda_{r2}$) having velocity $\vec{v}_{m1}$, $\vec{v}_{m2}$, 0 and 0. $\vec{E}_{m1}$ and $\vec{E}_{r1}$ is electric field due to λ_{m1} and λ_{r1} ($\vec{E}_{m1} + \vec{E}_{r1} = 0$).

Case-1: $(w_1 \parallel w_2)$

Lets calculate force on w_2 (for length=l) due to w_1 . Here, we have four relative velocities:
(1) between $\vec{E}_{r1}$ and λ_{m2}, which is $\vec{v}_{r1} - \vec{v}_{m2} = -\vec{v}_{m2}$
(2) between $\vec{E}_{r1}$ and λ_{r2}, which is $\vec{v}_{r1} - \vec{v}_{r2} = 0$
(3) between $\vec{E}_{m1}$ and λ_{r2}, which is $\vec{v}_{m1} - \vec{v}_{r2} = \vec{v}_{m1}$
(4) between $\vec{E}_{m1}$ and λ_{m2} which is $\vec{v}_{m1} - \vec{v}_{m2}$



These all velocities are perpendicular to the electric fields $\vec{E}_{m1}$, $\vec{E}_{r1}$, $\vec{E}_{m2}$, and $\vec{E}_{r2}$ and so $\vec{F}_{\perp E} = 0$ (as $v_{\parallel} = 0$) i.e., $\vec{F} = \Sigma \vec{F}_{\parallel E}$. Hence,

$$\vec{F} = -a \sum q\vec{E}\, \frac{(v_{r\perp})^2}{c^2}$$
$$= -a \left[\lambda_{m2} l\, \vec{E}_{r1}\, \frac{(-v_{m2})^2}{c^2} + \lambda_{r2} l\, \vec{E}_{r1}\, \frac{(0)^2}{c^2} + \lambda_{r2} l\, \vec{E}_{m1}\, \frac{(v_{m1})^2}{c^2} + \lambda_{m2} l\, \vec{E}_{m1}\, \frac{(v_{m1} - v_{m2})^2}{c^2} \right]$$

$$= -a \left[-\lambda_{m2} l\, \vec{E}_{m1}\, \frac{(v_{m2})^2}{c^2} - \lambda_{m2} l\, \vec{E}_{m1}\, \frac{(v_{m1})^2}{c^2} + \lambda_{m2} l\, \vec{E}_{m1}\, \frac{(v_{m1}^2 + v_{m2}^2 - 2v_{m1}v_{m2})}{c^2} \right]$$

$$= 2a\, \lambda_{m2} v_{m2} \frac{\vec{E}_{m1} v_{m1}}{c^2} l = 2a\, \lambda_{m2} v_{m2}\, \frac{\lambda_{m1}}{2\pi\epsilon\, r}\, \frac{v_{m1}}{c^2}\, l\, \hat{r}$$
$$= 2a\, \frac{\mu\, I_1 I_2\, l}{2\pi\, r}\, \hat{r} \qquad (\because I = \lambda v \;,\; c^2 = \frac{1}{\mu\epsilon})$$

Putting $a = -1/2$, we get the exact same force as the Lorentz law describes, i.e.,

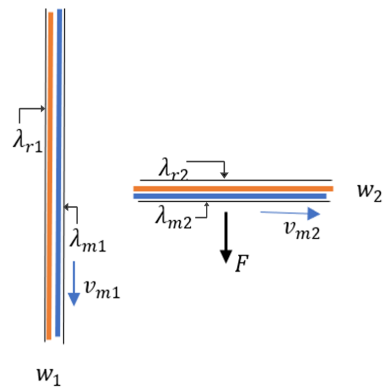
$$\vec{F} = -\frac{\mu\, I_1 I_2\, l}{2\pi\, r}\, \hat{r} \tag{24}$$

It proves that the magnetic force between two current-carrying wires arises because of the relative velocity between the charges but not because of the motion of the electrons w.r.t. the observer (existing understanding) i.e., the forces are in between the rest charge (of one wire) and moving charge (of another wire), but not in between the moving charges (if their relative velocity is zero).

Here, $\frac{d(U_{battery})}{dt} = 0$ as $\sum \vec{F} \cdot \vec{v} = 0$. So, it can be treated as an ideal case because energy of battery is not participating in the process.

Case-2: $(w_1 \perp w_2)$ and $(w_2 \parallel E_{r_1})$

Here also, we have four relative velocities
(1) between $\vec{E}_{r1}$ and λ_{m2} which is $\vec{v}_{r1} - \vec{v}_{m2} = -v_{m2}\, \hat{E}_{r1}$
(2) between $\vec{E}_{r1}$ and λ_{r2} which is $\vec{v}_{r1} - \vec{v}_{r2} = 0$
(3) between $\vec{E}_{m1}$ and λ_{r2} which is $\vec{v}_{m1} - \vec{v}_{r2} = v_{m1}\, \hat{E}_{r1,\perp}$
(4) between $\vec{E}_{m1}$ and λ_{m2} which is $\vec{v}_{m1} - \vec{v}_{m2} = v_{m1}\, \hat{E}_{r1,\perp} - v_{m2}\, \hat{E}_{r1}$



Force on elemental length $d\vec{l}$ of w_2 due to w_1 is

$$\vec{F}_{\parallel E} = -\sum a\; q\vec{E}\; \frac{(v_{r\perp})^2}{c^2}$$
$$= -a \left[\lambda_{m2}\, dl\;\, \vec{E}_{r1}\; \frac{(0)^2}{c^2} + \lambda_{r2}\, dl\;\, \vec{E}_{r1}\; \frac{(0)^2}{c^2} + \lambda_{r2}\, dl\;\, \vec{E}_{m1}\; \frac{(v_{m1})^2}{c^2} + \lambda_{m2}\, dl\;\, \vec{E}_{m1}\; \frac{(v_{m1})^2}{c^2} \right]$$
$$= 0$$

$$\vec{F}_{\perp E} = \sum b \; qE \; \frac{v_{r\parallel} v_{r\perp}}{c^2} \; \hat{E}_{\perp}$$
$$= b \Big[\lambda_{m2} \, dl \; E_{r1} \; \frac{(-v_{m2}).0}{c^2} \; \hat{E}_{r1,\perp}$$
$$+ \lambda_{r2} dl E_{r1} \; \frac{(0)^2}{c^2} \; \hat{E}_{r1,\perp}$$
$$+ \lambda_{r2} \, dl \; E_{m1} \; \frac{0.(v_{m1})}{c^2} \; \hat{E}_{m1,\perp}$$
$$+ \lambda_{m2} \, dl \; E_{m1} \; \frac{v_{m1}.v_{v_{m2}}}{c^2} \; \hat{E}_{m1,\perp} \Big]$$

$$= b \; \frac{\lambda_{m2} \, E_{m1} \, v_{m1} \, v_{v_{m2}}}{c^2} \; dl \; \hat{E}_{m1,\perp}$$
$$= b \; \frac{\lambda_{m2} \, \lambda_{m1} \, v_{m1} \, v_{v_{m2}}}{2\pi\epsilon r \;\; c^2} \; dl \; \hat{E}_{m1,\perp}$$
$$= b \; \frac{\mu \, I_1 I_2 \, dl}{2\pi \, r} \; \hat{E}_{m1,\perp}$$

Total force on dl is $\vec{F} = \vec{F}_{\parallel E} + \vec{F}_{\perp E}$
$$= b \; \frac{\mu \, I_1 I_2 \, dl}{2\pi \, r} \; \hat{E}_{m1,\perp}$$

Taking $b = -1$, it becomes

$$\vec{F} = -\frac{\mu \, I_1 I_2 \, dl}{2\pi \, r} \; \hat{E}_{m1,\perp} \tag{25}$$

It also matches the result we get from Lorentz law.

Here, $\dfrac{d(U_{battery})}{dt} \neq 0$ as $\sum \vec{F} \cdot \vec{v} \neq 0$ (drag forces are always equal and opposite) and so, it can't be treated as an ideal case. Due to this reason, value of a changes to b i.e., $a = -1/2$ and $b = -1$. From these two case, we got the value of a and b. We choose these above two cases for finding the value of a and b because these are experimentally verified (case of absolute magnetic field), but none of the experiment related to non-absolute magnetic field is verified and so we can't use them to find the value of a.

So, the final expression of electric drag force will look like:
(i) For ideal case:

$$\vec{F} = -\frac{1}{2} \; q\vec{v}_r \times \mu\epsilon(\, \vec{v}_r \times \vec{E} \,) \tag{26}$$

(ii) For non-ideal case:

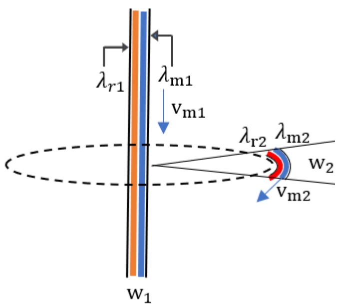
$$\vec{F} = \frac{1}{2} \; qE \; \frac{(v_{r\perp})^2}{c^2} \hat{E} \; - \; qE \; \frac{(v_{r\perp} \; v_{r\parallel})}{c^2} \; \hat{E}_{\perp} \tag{27}$$

Note that the value of a in equations 19 and 20 also is $-1/2$ $\;(a = -1/2)$, In case of non-absolute magnetic field, result comes from electric drag force is different from the result we get from the Faraday law or Lorentz law. But it doesn't mean that concept of electric drag force is wrong as these law themselves fails in case of non-absolute magnetic as they predict different result for the experiment, when observed different frame, and so we can't rely on these law. These laws hold for absolute magnetic field only as these are experimental law, developed from experiments with absolute magnetic field. In case of absolute magnetic field, result from electric drag force and from these laws will match always (we will see later).

Case-3: $(w_1 \perp w_2)$ and $(w_2 \perp E_{r1})$ i.e., w_2 is along the magnetic field of w_1

Here, $\vec{v}_{r\parallel} = 0$, so $\vec{F}_{\perp E} = 0$ and

$$\vec{F}_{Total} = \vec{F}_{\parallel E} = -\sum a \; q\vec{E} \; \frac{(v_{r\perp})^2}{c^2}$$
$$= -a \Big[\lambda_{m2} \, dl \; \vec{E}_{r1} \; \frac{(v_{m2})^2}{c^2} \; + \lambda_{r2} \, dl \; \vec{E}_{r1} \; \frac{(0)^2}{c^2}$$
$$+ \quad \lambda_{r2} \, dl \; \vec{E}_{m1} \; \frac{(v_{m1})^2}{c^2}$$
$$+ \lambda_{m2} \, dl \; \vec{E}_{m1} \; \frac{(\sqrt{v_{m1}^2 + v_{m2}})^2}{c^2} \Big]$$
$$= 0 \tag{28}$$

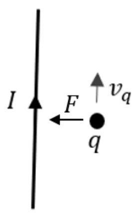


5.4 Force on moving charge in the magnetic field of current carrying wire (using the concept of electric drag force)

1. Charge's motion is along the wire

Here, $v_{r\|} = 0 \Rightarrow F_{\perp E} = 0$, but

$$\begin{aligned}\vec{F}_q = \vec{F}_{\|E} &= \sum \frac{1}{2}\frac{q\vec{E}}{c^2}\, v_{r\perp}^2 \\ &= \frac{1}{2}\frac{q\vec{E}_r}{c^2}\,(v_q)^2 + \frac{1}{2}\frac{q\vec{E}_m}{c^2}\,(v_q - v_m)^2 \\ &= -\frac{1}{2}\frac{q\vec{E}_m}{c^2}\,(v_q)^2 + \frac{1}{2}\frac{q\vec{E}_m}{c^2}\,(v_q - v_m)^2 \\ &= -\frac{q\vec{E}_m}{c^2}\,\frac{(2v_q - v_m)v_m}{2}\end{aligned} \tag{29}$$



Note: $\vec{E} = E\,\hat{r}$, where $E = +ve/-ve$ (because $E = f(q)$ i.e., $E_r = +ve$ and $E_m = -ve$) and the direction is always along the $\hat{r}$ (radial direction).

The value of v_m, i.e., the drift velocity of the electron lies in the range of 10^{-3}m/s. So, if v_q is even few meters per second, it can be neglected ($v_n << v_q$), and this equation reduces to

$$F_q = \frac{qE_m}{c^2}\, v_m\, v_q = q\, v_q\, B \tag{30}$$

It matches with Lorentz law. But for small value of v_q (comparable to v_d or zero), Lorentz law will fail, as in that case

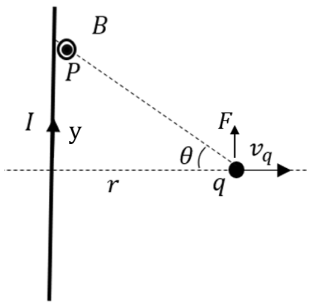
$$F_q = \frac{qE_m}{c^2}\left(v_q - \frac{v_m}{2}\right) v_m = q\left(v_q - \frac{v_m}{2}\right) B \tag{31}$$

- If $v_m = 0$, $F_q = 0$, because of net zero drag ($I = 0$)
- if $v_q = 0$, $F_q = -\dfrac{q\,v_m\,B}{2}$ $\quad (F \propto v_m^2)$
- If $v_q = v_m$, $F_q = \dfrac{q\,v_m\,B}{2}$
- if $v_q = v_m/2$, $F_q = 0$, as drag force due to E_p and E_n becomes equal and opposite.

This is the reason when a charge is placed in a magnetic field (such that $v_q = 0$) of current carrying wire, it experiences a net minute force [[]6. It can't be explained by Lorentz law.

2. Charge's motion is $\perp$ to the wire, moving away from it

Here, the charge q is moving toward the current-carrying wire (having current I) with velocity $\vec{v}$ (perpendicular to the wire).



If we use the concept of magnetic force, Newton's third law get violates [0] as magnetic force on charge is

$$\vec{F}_q = q\vec{v}_q \times \vec{B} = \frac{\mu I\, q v_q}{2\pi r}\ \hat{z}$$

Magnetic field at point P due to moving charge is

$$\vec{B} = \frac{\mu q v_q \sin\theta \cos^2\theta}{4\pi r^2}\ \odot$$

and so magnetic force on wire due to charge (reaction force) is

$$\begin{aligned}F_w &= \int BI\,dy = \int \frac{\mu q v_q \sin\theta\cos^2\theta}{4\pi r^2}\, I\, r\sec^2\theta d\theta \\ &\left(\ y = r\tan\theta \quad \therefore\ dy = r\sec^2\theta d\theta\ \right) \\ &= \int \frac{\mu q v_q \sin\theta}{4\pi r}\, I d\theta\ = 0\end{aligned}$$

But if we use electric drag force, we get the same action-reaction force, which also matches the result that came from the Lorentz law.

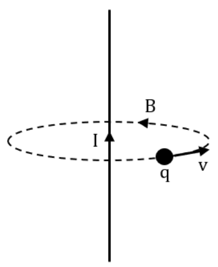
$$\vec{F}_{\parallel E} = \sum \frac{1}{2}\frac{qE}{c^2}\, v_{r\perp}^2\ \hat{E}$$
$$= \frac{1}{2}\frac{qE_r}{c^2}\,(0)^2\ \hat{E}_r + \frac{1}{2}\,\frac{qE_m}{c^2}\,(v_m)^2\ \hat{E}_m$$
$$= \frac{qE_m v_m^2}{2\ c^2}\ \hat{E}_m$$
$$\vec{F}_{\perp E} = -\sum qE\ \frac{v_{r\parallel} v_{r\perp}}{c^2}\ \hat{E}_\perp$$
$$= -qE_r \frac{v_q.0}{c^2}\ \hat{E}_{r\perp} - qE_m\ \frac{v_q.v_m}{c^2}\ \hat{E}_{m\perp}$$
$$= -\frac{qE_m\ v_q.v_m}{c^2}\ \hat{E}_{m\perp}$$

$$\Rightarrow F_q\ = \left|\vec{F}_{\parallel E} + \vec{F}_{\perp E}\right|\ = q\Big(\sqrt{\frac{v_m^2}{4} + v_q^2}\Big)\frac{E_m v_m}{c^2}$$
$$= qv_q B$$
$$(\ v_m << v_q \text{ as } v_m = 10^{-3}\text{m/s}) \qquad (32)$$

Here also, Lorentz law will fail for small velocity of charges.

The force on the wire due to the charge (reaction force) will be same as this F_q (action force) because drag force is always equal and opposite i.e., $\vec{F}_{q_1,q_2} = -\vec{F}_{q_2,q_1}$.

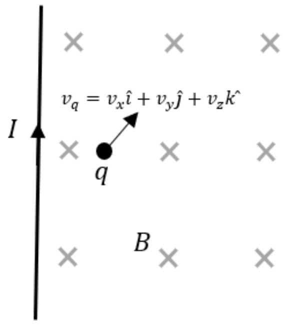
3. Similarly, if charge's motion is $\perp$ to wire as well as E_r, i.e., along the magnetic field, then the drag force (or the magnetic force) on charge comes out will be zero (using equations 21).



General derivation of Lorentz law using the concept of electric drag force

If charge has any random velocity $\vec{v}_q = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$ in the magnetic field, the total force on it will be (using equation 30 and 32)

$$\begin{aligned}\vec{F}_q &= qE_m\ \frac{v_y.v_m}{c^2}\hat{i} - qE_m\ \frac{v_x.v_m}{c^2}\hat{j} \\ &= q\ \frac{E_m v_m}{c^2}(v_y\hat{i} - v_x\hat{j}) \\ &= q\,(v_x\hat{i} + v_y\hat{j} + v_z\hat{k}) \times \frac{E_m v_m}{c^2}\hat{k} \\ &= q\vec{v}_q \times \vec{B}\end{aligned} \qquad (33)$$



So, there is no need to consider the direction of motion of the producer electric field as the overall force becomes independent of it, i.e., depends only on the direction of the magnetic field (provided $v_n << v_q$).

So, if there is more than one source of magnetic field, it will becomes

$$\begin{aligned}\vec{F}_q &= q\vec{v}_q \times \vec{B}_1\ +\ q\vec{v}_q \times \vec{B}_2\ + \cdots +\ q\vec{v}_q \times \vec{B}_n \\ &= q\vec{v}_q \times (\vec{B}_1 + \vec{B}_2 + \cdots + \vec{B}_n) \\ &= q\vec{v}_q \times \vec{B}_{net}\end{aligned} \qquad (34)$$

It will holds only when v_n (velocity of electron) is very small w.r.t the charge's velocity; otherwise, this magnetic force will depend on the direction of motion of the producer electric field producing the magnetic field (w.r.t. the charge).

Lorentz law is developed from experimental observation (using absolute magnetic field), but here it is derived using the concept of electric drag force. Lorentz law is a special case of electric drag force . We derive this formula for absolute magnetic field (with $v_n << v_q$) and so it holds for absolute magnetic field only. In the case of a non-absolute magnetic field or $v_m \cong v_q$, it fails, but the concept of electric drag force holds everywhere.

5.5 Solution of section-4.1

In fig-10(b), $\left.\frac{d\Phi_B}{dt}\right|_{coil} \neq 0$ but $\mathcal{E}_{coil} = 0$ while in fig-9, $\frac{d\Phi_B}{dt} = 0$ and $\mathcal{E}_{coil} \neq 0$. This violets the Faraday law. It can't be explained if we rely only on the concept of magnetic field as there is no magnetic field in fig-9, but still the generation of EMF is happening. We won't have any solution of it, if we don't believe on the concept of drag property of electric field. Even the special theory of relativity can't fix it, which also proves that all magnetic phenomena are not the effect of length contraction of electric fields. So, the only solution of this case is the electric drag force.

In fig-9, the velocity of coil w.r.t the electric field (i.e., relative velocity) is $v_c\hat{E}_{\parallel} - v_m\hat{E}_{\perp}$. Here $v_{r\perp} = v_m$ and $v_{r\parallel} = v_c$ and so the EMF induced in it can be found using equation 21 as

$$\mathcal{E} = \frac{1}{q}\oint_l \vec{F}_q \cdot \vec{dl} = \oint_l \left(\frac{E v_{r\perp}^2}{2\,c^2}\hat{E} - \frac{E v_{r\parallel} v_{r\perp}}{c^2}\hat{E}_{\perp}\right) \cdot \vec{dl}$$
$$= \frac{\mu\,\lambda_e v_{r\perp} v_{r\parallel}\, l}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \tag{35}$$

This expression of EMF is same as equation-13 and it is frame-independent (no matter from which frame the system is being observed, it will remain the same for all), and so it will remains same for fig-8(b) also. Hence, in both the fig-8(b) and fig-9, same EMF is inducing and it is true because these two figure is representing the same experiment (observed from the different frame of reference). It can't be explained if we use concept of magnetic field.
For the fig-8(b), this equation can also be written as ($\lambda v_{r\parallel} = I$),

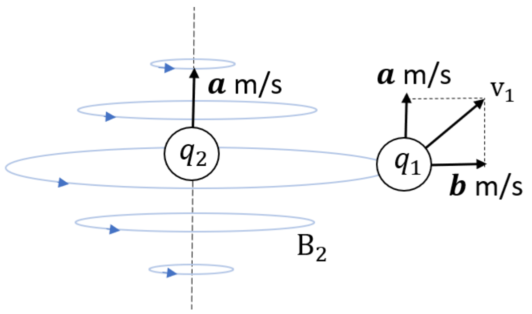
$$\mathcal{E} = \frac{\mu I v_c l}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = -\frac{d\Phi_{B,q}}{dt} \tag{36}$$

where it seems like, it is generated due to the changing magnetic flux, but the actual reason is the electric drag force, as the concept of magnetic field is limited to some particular fame only.
In similar way, in fig-10(a) and fig-10(b), $v_{r\perp} = 0$ and so from the equation-21, in both the cases, $\mathcal{E}_{coil} = 0$, even there is changing magnetic flux inside the coil in fig-10(b).
Fig-8(a) i,e case of neutral current carrying wire is the combination of these above two case, and so $\mathcal{E}_{coil} = \mathcal{E}_{\lambda_e} + \cancelto{0}{\mathcal{E}_{\lambda_r}}$ which is equation-35, and it again matches with equation-12 (case of absolute magnetic field). In this situation, if the system is observed from the λ_e frame, it seems like the EMF is generating because of motion of the coil in the magnetic field produced by moving λ_r and if we calculate the EMF produced using this concept of magnetic field, it will match exactly with the equation-12, but it is not actually true as λ_r can't generate any EMF (as its $v_{r\perp} = 0$). In both λ_e or λ_r frame, it is produced only due to the electric field of λ_e (through the drag property). So, matching of few result doesn't always prove that the physics or concept used behind is 100% correct.

6 Magnetic field doesn't exist

The only source of magnetic field is the moving electric charges or the changing electric field, as magnetic charge doesn't exist. But what if I say that "neither the moving charge nor the changing electric field produces any such real field, which we call a magnetic field". Here are a few situations that proves this statement:

(1) Taking the case of moving charge: If a moving charge really produces a field (magnetic field) on its motion, then a charge (q_1) moving with velocity $a\hat{j} + b\hat{i}$ m/s should must experience a magnetic force near a moving charge (q_2) having velocity $a\hat{j}$ (where charges are approaching each other as shown in the figure) due to the surrounding magnetic field (B_2) produced by the moving charge q_2. But the charge q_1 doesn't experiences any such magnetic force (proved in sec-3.2), which proves that, no any such real field (magnetic field) is there, other than the primary electric field of the charges.



(2) Similarly in figure 10(b), there is a magnetic field in the surrounding space of line charge, but still no EMF is inducing in the coil during its motion in that magnetic field (having net increasing magnetic flux inside). It also proves that there isn't any magnetic field; otherwise, generation of EMF would have happened.

(3) Let's see this case (fig-10(b)) in some another way also. Here, λ_e is moving with velocity $\vec{v}_m$, and so it is producing a magnetic field $B = \dfrac{\mu\lambda_e v_m}{2\pi r}$ around itself. If any coil moves in this magnetic field with any velocity $a\,\hat{i}$, parallel to the line charge, no emf will be generated in the coil as the magnetic flux inside the coil remains constant ($\frac{d\Phi_B}{dt} = 0$). It means a velocity (of coil) along the line charge can't generate any EMF, nor can it affect the existing EMF (if any).
When the coil moves with velocity $b\,\hat{j}$, a non-zero EMF induces in the coil because of $\frac{d\Phi_B}{dt} \neq 0$, given by equation-13. So, if the same coil starts moving

with the velocity $a\,\hat{i} + b\,\hat{j}$, the same EMF should be there in the coil, as the velocity component $a\hat{i}$ can't affect or change the EMF induced due to the velocity $b\,\hat{j}$. But it also doesn't happen as in when $a = v_m$, $\mathcal{E}_{coil} = 0$ (identical to fig-10(b)) and $\mathcal{E}_{coil} \neq 0$ when $a \neq v_m$.

It again proves the same thing i,e no such real field (magnetic field) is present in that surrounding region of the moving line charge. Even the expression of EMF derived from the concept of magnetic field (equation-13) is wrong as it is depending on the velocity of line charge w.r.t. the observer, i.e., larger the observer's velocity (w.r.t. the system), the larger will be the EMF, which is absolutely wrong as the EMF can't depend on the state on observer.

The actual expression for this EMF is equation-35 (derived using the electric drag force equation), which state that until $v_{r\perp}$ is zero, no EMF will generates, no matter what magnitude of magnetic field is present there, because the actual cause of EMF is the electric drag force, not the magnetic field. In another word, magnetic force is nothing but electric drag force, which seems to be generated because of magnetic field, but the actual reason is the relative drag with the primary electric field.

Conclusion of these all is "Magnetic field is not a field, but just a mathematical parameter which measures the flow of electric field (primary), given by $\vec{B} = \mu\epsilon\,\vec{v} \times \vec{E}$ and the effect or phenomena seems to be arose due to magnetic field is basically the effect of electric drag force.". In another word, moving electric field itself is magnetic field. A stationary charge also has the magnetic field, but for the moving observer. It means it doesn't have any physical existence. This is the reason why particle corresponding to magnetic field (magnetic charge or magnetic monopole) doesn't exist or has not been found yet.

In case of current carrying also, there isn't any real field (magnetic field) around the wire, but there's just moving electric fields. When charge moves in this region, it experiences force not because of a magnetic field but because of the drag property of an electric field, which is equal to $q\vec{v} \times \vec{B}$ (equation-33) where $\vec{B}$ is a mathematical expression which is equal to $\vec{B} = \sum \mu\epsilon(\vec{v} \times \vec{E})$. Because of this expression (equation-33), illusion of magnetic field is created as it seems to have been generated because of any such real field $\vec{B}$, called magnetic field, but that is not actually true.

Similarly, (i) the magnetic force between two current carrying wire arises not because of any magnetic field (as the equation $\vec{F} = i\,\vec{l} \times \vec{B}$ describes) but it arises because of the drag property of the electric field (electric drag force) as mentioned in section-5.3 which is mathematically equal to the the expression $\vec{F} = i\,\vec{l} \times \vec{B}$ where $\vec{B}$ is just a mathematical term.

(ii) A stationary charge also applies magnetic force or electric drag force to moving charge as mentioned in section-5.2.1 which can't be explained if we consider the magnetic field instead of the drag property of electric field.

So, all the phenomena which seems to be caused by a real filed called as a magnetic field are basically the effect of drag property of the electric field or electric drag force.

We will discuss the case of the permanent magnet later.

Note that we can't consider both the magnetic force as well as electric drag force; otherwise force on charge in sec-5.4 will be $2\,qvB$ which is wrong (experimental fact), and if we consider magnetic force instead of electric drag force then sec-4.1, 4.3 and 3.2 can't be explained. So, the only option is electric drag force which explains all the cases.

Here are a few more situations that prove the non-existence of magnetic fields, but before that, let's examine the validity of electric drag force equation once again.

Final verification of electric drag force

Now there is no doubt on the existence of drag property of electric field as without it, sec-3.2, 4.1, 4.2 and 4.3 can't be explained. So this property of electric field can't be disproved at any cost. Also, the expression of electric drag force will be $\vec{F}_d = a\ q\vec{v}_r \times \mu\epsilon(\,\vec{v}_r \times \vec{E}\,)$ because equation-6 is dimensionally correct for the extra or non-coulombic force on charges, but if we take it as it is, then it starts to fails in many situations i.e., if

- $\vec{F}_d = a\ q\vec{v}_q \times \mu\epsilon(\,\vec{v}_E \times \vec{E}\,)$, it fails in sec-3.1.
- $\vec{F}_d = a\ q\vec{v}_r \times \mu\epsilon(\,\vec{v}_E \times \vec{E}\,)$, it fails in sec-3.2 and in figures 14, 12 and 9 on studying from the frame of electric field.
- $\vec{F}_d = a\ q\vec{v}_q \times \mu\epsilon(\,\vec{v}_r \times \vec{E}\,)$, it fails in figures 14, 15(b), 12 and 9 (study from any random frame and calculate the $\mathcal{E}_{coil}$ using this equation i.e., $\mathcal{E}_{coil}$ will depends on the observer's velocity (w.r.t the system), which can't be possible).

Hence the only option we left with is

• $\vec{F}_d = a\ q\vec{v}_r \times \mu\epsilon(\ \vec{v}_r \times \vec{E}\ )$, it handles all the cases (so, both the velocity should must be the relativistic velocity).

6.1 Moving rod system

Here is a current carrying wire (λ_e+λ_p) having current I (λ_e is moving with velocity $\vec{v}_m$) and a line charge λ'_e ($= \lambda_e$), moving with velocity $\vec{v'}_m$ ($= \vec{v}_m$). There is a rail with a moving rod (having length l and velocity $\vec{v}$) on the side of both the wire and line charge as shown in fig-15.
According to the concept of magnetic field, EMF induced in both the circuits will be the same as in both cases; the same magnetic field is there in the surrounding space, and so

$$\mathcal{E}_1 = \mathcal{E}_2 = \int Bvdr = \int \frac{\mu I}{2\pi r} vdr = \frac{\mu \lambda_e v_m v}{2\pi r}\, ln\left(\frac{r_2}{r_1}\right)$$

But, according to the concept of electric drag force, it isn't the same.
In case of wire: Using equation-21, we get the EMF same as this above equation i,e $\mathcal{E}_1 = \dfrac{\mu \lambda_e v_m v}{2\pi r}\, ln\left(\dfrac{r_2}{r_1}\right)$.
But in case of line charge: Using equation-21, we get

$$\mathcal{E}_2 = \frac{1}{2}\int E\frac{v_r^2}{c^2}dr = \frac{1}{2}\frac{\lambda_e}{2\pi\epsilon r}\frac{(v - v_m)^2}{c^2}dr$$
$$= \frac{\mu \lambda_e (v - v_m)^2}{4\pi r}\, ln\left(\frac{r_2}{r_1}\right)$$

It is not same as the above one. To cross-check it, study this fig-15(b) from moving rod frame. In that frame, the result from concept of magnetic field and electric drag force will matches exactly with each other.

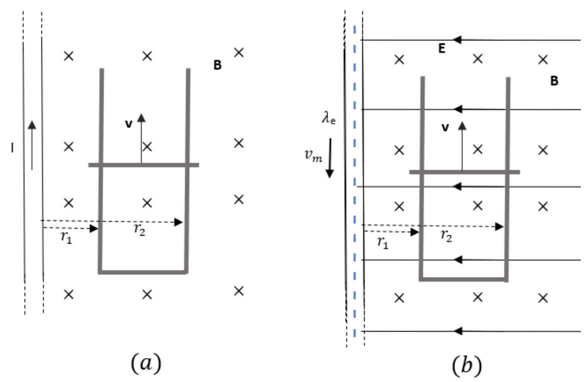


Figure 15: Two rods are moving in identical magnetic field, having different source

(A suitable experiment is mentioned in paper-2 for its experimental verification)
So, even though the same magnetic field is there, they are not inducing the same EMF. Also, (i) in the first one, it is directly proportional to the rod's velocity, while in the second one it is proportional to $(v - v_m)^2$ (ii) if $v_m = 0$, $\mathcal{E}_1 = 0$, but if $v'_m = 0$, $\mathcal{E}_2$ may or may not be zero, depending upon v, i.e., here v_m is not the deciding factor (iii) $\mathcal{E}_1$ depends on the direction of motion of rod but $\mathcal{E}_2$ in independent of this direction.

Here, Faraday law and Lorentz law is holding for the neutral current-carrying wire (and also matching with electric drag force result), but violating in case of line charge system. It happens because these laws are experimental law, designed on the basis of experimental observation, where an absolute magnetic field is used (not the non-absolute one), and hence these laws holds in all those cases where the magnetic field is absolute (providing $v_m \to 0$).

6.2 Rotating coil in an electric field

6.2.1 Plane of coil is parallel to electric field

If a rectangular coil rotates in an electric field (non-varying) about one of its sides such that the axis of rotation is along the electric field (fig-16), then in this case also, an EMF will be induced in the coil due to the drag property of electric field, given by

$$\mathcal{E} = \frac{1}{q}\oint_l \vec{F}_q \cdot d\vec{l} = \oint_l \left(\frac{Ev_{r\perp}^2}{2\,c^2}\hat{E} - \frac{Ev_{r\parallel}v_{r\perp}}{c^2}\hat{E}_\perp\right)\cdot d\vec{l}$$
$$= \frac{E\omega^2 b^2 l}{2\,c^2} \tag{37}$$

where, E=Electric field applied in the region
ω=angular velocity of the coil
l, b= length and breath of the coil

But if we use the concept of magnetic field, there shouldn't be any EMF in the coil as there is neither any magnetic field nor any changing electric field (which can act as the source of magnetic field). The only field present is the non-varying primary electric field, which itself is a conservative field, and so it also can't induce any EMF in that close loop.
But now it is 100% sure that EMF will be induced in the coil, as it is proved in Sec. 6 that we don't

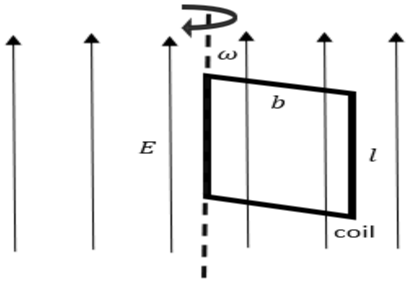


Figure 16: Rotating coil in a stationary electric field

have any option other than the equation-21. (A suitable experiment is mentioned in paper-2 for its experimental verification)

6.2.2 Plane of coil is perpendicular to electric field

Here, we have a circular coil whose plane is perpendicular to the electric field (take the direction of the electric field as the z-axis). If this coil moves in the direction of an electric field along with an angular motion, EMF will be generated in the coil due to the drag force, which will be equals to

$$\begin{aligned}\mathcal{E} &= \oint_l \left(\frac{E v_{r\perp}^2}{2\,c^2} \hat{E} - \frac{E v_{r\parallel} v_{r\perp}}{c^2} \hat{E}_\perp \right) \cdot d\vec{l} \\ &= -\frac{2\,\pi\, E\, \omega\, r^2\, v}{c^2}\end{aligned} \tag{38}$$

where v= velocity of coil along the electric field E
ω= angular velocity of coil
r= radius of the coil

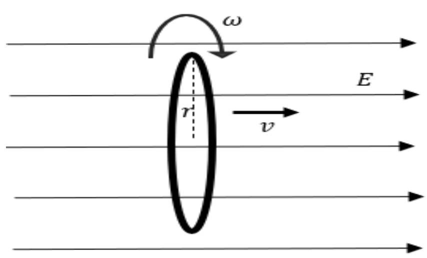


Figure 17: Motion and rotation of a coil in an stationary electric field

If this coil only moves (without rotation) or only rotates (without motion) in the electric field, then no EMF will be induced. (A suitable experiment is designed and mentioned in paper-2 for its experimental verification) Here also, if we apply the concept of magnetic field, then EMF shouldn't be induced, but that is not true.

6.3 Electric drag force on a current carrying wire in an electric field

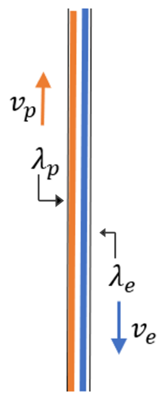
If a current carrying wire is placed in an electric field , it will experience zero electric force as wire is electrically neutral. But due to moving electron inside , it will experience a non-zero electric drag force. For the length l , it will be equals to (using equation-18)

$$F_d = \frac{1}{2} \lambda_e l E \,\frac{v_e^2}{c^2} \sin\theta = \frac{I E v_e \sin\theta}{2\,c^2} \tag{39}$$

where I, E and θ is the current, applied electric field and angle between l and E. To estimate the range of this force , let's take $I = 1$A, $E = 10^6$ V/m and $\theta = 90^o$ ($v_e = 10^{-3}$ m/s). So the magnitude of this force is about 10^{-14}N which is very,very small. So, it very difficult to observe this force.

6.4 Current carrying wire doesn't produce stationary magnetic field

As sec-3.1 suggest that magnetic field travels along with its producer charge and so , in case of current carrying wire also , magnetic field isn't stationary but moves along with its producer charge (as magnetic field is nothing but the moving electric field itself). If not and taken to be stationary, then the first question arise here is, w.r.t whom it is stationary?
(i) w.r.t observer (ii) w.r.t λ_p , or (iii) w.r.t λ_e



If it is taken w.r.t observer, then any charge moving is its magnetic field with any velocity should experience zero magnetic force because as when it is studied from the charge frame, then according to option-(i), $v_{q,B} = 0$ which implies $\vec{F}_m = 0$. So, option-(i) can't be true. If it is taken w.r.t λ_p, then why not it can be taken w.r.t λ_e as (i) both are moving (as shown in the figure, $I = \lambda_e v_e + \lambda_p v_p$), (ii) both are electric charge, which caries same property (the only difference is the polarity, which can't make their behavior different). Hence, it can't be taken stationary w.r.t any one of them as both will behave in a same way. If we take $v_B = (v_e + v_p)/2$, then it also can't be true as it is independent of magnitude of λ_e and λ_p, so when

$\lambda_p = 0$, what will be the value of v_B? Also, it can't be $v_e/2$; otherwise there will be a magnetic force on a stationary point charge placed near a line charge, when observed from S' frame.
So, the solution is that magnetic field corresponding to each producer charge moves along with them as sec-3.1 suggest (i.e., $v_{q,B} = 0$). Practically, this velocity is very, very small as electron velocity in wire is about 10^{-3} m/s and so it can be treated as stationary w.r.t the wire.

So, the explanation of magnetic force between two current carrying wire using the concept of stationary magnetic field is wrong.

7 Failure of Ampere-Maxwell Law

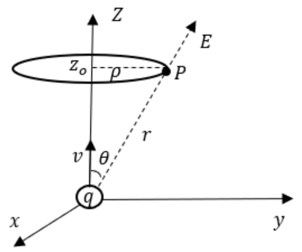
As we saw, moving charge doesn't produce any real field called a magnetic field. Similarly, the changing electric also doesn't produce any magnetic field. Here are a few proofs of this.

7.1 Magnetic field due to moving charge

Magnetic field due to moving charge q, having velocity $\vec{v}$ ($v << c$) is given as

$$\vec{B}_p = \frac{\mu}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2} = \mu\epsilon\,\vec{v}\times\vec{E} \tag{40}$$

and electric field due to the same charge at any random point $p(\rho, \phi, z)$ is (taking cylindrical coordinate with origin at q and direction of velocity as z-axis),



$$\begin{aligned}\vec{E}_p &= \frac{kq}{r^2}\hat{r} = \frac{kq}{\rho^2+(z-vt)^2}\ (\sin\theta\hat{\rho}+\cos\theta\hat{z})\\ &= \frac{kq\rho}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{\rho} + \frac{kq(z-vt)}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{z}\end{aligned} \tag{41}$$

Putting it in above equation-40, we get

$$\begin{aligned}\vec{B}_p &= \mu\epsilon\,\vec{v}\times\vec{E}_p\\ &= \mu\epsilon\,\vec{v}\times\left(\frac{kq\rho}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{\rho} + \frac{kq(z-vt)}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{z}\right)\\ &\quad \text{(as v is along the z-axis)}\\ &= \frac{\mu}{4\pi}\,\frac{qv\rho}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{\phi}\end{aligned} \tag{42}$$

Value of $\int\vec{B}\cdot d\vec{l}$ across the circle of radius ρ at $z = z_0$ in the x-y plane will be

$$\begin{aligned}\int\vec{B}\cdot d\vec{l} &= \int\frac{\mu}{4\pi}\,\frac{qv\rho}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\hat{\phi}\cdot dl\hat{\phi}\\ &= \frac{\mu}{4\pi}\,\frac{qv\rho}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}.2\pi r_1\\ &= \frac{\mu}{2}\,\frac{qv\rho^2}{(\rho^2+(z-vt)^2)^{\frac{3}{2}}}\end{aligned} \tag{43}$$

Here, this $\oint\vec{B}\cdot d\vec{l}$ is produced only due to $\vec{E}_\rho$. There is no contribution of $\vec{E}_z$ in it. It violets the Maxwell fourth equation as it suggest that changing electric field also produces a circular magnetic field, given by equation $\oint\vec{B}\cdot d\vec{l} = \frac{d\Phi_E}{dt}$, which is not happening here as $\vec{E}_z$ is changing with time inside the loop (i.e., $\frac{d\phi_{Ez}}{dt} \neq 0$), but still it isn't producing any magnetic field ($\vec{B}$ is produced by $\vec{E}_\rho$ only) and so has zero contribution in $\oint\vec{B}\cdot d\vec{l}$.

7.2 Magnetic field due to changing electric field

Suppose we have a very long cylinder (as shown in figure 18) of radius r_0, placed along z-axis, containing electric field

$$\vec{E} = \begin{cases}\frac{E_0}{z}\hat{z}, & r < r_0\\ 0, & r \geq r_0\end{cases} \tag{44}$$

where E_0 is a constant. This complete system (cylinder+electric field) is moving with velocity $v\hat{z}$ w.r.t. observer S. Also, there is a charge q moving with velocity $v_q\hat{z}$ w.r.t. observer S.
In the cylinder frame, electric field is stationary (non-changing), which implies no magnetic field would produced, and hence, magnetic force on charge q is zero ($\vec{F}_q = 0$) as $\vec{B} = 0$. But, for observer S, electric field is changing with time in

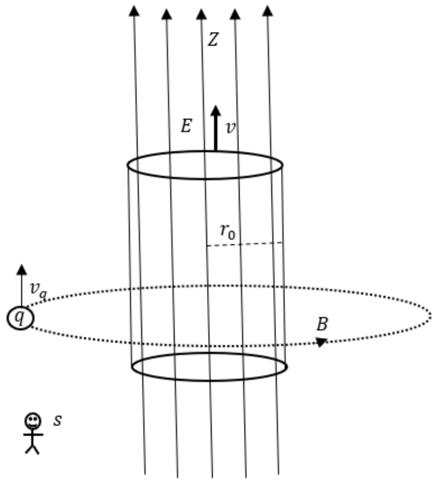


Figure 18: A charge is moving near a moving electric field region

the region S as $\vec{E} = \dfrac{E_0}{z}\hat{z} = \dfrac{E_0}{z_0 - vt}\hat{z}$ and so according to Maxwell-Ampere equation, it will produce a magnetic field $\vec{B}$ around the cylinder (Note: Maxwell's equation doesn't care, how the field is changing i.e., the only condition for the generation of magnetic field is the changing electric field, doesn't matter how it is changing), which will be equals to

$$
\begin{aligned}
&\oint \vec{B}\cdot\vec{dl} = \cancelto{0}{\mu I} + \mu\epsilon\,\frac{d\Phi_E}{dt}\\
&B.2\pi r = \mu\epsilon\,\frac{d(\pi r_0^2\,E)}{dt} = \mu\epsilon\;\pi r_0^2\frac{dE}{dt}\\
&B = \mu\epsilon\,\frac{r_0^2}{2r}\frac{dE}{dt} = \mu\epsilon\,\frac{r_0^2}{2r}\frac{vE_0}{(z_0 - vt)^2}\\
&\text{(encircling around the cylinder)}
\end{aligned}
\tag{45}
$$

which implies that there should be a force on the charge q, given by $\vec{F_q} = q\,v_q\hat{z}\times\vec{B}$. Even if we take the produced magnetic field moving along with the producer electric field, in this case also, there should be a force on charge $\vec{F_q} = q\,(v_q - v)\hat{z}\times\vec{B}$. Here, force on charge q is different for different frames, which is not possible as if it is zero in any one frame, it will be zero in all other frames also and it is possible if and only if there is no magnetic field produced outside the cylinder.
So, there is something wrong with the existing concept of electrodynamics. This problem arose because of the wrong correction in the Amperes law (mentioned in Sec-8.2), which is "changing electric field produces magnetic field." The actual cause of magnetic field is not the change of electric field but it is the motion of electric field (we will prove it later mathematically).

7.3 Tom Colbert Paradox (w.r.t. electric field)

Suppose there is an electric field $\vec{E} = E_0\,t\,\hat{k}$ in the region $x, y\;\epsilon\;(-\infty, \infty)$. Here, the electric field is increasing with time linearly. According to the Maxwell's fourth equation, this changing electric field will produce magnetic field in the given region.
The question that arises here is, what will be the direction of the magnetic field produced at any general point P(x, y)? If a magnetic charge is placed at that point P, in which direction, it will move?

At every point, the electric field is changing in identical manner, which leads to the direction of produced magnetic field to be indeterminate or unpredictable as each direction is equally valid for it. There is no such parameter in Ampere-Maxwell law that restricts this direction in any one particular direction.
But this is not possible that a vector quatity (magnetic field) have an unpredictable direction. It will have or must have a fixed direction.
The other possibility is that the produced magnetic field will encircle the changing electric flux region as given by equation

$$
\begin{aligned}
&B = \mu\epsilon\,\frac{r}{2}\frac{dE}{dt}\\
&\text{(circling around the changing flux region)}
\end{aligned}
\tag{46}
$$

as shown in figure-19, which is also not true as we still have the same problem regarding the direction of produced magnetic field at a given point.

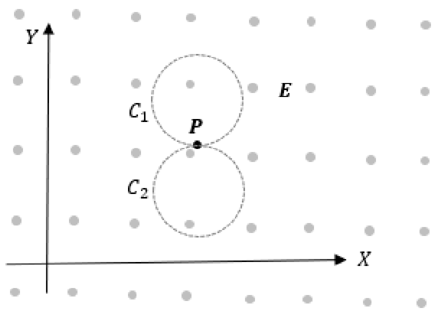


Figure 19: Changing electric field over infinite region

If we take the region C_1 (fig-19), the direction of the produced magnetic field at P will be along the x-axis (anticlockwise direction, because the magnetic field is increasing). But if we take the region C_2, then the direction of $\vec{B}$ at that same position P changes to -x axis (still anticlockwise because

of increasing field increasing). Its direction is depending on the region we are choosing, which is not possible as it will have a fixed direction which will be independent the loops chosen.
At end, if someone concludes that there will not be any magnetic field produced at point P, then it will be also wrong as it is against the Maxwell's fourth law which states that, for a closed loop, the closed line integral of magnetic field is equals to $\frac{d\Phi_B}{dt}$ which is non-zero here and so, it implies that the produced magnetic will also be non-zero.
These all again indicates that there is something wrong with Maxwell's law.
Solution of this paradox :
Whenever a field changes at any random point P, then the produced field can have two possibilities: either it encircles the point P (flux changing region) or it passes through the point P.
The first one can't be true as proven in sec-7.2, and here also, if we use this fact then the direction of $\vec{B}$ will remain indeterminate at every points (i.e., direction of force on the placed magnetic charge remains unpredictable).
Hence, we left with the second one, which also seems to be incorrect because in this case also, the direction of $\vec{B}$ is indeterminate, but it is not incorrect; it is incomplete. Here is it's completion.
For a given field in space, we have only two information regarding the field:
(i) Field itself and
(ii) its position (flux line)
Strength of field at any point can change in combination of these two ways:
I) Change of flux density, without any change in position of flux line
Number of flux line or the strength of flux lines increases/decreases without any change in position of flux lines (Formation or strengthening of flux line)
II) Change of flux density due to change in position of flux line, without any formation or strengthening of flux

Note: Position of line-structured quantity (like field line) refers to the position of that point on the line which is nearest to the origin, i.e., position of field line = position of nearest point on that field line.

Whenever magnetic field is produced by changing electric field, it will be always perpendicular to it (i.e, $\vec{B}_{produced} \perp \vec{E}_{producer}$). So, the one parameter only (the electric field itself) can never decide that direction of the produced magnetic field, as every direction will be equivalent for it. It indicates that there must be another vector parameter that restricts this direction in one single direction. The additional information we have is the position vector of the flux line. But it is a frame-dependent quantity, and so it can't be our required parameter as $\vec{B}$ can't depend on the frame from which it is observed. The change of position vector doesn't depend on frame, and this is our required parameter that determines the direction of the produced electric field. Equation-4 also suggests the same thing as $\vec{B} = \mu\epsilon \dfrac{\Delta\vec{x}}{\Delta t} \times \vec{E}$.
Hence, the direction of $\vec{B}$ is along $\Delta\vec{x} \times \vec{E}$ or $\vec{v} \times \vec{E}$. This equation further reduces to Maxwell's fourth law with little modification, mentioned in Sec-8.1.

Conclusion of this paradox: Conclusion of this paradox is that *"if electric field changes without any change in position of its flux lines, it won't produce any magnetic field"*, otherwise direction of produced magnetic field at any point will be unpredictable (as $\Delta\vec{x} = 0 = \vec{v}$), which is not possible for a vector quantity. (later, we will derive this conclusion mathematically also (sec-8.2))
This explains the previous two experiment also as in the first one (sec-7.1), position of E_z is not changing, even the position of charge is changing (position of flux line changes only when it moves (or has a velocity component) in a direction perpendicular to itself) and so, it doesn't produces any magnetic field. In the second experiment (sec-7.2), same thing is happening i,e position of electric flux line is not changing.
So, the only condition to produce a magnetic field is to change the position of electric flux line.

8 Modifying Ampere-Maxwell law

We can derive the evergreen Ampere-Maxwell law using transformation equation-4. But before that, we need to see something more.

8.1 Different forms of $\dfrac{d\Phi}{dt}$

Sometimes, the same mathematical expression represents multiple things. Rate of change is one of them.
For example, the rate of change of mass, i.e., $\dfrac{dm}{dt}$, can be mass flowing per unit time through a given

surface, called the flow rate. For the fluid flowing through a pipe, it is equal to $\rho A v$, where ρ, A, v are density, area of tube, and velocity of the fluid, respectively.
Also, $\frac{dm}{dt}$ can be mass increasing or decreasing in a given volume V per unit time, called the change rate or accumulation rate, which is equal to $V\frac{d\rho}{dt}$.
Both are represented by the same mathematical expression $\frac{dm}{dt}$, but they are totally different as one is defined w.r.t. surface (flow rate) while another is w.r.t. volume or closed surface (accumulation rate).

$$\frac{dm}{dt} = \frac{d(\rho V)}{dt} = \underbrace{\rho\frac{dV}{dt}}_{\substack{\text{Flow rate} \\ =\rho\frac{A\,dr}{dt}=\rho A v}} + \underbrace{V\frac{d\rho}{dt}}_{\text{Accumulation rate}} \tag{47}$$

In similar fashion, $\frac{d\Phi}{dt}$ is of two types:
(1) Flow rate (2) Change rate
Mass is a three-dimensional quantity; hence, flow rate and accumulation rate are defined w.r.t. surface and volume, respectively, but field line is a one-dimensional quantity, and so it's flow rate and change rate are defined w.r.t. line and surface, respectively.

$$\frac{d\Phi}{dt} = \frac{d(\vec{E}\cdot\vec{A})}{dt} = \frac{d(E_\perp A)}{dt} = E_\perp\frac{dA}{dt} + A\frac{dE_\perp}{dt}$$
$$= \text{Flow rate} + \text{Change rate} \tag{48}$$

(1.) $\frac{d\Phi}{dt}$ as flow rate: $\frac{d\Phi}{dt}\Big|_F$

$$\frac{d\Phi}{dt}\bigg|_F = E_\perp\frac{dA}{dt} = E_\perp\frac{l\,dr_\perp}{dt} = E_\perp l v_\perp$$
$$= (\vec{v}\times\vec{E})\cdot\vec{l} = \int(\vec{v}\times\vec{E})\cdot d\vec{l} \tag{49}$$

It is the measurement of flow of electric field $\vec{E}_\perp$ (due to $v_\perp$) w.r.t. the line $\vec{l}$, in direction perpendicular to it . It is equal to the amount of normal flux flowing through a given line l in its perpendicular direction per unit time.
In any region, if the strength of electric field is not increasing or decreasing with time, it doesn't mean $\frac{d\Phi_E}{dt} = 0$. For this situation, only flux change rate is zero, i.e., $\frac{d\Phi}{dt}\Big|_C = 0$.
In case of current-carrying wire, region near the wire has $\frac{d\Phi}{dt}\Big|_C = 0$, but $\frac{d\phi}{dt}\Big|_F \neq 0$ because the electric fields always move with its source charge. The close line integral of magnetic field produced around the wire due to this flowing electric field can also be written as (using equation-4 and 49)

$$\oint \vec{B}\cdot d\vec{l} = \oint \mu\epsilon\,(\vec{v}\times\vec{E})\cdot d\vec{l} = \mu\epsilon\,\frac{d\Phi}{dt}\bigg|_F \tag{50}$$

which equals to μI (for long wire) as (using equation-49)

$$\mu\epsilon\,\frac{d\Phi}{dt}\bigg|_F = \mu\epsilon\; v_\perp E_\perp l = \mu\epsilon\; v_\perp\frac{\lambda_e}{2\pi\epsilon r}2\pi r = \mu I$$
$$I = \epsilon\,\frac{d\Phi}{dt}\bigg|_F \tag{51}$$

(2.) $\frac{d\Phi}{dt}$ as change rate: $\frac{d\Phi}{dt}\Big|_C$

$$\frac{d\Phi}{dt}\bigg|_C = A\frac{dE_\perp}{dt} \tag{52}$$

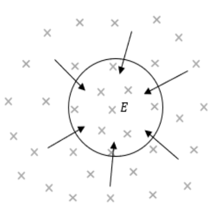
It is measurement of change of electric field $\vec{E}_\perp$ w.r.t. the area A. It is the amount of normal flux increasing or decreasing in a given area A per unit time.
Change of flux is of two types:
(i) Non-positional change: It is a change of electric field $\vec{E}_\perp$ in the given area without any change in position of the flux line. Let's denote the rate of this change as $\frac{d\Phi}{dt}\Big|_{npc} = A\frac{dE_\perp}{dt}\Big|_{npc}$ (eg-sec-7.2).
(ii) Positional change: In this case, electric field $\vec{E}_\perp$ changes in the given area due to the change of position of flux line. Let's denote this with $\frac{d\Phi}{dt}\Big|_{pc} = A\frac{dE_\perp}{dt}\Big|_{pc}$.

Total change in the given area is the sum of these two changes i.e.,

$$\frac{d\Phi}{dt}\bigg|_C = A\frac{dE_\perp}{dt}\bigg|_{npc} + A\frac{dE_\perp}{dt}\bigg|_{pc} \tag{53}$$

Relation between positional change rate and flow-in rate (flow rate of flux moving inside the loop)

For any closed loop L (perimeter=l), containing area A, positional change rate of flux is equal to flow rate of normal flux moving inside the loop from outside (through perimeter of the area), i.e.,



$$\frac{d\Phi}{dt}\bigg|_{pc} = \frac{d\Phi}{dt}\bigg|_{F(inside)} \tag{54}$$

as it can't happens in any other way i.e, in case of positional change, $\vec{E}_\perp$ increases only when more flux comes inside from the out side of the loop . So, $\oint \vec{B} \cdot d\vec{l}$ due to this inside flowing flux will be (using equation-4 and 49)

$$\oint \vec{B} \cdot d\vec{l} = \oint \mu\epsilon\,(\vec{v} \times \vec{E}) \cdot d\vec{l} = \mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{F(in)}$$

$$= \mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{pc}$$

$$\boxed{\oint \vec{B} \cdot d\vec{l} = \mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{pc}} \tag{55}$$

Simplifying this equation using Gauss-divergence theorem

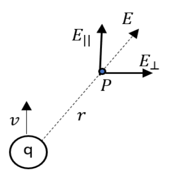
$$\int (\nabla\times\vec{B})\cdot d\vec{A} = \mu\epsilon \frac{d(\int \vec{E}\cdot d\vec{A})}{dt}\bigg|_{pc} = \mu\epsilon \int \frac{d\vec{E}}{dt}\bigg|_{pc} \cdot d\vec{A}$$

$$\nabla \times \vec{B} = \mu\epsilon\, \frac{d\vec{E}}{dt}\bigg|_{pc} \tag{56}$$

For moving charges, this equation becomes

$$\nabla \times \vec{B} = \mu\epsilon\, \frac{d\vec{E}_{\perp v}}{dt} \tag{57}$$

as at any point P (as shown in the figure),



$$\frac{dE}{dt} = \underbrace{\frac{d\vec{E}_{\|v}}{dt}}_{\text{Non-positional change}} + \underbrace{\frac{d\vec{E}_{\perp v}}{dt}}_{\text{Positional change}}$$

where $E_{\|v}$ and $E_{\perp v}$ is the component of electric field, along the velocity and perpendicular to the velocity of charge.

Modified Ampere-Maxwell law

Combining equations 50 and 55, we have

$$\oint \vec{B} \cdot d\vec{l} = \underset{\substack{\text{Due to}\\ \text{flow rate of}\\ \text{electric flux}}}{\mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{F}} + \underset{\substack{\text{Due to}\\ \text{change rate of}\\ \text{electric flux}}}{\mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{pc}} \tag{58}$$

which is equal to

$$\oint \vec{B} \cdot d\vec{l} = \mu I + \mu\epsilon\, \frac{d\Phi}{dt}\bigg|_{pc} \tag{59}$$

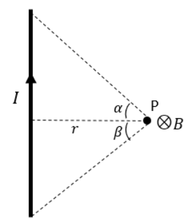
This equation is slightly different from the Ampere-Maxwell equation, as here, non-positional change rate of electric field is not allowed. Maxwell used mathematics to derive the second term, but there are mistakes in that (mentioned below).

8.2 Problem in Maxwell's correction in Ampere's law

(1) Maxwell used $\oint \vec{B} \cdot d\vec{l} = \mu I$ (Ampere law) to find the expression of displacement current, but this equation itself doesn't hold in every situation. It holds only for infinite-length wires and closed-loop circuits.

For a finite-length wire, the closed-line integral of the magnetic field can be written as

$$\begin{aligned}\oint \vec{B} \cdot d\vec{l} &= \oint \frac{\mu I}{4\pi r}\,(\sin\alpha + \sin\beta)\ \hat{n} \cdot d\vec{l} \\ &= \frac{\mu I}{4\pi r}\,(\sin\alpha + \sin\beta)\ 2\pi r \\ &= \mu I\ (\sin\alpha + \sin\beta)/2\end{aligned} \tag{60}$$



(2) Using Gauss-divergence theorem, Ampere's equation is modified as

$$\int (\nabla \times \vec{B}) \cdot d\vec{s} = \mu \int \vec{J} \cdot d\vec{s}$$

$$\nabla \times \vec{B} = \mu \vec{J} \tag{61}$$

Taking divergence to both sides and using the property of vector calculus

$$\underbrace{\nabla \cdot (\nabla \times \vec{B})}_{0} = \nabla \cdot (\,\mu\, \vec{J}\,)$$

Left side expression is always zero, but not the right side. Hence, to hold this equation, an extra term $\vec{J}_d$ is added in the above equation-61.

$$\underbrace{\nabla \cdot (\nabla \times \vec{B})}_{0} = \nabla \cdot\ \mu(\vec{J}\ + \vec{J}_d\ )$$

$$\nabla \cdot \vec{J}_d\ = -\nabla \cdot \vec{J} \tag{62}$$

$$\textbf{or},\ \vec{J}_d\ = -\vec{J} \tag{63}$$

Using equation of continuity of charge and Gauss law (equation-5), we can write above equation-62 as

$$\nabla\cdot\vec{J}_d = -\left(-\frac{d\rho}{dt}\right) = \frac{d(\epsilon\nabla\cdot\vec{E}_p)}{dt}$$

$$\left[\rho=\epsilon(\nabla\cdot\vec{E}_p),\ \text{but not } \epsilon(\nabla\cdot\vec{E}) \text{ or } \epsilon(\nabla\cdot\vec{E}_s)\ \right]$$

$$\nabla\cdot\vec{J}_d = \nabla\cdot\left(\epsilon\,\frac{d\vec{E}_p}{dt}\right) \tag{64}$$

But we can't write this equation-64 as

$$\vec{J}_d=\epsilon\,\frac{d\vec{E}_p}{dt} \tag{65}$$

because

$$\nabla\cdot\vec{A}=\nabla\cdot\vec{B} \quad \not\Rightarrow \quad \vec{A}=\vec{B}$$

$\vec{A}$ may or may not be equal to $\vec{B}$. For example: $\vec{A}=9x\hat{i}+y\hat{j}$ and $\vec{B}=5x\hat{i}+5y\hat{j}$. Here, the divergence of $\vec{A}$ and $\vec{B}$ are equal $\nabla\cdot\vec{A}=\nabla\cdot\vec{B}$, but they don't $\vec{A}\neq\vec{B}$ (neither the magnitude nor the direction). So, the only significance of equation-64 is that their divergence are equal but the expressions inside may or may not be equal, i.e., we can't conclude that $\vec{J}_d=\epsilon\,\frac{d\vec{E}_p}{dt}$.

(3) Consider the case as shown in fig-20 i.e., we have a tube filled with charged gas and a piston is attached on the top side. Here, the piston is pressed and a magnetic field is produced at point P due to the flow of ions inside it.

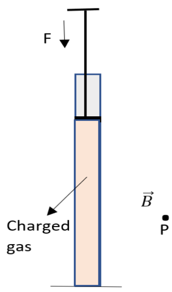


Figure 20: A charged gas tube with a piston

Here, $\vec{J}$ (conduction current) $\neq$ $\vec{J}_d$ (displacement current) as $\vec{J}$ is along -Y-axis while $\vec{J}_d$ is along $\vec{E}_p$ (taking $\vec{J}_d=\epsilon\,\frac{d\vec{E}_p}{dt}$), which is against equation-63.

So, (1), (2) and (3) shows that there are problems in Maxwell's correction. But we can find the actual equation using the concept of flow rate and accumulation rate as mentioned here:

Closed line integral of magnetic field due to conduction current will be

$$\oint\vec{B}\cdot d\vec{l}=\mu\epsilon\left.\frac{d\Phi}{dt}\right|_F=\mu I\,(\sin\alpha+\sin\beta)/2 \tag{66}$$

$$=\mu\epsilon\oint v_\perp E_\perp dl \tag{67}$$

It is produced due to moving $\vec{E}_\perp$ ($\vec{E}_\parallel$ can never produce any magnetic field). It can also be written as

$$\nabla\times\vec{B}=\mu\vec{J}\,(\sin\alpha+\sin\beta)/2 \tag{68}$$

If the current (I) doesn't flow uniformly ($\nabla\cdot\vec{J}\neq 0$) i.e., charges are accumulating somewhere then in that case, the corresponding moving $\vec{E}_\perp$ starts to accumulate in the surrounding region, which will also produces a curl of magnetic field given by equation-55 or 57 i.e.,

$$\nabla\times\vec{B}=\mu\epsilon\,\frac{d\vec{E}_{\perp v}}{dt} \tag{69}$$

So at point P, there will be two curl of magnetic field, one along the direction of conduction current (produced due to J) and another along the $\vec{E}_\perp$ (produced due to accumulating $\vec{E}_\perp$ (because of $\nabla\cdot\vec{J}\neq 0$ or accumulating charges)). On combining equation-68 and 69, we get

$$\nabla\times\vec{B}_P=\mu\vec{J}\,(\sin\alpha+\sin\beta)/2+\mu\epsilon\,\frac{d\vec{E}_{\perp v}}{dt} \tag{70}$$

For infinite length wire, it reduces to

$$\nabla\times\vec{B}=\mu\vec{J}+\mu\epsilon\,\frac{d\vec{E}}{dt} \tag{71}$$

as $\alpha=\beta=90^o$ and $\vec{E}_{\perp v}=\vec{E}$. If we apply divergence to both side here, we will get the same expression as we got from the Maxwell's correction procedure as mentioned in equation-64.

A suitable experiment is mentioned in paper-2 for the experimental verification of the equation-69.

8.3 Parallel plate capacitor experiment

For better understanding, let's take a single plate (effects will combine for a double plate system). Here are two plates (independent of each other) having the electrical connection as shown in fig-21, where both plates are becoming negatively charged because of current I. The direction of current in these two plates is in the opposite direction.

According to Maxwell's fourth equation, the magnetic field produced above the both plates

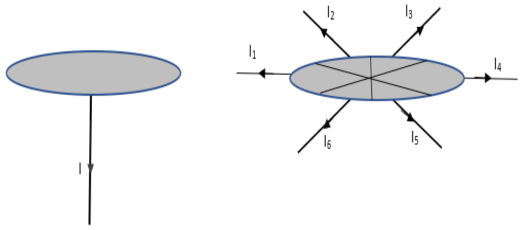


Figure 21: Plates with different electrical connections

(due to the changing electric field) will have the same direction (anti-clockwise) as $\frac{d\vec{E}}{dt} = -ve$ in both cases. But according to equation-59 (modified Maxwell law), it will be in the opposite direction as in second one $\frac{d\vec{E}}{dt}\Big|_{pc} = -ve$ (negative flux is flowing inside the loop) while in first one, it is $\frac{d\vec{E}}{dt}\Big|_{pc} = +ve$ (negative flux is flowing outside the loop).

Now question is which one is true?
As we have already seen in sec-8.2 that Maxwell's correction isn't true as it failed in the sec-7.1, 7.2 and 7.3, and after its correction, we got the equation-59 i.e., it is derived mathematically and so we can surely say that magnetic field will be produced in opposite direction.
We can see this situation in another way also as the plate can be treated as composed of two charged sheets, one positive charged sheet having fixed +ve charges and another a negative charged sheet having movable negative charge (free electrons). The electric field corresponding to the positively charged sheet can't create any magnetic field as it is stationary. So, presence of this field doesn't matter for the magnetic field (because of its $\frac{d\vec{E}}{dt}\Big|_{pc} = 0$). In both cases, magnetic field is generated only due to moving electrons or a moving electric field corresponding to a negatively charged sheet.
In the first figure, the plate is becoming negatively charged when electrons are moving away from the center, while in second figure, when it is toward the center. Because of this opposite direction of the electron's motion, the corresponding electric field ($E_\perp$) also moves in the opposite direction, and so produces the magnetic field is in the opposite direction. Hence, no matter what $\frac{d\vec{E}}{dt}$ is, production of magnetic field depends only on $\frac{d\vec{E}}{dt}\Big|_{pc}$.
So, it also proves that it is the motion of electric field which produces magnetic field , but not the change of electric field. (A suitable experiment is mentioned in paper-2 for its experimental verification)

8.4 Energy stored in the form of magnetic field

Energy stored in the magnetic field in volume dV is given as

$$dU = \frac{1}{2\mu} B^2 dV \tag{72}$$

In sec-6, we saw that magnetic field is nothing but the moving electric field itself, hence it can be written as $\vec{B} = \mu\epsilon\ \vec{v} \times \vec{E}$ or $B = \mu\epsilon\ vE \sin\theta$

$$\begin{aligned} dU_B &= \frac{1}{2\mu} B^2 dV = \frac{1}{2\mu}(\mu\epsilon\, vE\sin\theta)^2 dV \\ &= \frac{1}{2}(\mu\epsilon^2 E^2 \sin^2\theta\ dV\ v^2 \\ U_B &= \frac{1}{2}\left(\int \mu\epsilon^2 E^2 \sin^2\theta\ dV\right)\ v^2 \end{aligned} \tag{73}$$

which can be written as

$$U_B = \frac{1}{2} k v^2 \tag{74}$$

where $k = \int \mu\epsilon^2 E^2 \sin^2\theta\ dV$, θ is angle between $\vec{v}$ and $\vec{E}$. This magnetic energy is stored by the moving electric field by virtue of its motion i.e., if $v = 0$, magnetic energy stored will be zero.

Inertia of field

Suppose a charge of mass m is moving with initial velocity $\vec{u}$. It is then accelerated to velocity $\vec{v}$ by a force $\vec{F}$, by doing work W on it during its displacement dl. Using the conservation of energy (neglecting the energy radiated in the form of radiation during acceleration)

$$\begin{aligned} W &= \Delta(K.E) + \Delta(\cancelto{0}{P.E}) + \Delta U_B \\ &= \frac{1}{2}m(v^2 - u^2) + \frac{1}{2}k(v^2 - u^2) \\ &= \frac{1}{2}(m+k)(v^2 - u^2) \\ \Rightarrow \vec{F}\cdot d\vec{l} &= \frac{1}{2}(m+k)2\vec{a}\cdot dl \\ \Rightarrow \vec{F} &= (m+k)\vec{a} = m_{eff}\ \vec{a} \end{aligned} \tag{75}$$

where $m + k = m_{eff}$ is the effective mass of an electric charge+field system. It means k is inertia of the field (electric field), which is independent of

its velocity, as the mass of charge is m only.
Hence the equation 74 means that magnetic energy U_B is nothing but the kinetic energy stored in the primary electric field because of its inertia (if $v = 0 \Rightarrow U_B = 0$). So, magnetic energy also is not the energy stored in any such real field called magnetic field, but it is just the K.E of primary electric field.

When a charge accelerates, its mass opposes the change of state of charge, while the inertia of the field line opposes the change of state of the field line. Charge and field are constrained together, and so the change in state of the charge+field system is opposed by m_{eff}, i.e., to accelerate a charge of mass m with acceleration a, an extra force ka is needed in addition to ma (neglecting the oppose due to radiation loss). This ka force is responsible for the transfer of energy to the field, which is stored as kinetic energy in the field. When charge retards (somehow), this field's kinetic energy or field's momentum tries to maintain the state of motion (inductive property).
• Self-energy of an electric field (per unit volume) is $U_E = \frac{1}{2}\epsilon E^2$ and it doesn't depends on its velocity.

8.5 Phase difference between producer and produced fields

As we saw that moving electric field itself is the magnetic field and so the phase difference between E and B will be always zero. In the case of propagation of electromagnetic magnetic wave in a conducting medium, this phase difference between E and B becomes non-zero because here we measures the phase difference between the [electric field of the wave] and [magnetic field of the wave + magnetic field produced by the current density J_c arises in the medium due to that electric field of traveling wave] and so overall phase difference becomes non-zero (as J_c lags behind J_d). But the phase difference between the individual electric and magnetic field (producer and produced electric and magnetic field) still remains zero.

9 Deriving Faraday law using the concept of electric drag force

Faraday law is also an experimental law. But we can derive it using the electric drag force equation because it is also the consequence of electric drag force.

1. For absolute magnetic field:
As we have already seen, magnetic field doesn't exist. The magnetic force on a moving charge in a magnetic field is basically an electric drag force. For absolute magnetic field, it is given by equation-34, which is

$$\vec{F}_q = q\vec{v}_{q,B} \times \vec{B}$$

If it generates any EMF in a closed loop (perimeter=l), it will be equals to

$$\begin{aligned}\mathcal{E} = \frac{\oint \vec{F}_q \cdot \vec{dl}}{q} &= \oint (\vec{v}_{q,B} \times \vec{B}) \cdot \vec{dl} \\ &= -\oint (\vec{v}_{B,q} \times \vec{B}) \cdot \vec{dl}\end{aligned} \tag{76}$$

Here, $\vec{v}_{B,q}$ is velocity of magnetic field w.r.t. charge or coil. Proceeding in the same fashion as did for Ampere-Maxwell law, we get

$$\boxed{\mathcal{E} = -\left.\frac{d\Phi_B}{dt}\right|_{pc} = -\left.\frac{d\Phi_B}{dt}\right|_{F(inside)}} \tag{77}$$

which can also be written as

$$\oint \vec{E}_s \cdot \vec{dl} = -\left.\frac{d\Phi_B}{dt}\right|_{pc} \tag{78}$$

as $\mathcal{E} = \oint \vec{E} \cdot \vec{dl} = \oint(\vec{E}_p + \vec{E}_s) \cdot \vec{dl} = \oint \vec{E}_s \cdot \vec{dl}$. So, secondary electric field is nothing but the equivalent electric field corresponding to electric drag force i.e, drag force experienced by a unit charge, $\vec{E}_s = \frac{\vec{F}_d}{q}$.
Here this positional change is w.r.t. coil ($\vec{v}_{B,q}$), which means that if magnetic field is stationary and area of coil is increasing, in this case also, EMF will be generated in the coil.
This magnetic field is an absolute magnetic field, and so this EMF will remain same for every frame of reference.
2. For non-absolute magnetic field:
In non-absolute magnetic field, force on charge is given by equation-17 i,e

$$\vec{F}_q = a\mu\epsilon\, q\vec{v}_{E,q} \times (\vec{v}_{E,q} \times \vec{E})$$

which can also be written as

$$\vec{F}_q = a\, q\vec{v}_{E,q} \times \vec{B}_q$$

where $\vec{B}_q$ is the magnetic field of system, when observed from the charge (or coil) frame , i.e., magnetic field w.r.t. any random frame is not allowed in this equation.
Put $\vec{v}_{E,q} = \vec{v}_{B,q}$ (as moving electric field itself is the magnetic field) and proceed in the same way i.e.,

if this force produces any EMF in a closed loop, it will be

$$\mathcal{E} = \frac{\oint \vec{F}_q \cdot \vec{dl}}{q} = a \oint (\vec{v}_{B,q} \times \vec{B}_q) \cdot \vec{dl} = a \left. \frac{d\Phi_{B_q}}{dt} \right|_{pc}$$

$$\oint \vec{E}_s \cdot d\vec{l} = a \left. \frac{d\Phi_{B_q}}{dt} \right|_{pc} \quad (79)$$

where Φ_{B_q} is the magnetic flux of the system, measured from the charge (i.e., coil) frame. This positional change rate of magnetic field is w.r.t. coil but not w.r.t. any random frame.
The value of a here is not always -1, but it depends on the situation, as for the situation shown in fig-8(b), $a = -1$, and for figures 12, 14 and 21, $a = -\frac{1}{2}$.

In fig-10(b), there is a net increasing magnetic flux inside the coil for S', but still the EMF induced in it is zero because the change of magnetic flux inside the coil w.r.t. the coil is zero i.e., $\frac{d\Phi_{B_q}}{dt} = 0$ while in figures 9,12 and 14, changing magnetic flux is zero in the frame of electric field, but still EMF induces because it is non-zero in charge or the coil frame ($\frac{d\Phi_{B_q}}{dt} = 0$).

9.1 Concept of induced electric field (generation of EMF due to accelerating charges)

As we saw that field line possesses inertia. Due to this, whenever a charge accelerates, its field line bends and makes the curl of the field non-zero ($\nabla \times \vec{E}_p \neq 0$), i.e., the primary electric field becomes non-conservative if the corresponding charge accelerates.
For a charge, the curl of its field at any point P having electric field strength $\vec{E}$ (before acceleration) is proportional to the acceleration of charge, the field E, and sin of the angle (θ) between the direction of electric field and acceleration (because bending is caused by the acceleration's component, which is perpendicular to the field).

$$|\nabla \times \vec{E}| \propto E \, \frac{dv}{dt} \sin\theta \quad \Rightarrow \quad \nabla \times E = a'(\vec{E} \sin\theta) \, \frac{dv}{dt} \hat{n}$$

where v is the velocity of charge, a' is a constant and $\hat{n}$ is a unit vector along $\nabla \times \vec{E}$. If the acceleration of charge is zero, then $\nabla \times \vec{E} = 0$, i.e., field is conservative.
Replacing the constant a' with $a' = a"\mu\epsilon$, we get

$$\nabla \times E = a"\mu\epsilon\vec{E}\sin\theta\frac{dv}{dt}\hat{n} = a"\frac{d}{dt}(Ev\sin\theta)\hat{n} = a"\frac{d\vec{B}}{dt}$$

If a coil is placed near this type of accelerating charge, a net EMF will be generated in the coil given by

$$\mathcal{E} = \oint \vec{E}.d\vec{l} = \int (\nabla \times \vec{E}) \cdot d\vec{s} = \int \left(a"\frac{d\vec{B}}{dt} \right) \cdot d\vec{s}$$
$$= a"\frac{d}{dt} \left(\int \vec{B} \cdot d\vec{s} \right) = a"\frac{d\Phi_B}{dt} \quad (80)$$

• Similarly, when a coil is placed in a changing magnetic field of a variable current-carrying wire, EMF induces in it, not because of change of any such real magnetic field but because of the bending of primary electric field.
• In the case of the solenoid also (having variable current), it seems like the changing magnetic field (inside) of the solenoid produces an electric field called as induced electric field, which causes the production of EMF in a coil placed inside or outside of the solenoid. But the actual reason is the non-conservative nature of the primary electric field of the accelerating charges. So the conclusion is that the induced electric field is also an phenomena of primary electric field.

10 Failure of Electromagnetic Wave Equation

10.1 EM wave generation due to a charge

When a charge moves with some velocity $\vec{v}$, then at any general point P (ρ, ϕ, z), both electric field and magnetic field change with time as

$$\vec{E}_p = \frac{kq\ \hat{r}}{\rho^2 + (z - vt)^2}\ ,\ \vec{B}_p = \frac{\mu}{4\pi}\frac{qv\rho}{(\rho^2 + (z - vt)^2)^{\frac{3}{2}}}\hat{\phi}$$

as mentioned in sec-7.1. Here, $\frac{d\vec{E}}{dt} \neq 0$, $\frac{d\vec{B}}{dt} \neq 0$ and so $\nabla \times \vec{B} \neq 0$, $\nabla \times \vec{E} \neq 0$. According to Maxwell's equation, whenever electric field or magnetic field changes, generation of electromagnetic wave takes place due to sequential formation of $\vec{E}$ and $\vec{B}$ field (as equations 1 and 2 describe). The only condition required for the generation of an electromagnetic wave is the changing electric field or magnetic field. Also, the Maxwell equation doesn't care about how the field is changing, i.e., whether it is from moving charge or from accelerating charge, in both cases, equation-1 and 2 will behave in the same way. So, according to it, generation of EM wave should take place in case of moving charge also (and also in the fig-22(b) and (c) as the electric and magnetic field is changing at

point P, periodically). But it doesn't happen and so, it the failure of concepts as well as the equation of electromagnetic wave.
If it generates, it will be a violation of the law of conservation of energy because a stationary charge also has some velocity with respect to some other observer, i.e., moving with respect to someone.

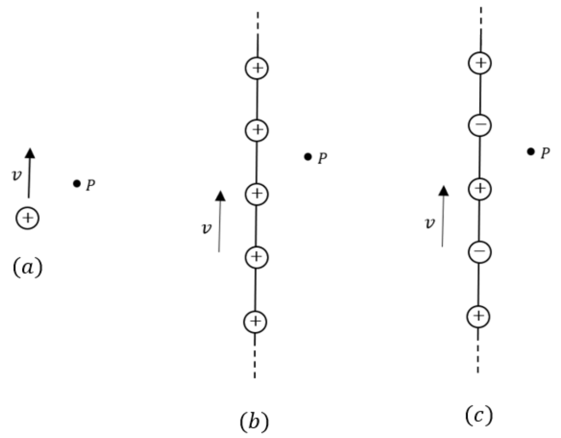


Figure 22: Moving charges

An EM wave will be generated if and only if the source charge accelerates (Larmor formula); otherwise not, even the electric or magnetic field changes with time.
So why is this acceleration important, which is not even required to derive the traveling wave equation using Maxwell's equation?

10.2 Problem in derivation of electromagnetic wave equation

Maxwell's third law $\left(\nabla \times \vec{E} = -\frac{d\vec{B}}{dt}\right)$ is valid only when producer field is magnetic field and produced field is electric field (i,e magnetic field is changing and electric field is getting produced). For reverse of this situation , this equation doesn't hold.
similarly, Maxwell's fourth law $\left(\nabla \times \vec{B} = \mu(\vec{J} + \epsilon\frac{d\vec{E}}{dt})\right)$ holds only when producer is electric field and produced field is magnetic field.
According to Maxwell, electric field produces magnetic field and magnetic field produces electric field and in this fashion, sequential production of field takes place which results into continuous propagation of electromagnetic wave. But there is a problem with this as mentioned here:
Suppose these is space having changing magnetic field (B_1), then it produces electric field (E_1) as

$$\nabla \times \vec{E}_1 = -\frac{d\vec{B}_1}{dt}$$

Now this E_1 also changes with time which further produces magnetic field (B_2) as

$$\nabla \times \vec{B}_2 = \mu\epsilon\frac{d\vec{E}_1}{dt}$$

Again this produced B_2 produces electric field E_2 as

$$\nabla \times \vec{E}_2 = -\frac{d\vec{B}_2}{dt}$$

In this way, we have

$$\nabla \times \vec{E}_n = -\frac{d\vec{B}_n}{dt} \quad \text{and} \quad \nabla \times \vec{B}_{n+1} = \mu\epsilon\frac{d\vec{E}_n}{dt}$$

On combining these equations using property of vector calculus, we get

$$\nabla^2\vec{E}_{n+1} = \mu\epsilon\ \frac{d^2\vec{E}_n}{dt^2} \quad \text{and} \quad \nabla^2\vec{B}_{n+1} = \mu\epsilon\ \frac{d^2\vec{B}_n}{dt^2}$$

But these equations are not the equation of traveling wave as E_n and E_{n+1} have different position. In wave equation, both side contain the amplitude of same position with LHS as changing amplitude w.r.t. distance and RHS as changing amplitude w.r.t. time. But here, it is not same as E_n and E_{n+1} have the different positions and E_n act as a producer or cause of E_{n+1}. If E_n and E_{n+1} have same position, then it can't create a traveling wave as the next produced field will superimpose over the previous field. Hence it is not the actual traveling wave equation of EM wave and the wave velocity we get from this equation matches with the actual value (experimental) but it is not the actual way of finding (as we have already seen in Sec-5.5 and in the case of calculation of the magnetic forces between two current wire that the matching of few results only doesn't always prove that the physics or theory used behind is 100% right).

10.3 Non-existence of magnetic field

As proved in sec-6 that magnetic field doesn't exist i,e it doesn't have any physical existence. In another word, magnetic field is just a mathematical parameter which measures the flow of electric field as given by equation-4.
So,(i) neither the changing electric field nor the moving electric field produces any further field, called as magnetic field and similarly
(ii) neither the changing magnetic field nor the

moving magnetic field produces any field further (called as secondary electric field) as it itself doesn't exist

So, the propagation of wave in space doesn't happens in the way as explained by Maxwell (sequential formation of E and B field in space) as the only field which exist is the primary electric field.

Secondary electric field also doesn't exist as the effect shown by the electric field produced by moving magnetic field is the effect of electric drag force (we will see the case of permanent magnet later) and the induced electric field produced by changing magnetic field is the bending of primary electric field i.e., the non-conservative nature of primary electric field.

So, these above three failure proves that our understanding regarding the generation and propagation of electromagnetic electromagnetic wave is wrong.

Generation and propagation of electromagnetic wave

Here, we have three points, which has been proved earlier:

1) An EM wave get generated only when the charges accelerate or oscillate.

2) The only field that exists (among all types of $\vec{E}$ and $\vec{B}$ fields) is the primary electric field.

3) A primary electric field possesses inertia.

Using these facts, we can clearly say that the electromagnetic wave is a phenomenon of primary electric field. Because of the inertial property of the primary electric field, when a charge accelerates or oscillates, it generates wave pulse on its field (primary), which propagates continuously to infinity, and that is our electromagnetic wave. Even though the strength of the primary electric field decreases with distance, electromagnetic waves don't decay to infinity (and the reason is mentioned in Sec-13.2.1). This wave carries a mathematical term $\vec{B}$ with itself as a magnetic field always travels with its producer electric field, and so, on putting $v = c$ in equation-4, it becomes $B = E/c$. The effect shown by this $\vec{B}$ is the effect of $\vec{E}$ as drag force.

So, light (EM wave) is a pure electric wave. It also requires a medium to propagate, which is nothing but the primary electric field. This medium always moves along with the producer of the wave (as electric field always travels along with the charge) and this is what Michael-Morley experiment proves, i.e., w.r.t. the experimental setup, the speed of light is the same in every possible direction, irrespective of the velocity of the setup or any external medium called ether because the medium itself travels with the setup.

11 Non-rotational property of primary electric field

When a charge changes its direction of motion or traverses any type of curve path, the orientation of the electric field of the charge doesn't change. Suppose an electron is moving in the x direction with the electric field's orientation as shown in fig-23, when it changes its direction to the y axis, this orientation of the electric field remains the same (fig-23(a)), i.e., it doesn't change to figure (b).

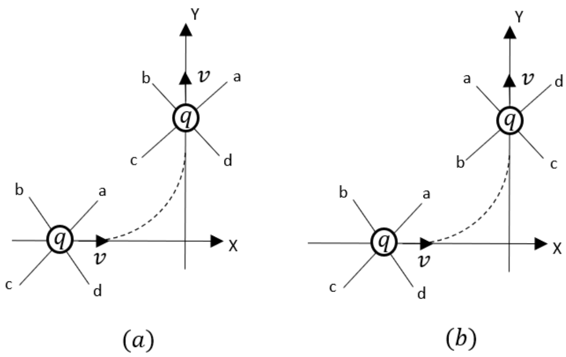


Figure 23: A charge is changing its direction of motion

Taking the case of magnetic field produced by the circular current carrying wire at centre :

Electric field due to elemental moving charge $\lambda_e dl$ at the center will be

$$d\vec{E} = \frac{\lambda_e dl}{4\pi\epsilon R^2}\ \hat{r} \tag{81}$$

If fig(b) is true, then velocity of this electric field at center will be zero and so the magnetic field also should be zero as

$$d\vec{B} = \mu\epsilon\ \vec{v} \times d\vec{E} = 0 \tag{82}$$

But, it isn't true which proves that fig. (b) is not correct.

If we consider fig-a, then velocity of eletric field at centre will be same as velocity of moving electron

($v_E = v_e$) and so

$$\begin{aligned} d\vec{B} &= \mu\epsilon\ \vec{v}_E \times d\vec{E} = \mu\epsilon\ v_e\ dE\ \hat{n} \\ &= \mu\epsilon\ v_e\ \frac{\lambda_e}{4\pi\epsilon R^2}\ dl\ \hat{r} = \frac{\mu}{4\pi}\frac{\lambda_e\ v_e}{R^2}\ dl\ \hat{n} \\ &= \frac{\mu}{4\pi}\frac{I}{R^2}\ dl\ \hat{n} \\ \vec{B}_R &= \int \frac{\mu}{4\pi}\frac{I}{R^2}\ dl\ \hat{n} = \frac{\mu I}{2R}\ \hat{n} \end{aligned} \tag{83}$$

So, it proves that fig. (a) is correct i,e orientation of field doesn't changes with change in direction of motion of charges. It also gives the reason why $\nabla\cdot\vec{B}$ is always zero. A charge can't produce any magnetic field due to the rotation of its field i.e., magnetic field is always due to linear motion of electric field, and it is (taking direction of velocity of charge as z-axis)

$$\begin{aligned} &\vec{B} = \vec{v}\times\vec{E} = \vec{v}\times(\vec{E}_\rho + \vec{E}_z) = \vec{v}\times\vec{E}_\rho\ = v\,E_\rho\ \hat{a}_\phi \\ &\Rightarrow \nabla\cdot\vec{B} = \frac{1}{\rho}\frac{\partial}{\partial\phi}(v\,E_\rho) = 0 \end{aligned} \tag{84}$$

But what if a field can rotate?
Suppose we have a charge whose charge+field is rotating with angular velocity ω about the z-axis (at origin) as shown in fig-24. The magnetic field produced at any point P(r,θ,ϕ) will be

$$\begin{aligned} \vec{B} &= \mu\epsilon\ \vec{v}\times\vec{E} = \mu\epsilon\ (\vec{\omega}\times\vec{r})\times\ \vec{E} \\ &= \mu\epsilon\ (\omega r\sin\theta)\ \hat{a}_\phi\times\ \vec{E} \\ &= \mu\epsilon\ \omega r\sin\theta\ E\ \ \hat{a}_\theta \end{aligned} \tag{85}$$

Taking divergence

$$\begin{aligned} \nabla\cdot\vec{B} &= \frac{1}{r\sin\theta}\ \ \frac{\partial}{\partial\theta}(\mu\epsilon\ \omega r\sin^2\theta\ \ E) \\ &= \frac{1}{r\sin\theta}\ \ \mu\epsilon\omega r\ 2\sin\theta\cos\theta\ E \\ &= 2\mu\epsilon\omega\ E\ \cos\theta \end{aligned} \tag{86}$$

Here, the divergence of produced magnetic field can be non-zero. For $\theta\ \epsilon\ (0^o, 90^o)$, $\nabla\cdot\vec{B} > 0$ and for $\theta\ \epsilon\ (90^o, 180^o)$, $\nabla\cdot\vec{B} < 0$. It means half of the space acts as magnetic north monopole and half as magnetic south monopole. Collectively, it is acting as a dipole but not as same as the dipole formed by the permanent magnet or electromagnet. In that case, the divergence of the magnetic field at every point, even at the pole, is zero, and the associated field line is a close field line. But here, the magnetic field line is not closed, as it is emerging from one side, going to the other side, but not returning back. This dipole is equivalent to an electric dipole formed by electric charges.

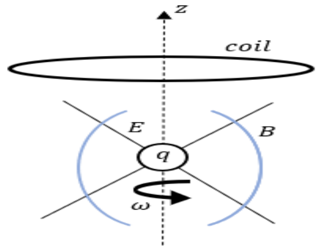


Figure 24: A rotating charge+field system

If this rotating system passes through a stationary coil with velocity v' (along its axis of rotation (z-axis)), it will produce a current I

$$\begin{aligned} I &= \frac{\mathcal{E}}{R} = \frac{\oint(\vec{B}\times\vec{v}')\cdot d\vec{l}}{R} = \frac{B_\rho v' l}{R} = \frac{\mu\epsilon\,\omega r\sin\theta E_z v' l}{R} \\ &= \frac{\mu}{4\pi r}\frac{q\omega v' l}{R}\sin\theta\cos\theta \end{aligned} \tag{87}$$

$$\begin{bmatrix} \vec{B} & = \mu\epsilon\ (\omega r\sin\theta)\ \hat{a}_\phi\times(\vec{E}_\rho + \vec{E}_z) \\ & = \mu\epsilon\ \omega r\sin\theta E_\rho\ \hat{a}_z + \mu\epsilon\ \omega r\sin\theta E_z\ \hat{a}_\rho \end{bmatrix}$$

But it can't happen as an electric field doesn't rotate. However we can achieve it indirectly as instead of rotating the charge, rotate the coil. For a rotating observer, this whole universe is rotating. So, if an observer is at the center of the rotating coil, all the surrounding fields of the charge will be rotating for it, exactly same as assumed earlier. Hence, in this case, if charge passes through it, the same current I current will induce.
So in this case, there is no magnetic field at all in the charge frame, but still the same current will be induced because of the drag force as

$$\begin{aligned} \mathcal{E} &= \oint \vec{F}_{(\perp,E_z)}\cdot d\vec{l} = \oint \frac{E_z(wr\sin\theta)(v')}{c^2}dl \\ &= \frac{1}{c^2}\left(\frac{q}{4\pi\epsilon r^2}\cos\theta\right)v' wr\sin\theta l \\ I &= \frac{\mathcal{E}}{R} = \frac{\mu}{4\pi r}\frac{q\omega v' l}{R}\sin\theta\cos\theta \end{aligned} \tag{88}$$

Hence, it is the same for every frame of reference. If we use the concept of magnetic field, it can't be explained.
It proves that, **for rotating observer,** $\nabla\cdot\vec{B}\neq 0$.

So note that, if an alpha or beta particle (or any charge particle) when passes through a rotating metal tube in discrete fashion (so that $E_z\neq 0$), it will produce a current in the tube. This current will be opposite on either side of the moving charge, and the speed of the moving charged particle will reduce gradually (a suitable experiment is mentioned in paper-2 for its experimental verification).

Its reverse technique can be used to accelerate or decelerate the charge.

12 Failure of Atomic Model

Here we have a total of three failures of the atomic model. The reason for all these three failures is the high revolving speed of electrons inside atoms.

1st Failure: Electric drag force on atom

In sec-5 (equation-21 and fig-14), it is proved that drag force in direction of applied electric field ($\vec{F}_{\parallel E}$) is independent of direction of motion of charge, and in sec-5.2.1, stationary charge also applies magnetic force on moving charge, in which the $\vec{F}_{\parallel E}$ component is independent of direction of velocity of moving charge.
It is also proved (sec-6) that we don't have any option other that equation-17 (Electric drag force equation). All the experiment of paper-2 also will prove the drag property of electric field.

According to Bohr's atomic model, an electron's revolving speed inside an atom is around 10^6m/s. So, if it is true, then a material, when placed in an electric field of strength E, should experience an electric drag force, given by

$$F_{\parallel E} = qE\,\frac{(v_{r\perp})^2}{2\,c^2} \quad , \quad F_{\perp E} = qE\,\frac{(v_{r\perp}\ v_{r\parallel})}{c^2}$$

(taking the dielectric constant of material as 1). Let the velocity of electron inside atom is $\vec{v} = v\cos\theta\ \hat{z} + v\sin\theta\cos\phi\ \hat{x} + v\sin\theta\sin\phi\ \hat{y}$. Here, $v_{r\parallel} = v\cos\theta$ and $v_{r\perp} = v\sin\theta$ (taking the direction of $\vec{E}$ as z-axis).

Using the equation-21, $\vec{F}_{\perp E}$ force on atom is

$$F_{\perp E} = qE\,\frac{(v_{r\perp}\ v_{r\parallel})}{c^2} = qE\,\frac{v\sin\theta\ v\cos\theta}{c^2}$$

Taking average of this force (θ varies with time during the revolution of electron) for significant duration of time, we get

$$< F_{\perp E} > = qE\,\frac{v^2}{c^2} < \sin\theta\cos\theta > = 0 \qquad (89)$$

Overall force on the sample in $\vec{E}_\perp$ direction is zero. But, $F_{\parallel E}$ force on atom is

$$F_{\parallel E} = qE\,\frac{(v_{r\perp})^2}{2\,c^2} = qE\,\frac{v^2\sin^2\theta}{2\,c^2}$$

Taking average

$$< F_{\parallel E} > = qE\,\frac{v^2}{2\,c^2} < \sin^2\theta > = \frac{1}{2}qE\,\frac{v^2}{2\,c^2} \qquad (90)$$

If the total number of electrons in material is N, then the net force on material is

$$< F_{\parallel E} > = \frac{N}{4}qE\,\frac{v^2}{c^2} \qquad (91)$$

Taking $N = 10^{23}$, $E = 10^5$ V/m, and $v = 10^6$ m/s (approximate calculation), the value of force came out to be $< F_{\parallel E} > \cong 10^4$ N, which is very high. It means that few moles (few grams) of material, when placed in an electric field of strength 10^5 V/m, should experience almost 10^4 N force. But it doesn't happen (study and measurement of breakdown voltage of dielectrics conducts at 10^6V/m strength of electric field)
It proves that electron isn't revolving with such a high speed inside atom and also proves the Bohr atomic model to be wrong as the high velocity of electron is the result of Bohr atomic model . Note that we have already proved that the drag property of electric property can be disproved at any cost, otherwise the situations 3.2, 3.1, 12, 14 and 9 can't be explained. So, the fault is not in the concept of electric drag force, but it is in the atomic model.
The evidence that supports Bohr's model is the hydrogen spectrum (or hydrogenic spectrum). It is because this model is developed on the basis of the spectrum's wavelength formula (the empirical formula for the wavelength of hydrogen spectrum was known earlier than Bohr's model), i.e., the hydrogen spectrum's wavelength formula didn't comes from Bohr's model, but the Bohr's model came on the basis of this formula by taking multiples of assumptions having no physical significance, just to explain or adjust the things accordingly, which also violates the law of physics. So, the hydrogen spectrum is not the evidence or proof of the Bohr's model, but instead it is the source or base of that model, i.e., it is obvious that a theory will explain all those things, on the basis of which it is developed. But to validate that, it should explain other things also, which it doesn't. Forcefully matching the result is not the actual way of finding.

2nd Failure (Radiation emission)

When a charge moves, its primary electric field always moves with it, i.e., it is not possible that a charge moves but its electric field remains stationary; otherwise, a moving charge can't produce any

magnetic field (as the magnetic field is nothing but the moving electric field).
Also from Section-10.3, it is clear that electromagnetic waves travel through a primary electric field, which get created when charge oscillates.
So, whenever electron will revolve around the nucleus, corresponding electric field will also move with it (without changing it's orientation, section-11) which will leads to the generation of EM wave (emission of energy), making the atom unstable.
Bohr overcomes this with just an assumption, having no physical significance that there are some fixed energy levels in which an electron revolves, and there it doesn't radiate any energy. But, revolution of electron in any type of special orbit can't stop the generation of EM wave, as in that special orbit also, primary electric field will move with the charge, and so, generation of EM wave will take place (because of the high frequency of revolution). If it is not generating, it means the primary electric field of the moving electron is stationary, which is not possible (otherwise charge and field will be separated from each other).

3rd Failure (Magnetic Effect of Material)

In sec-6, it is proved that a magnetic field doesn't exist or the moving electric field itself is the magnetic field. If a region has a magnetic field, it means it has moving electric fields.
So, a material can produce a magnetic field in its surroundings if and only if the electric field (primary) corresponding to the electron (moving inside) also moves with them (the only way to move an electric field); otherwise, it can't show any magnetic behavior. Even the moving charge can't produce a magnetic field if its field doesn't move with it (which isn't possible), as the reason for the magnetic field is not the moving charge but it is the moving electric field.
So, the overall problem here we have is that
⇒ if we take the electric field moving along with the moving charge to explain the magnetic behavior of material, then generation of an EM wave will also take place due to the high frequency of the revolution of the electron ($\approx 10^{15}$ Hz).
⇒ if we take the electric field stationary corresponding to moving charge to counter the radiation emission, then a material can't show any magnetic behavior.
But it is the truth that materials like permanent magnets show magnetic behavior as well as the generation of EM waves also doesn't take place, which indicates that there is something wrong with the existing atomic model.
If we take the spin of the electron as the cause of the magnetic field of a permanent magnet, then again we face the same problem, i.e., a spinning electron can't produce a magnetic field until its field doesn't rotate. And if it rotates, it will generate an EM wave and will cause the electron to stop spinning. Stern and Gerlach experimentally proved that spin is the intrinsic property of an electron, and it is possible only if an electron spins without affecting its field.

13 Space isn't empty

Feynman disc paradox:[7]
There is a solenoid (carrying current I), and a non-conducting sheet containing static charge is fixed as shown in Fig-25.

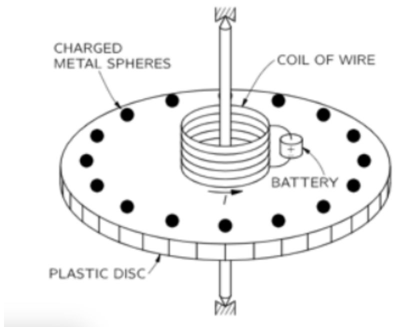


Figure 25: Feynman disc paradox setup

When the current of the solenoid is reduced to zero suddenly by switching off the circuit, this system starts to rotate, i.e., gain a net angular momentum, even though there was zero angular momentum in this system before switching. So, (i) where does it come from? (ii) Is it the violation of law of conservation of angular momentum?
Multiple textbooks mention its solution that a magnetic field stores angular momentum in its field (even without any rotation), and when it decays, it transfers it to the system, causing a net rotation.
But sections-6 proved that a magnetic field doesn't exist, and so the actual explanation can't be this.
Solution of Feynman disc paradox
Interaction between charges happens by means of field-particle interaction, as neither the fields interacts with each other (multiple of fields when come together, they all superimpose over one another and retain their position, i.e., they don't affect or interact with each other, e.g.: light wave:- When two light waves pass through the

same point, they don't affect each other, and all the parameters related to each wave remain the same as before). Nor can the particles (two charge particles can't interact with each other without field (except collision) by virtue of their charge or mass). It is the field produced by one charge or mass that interacts with the other charge or mass. No such magical thing exists that can make direct interaction between two particles having some distance, without having any interconnection between them (i.e., there must be something in between them to make the interaction possible, and that is nothing but the field). So, the only way of interaction is field-particle interaction, i.e.,
⇒ field-field: NO interaction
⇒ particle-particle: NO interaction (except collision).
⇒ field particle: the only way of interaction
Coulomb's law seems like a particle-particle interaction law as $\vec{F} = kqq'/r^2\,\hat{r}$, which isn't true. The actual equation of force on charge q due to q' is $\vec{F} = q\vec{E'}$ (field-particle interaction), where $\vec{E'}$ is electric field due to q'. This reduces to Coulomb's law when the value of E' is placed in it. There are few cases where Coulomb's law fails, but not this field-particle interaction law.
Example: When a charge (q') accelerates near a stationary charge (q), in that case, $\vec{F}_{q,q'} \neq \vec{F}_{q',q}$ because field lines of q' bend due to its acceleration (inertial property of field) while the field of q remains as usual. Hence $\vec{F}_{q',q} = q'\vec{E} = \dfrac{kqq'}{r^2}$ but $\vec{F}_{q,q'} = q\vec{E'} \neq \dfrac{kqq'}{r^2}$ (E and E' are fields of q and q', respectively). So, is this a violation of Newton's third law? Answer is NO! (mentioned in sec-13.1).
Same thing is happening in the above case (fig-25), as when current in the solenoid increases (or decreases), corresponding electrons in the wire accelerate (or decelerate), causing bending of the field of the surrounding i.e., electric field becomes non-conservative . Due to this, the charges of the non-conducting plate experiences a net rotating force and so start rotating. So, it is a phenomena of non-conservative nature of primary electric field. Using this concept, we can generate a net linear momentum also in a free space without using any propellant (space propulsion) by adjusting the charge and field accordingly as shown in the fig-26 where S_1 and S_2 is oscillating at same frequency with suitable phase difference.

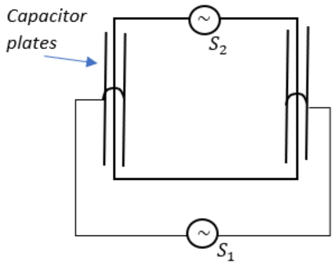


Figure 26: Coupled inductor and capacitor

Rotating homopolar motor

When a magnet, battery and wire is fixed as shown in fig-27, it start to rotate (Youtube video: Link-1 [7], Link-2 [8]). This also seems to violate the law of conservation of angular momentum, but it is not (mentioned at sec-13.1).

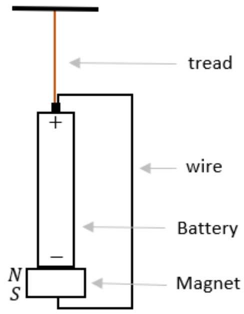


Figure 27: Rotating homopolar motor

Let's see why this entire system (magnet+battery+wire) rotates.
Electric drag force between two charge can be given as $\vec{F}_{\parallel E} = \dfrac{qE\,v_{r\perp}^2}{2\,c^2}\,\hat{E}$, $\vec{F}_{\perp E} = -\dfrac{qE\,v_{r\perp}\,v_{r\parallel}}{c^2}\,\hat{E}_{\perp}$ where $\vec{F}_{\parallel E}$ is along the line joining the two charges while $\vec{F}_{\perp E}$ is perpendicular to it. So whenever there is $v_{r\parallel}$ along with $v_{r\perp}$, $\vec{F}_{\perp E}$ arises which leads to a net torque in the two-charge system.
In the above fig-27, if we consider the permanent magnet as electromagnet magnet (circular coil), then we can clearly see that there is $v_{r\perp}$ as well as $v_{r\parallel}$ and so it rotates because of a net torque in the system. It mean that a system can generate a net angular momentum in free space, without any help of external agent.

Note: If the position of point of application of action and reaction force is same then Newton's third law and conservation of angular momentum, both will hold and if the position is not same (as seems in case of two charge-system, which is not actually true), then angular momentum of system will not remains conserved.

13.1 Global space fabric

In the previous cases, Newton's law and angular momentum conservation law seems to be violated because we consider this free space as empty space, which is not.
Suppose a hypothetical charge q' that doesn't have any field, if placed near ordinary charge q, will experience force $\vec{F} = q\vec{E} = kqq'/r^2\ \hat{r}$, but the ordinary charge q will not experience any force. It is because a field doesn't behave like a string or physical object that pulls or pushes another charge, and so action-reaction will always be equal, but instead it is a type of disturbance (stable) in free space.
There is global 3-dimensional space fabric in space everywhere. Through this space fabric, transfer of energy and momentum (force) takes place between two charges placed independently. Charge is a disturbance of this fabric, i.e., space fabric, when compressed or squeezed to a point, it becomes somehow stable and acts like charge (high density region), while the stretch produced in that fabric due to its compression acts like field (continuous variation in fabric density or fabric pressure). Fabric pressure is inversely proportional to fabric density; as less is the density, more will be the pressure or tension in the fabric. An electric field is something like the pressure gradient of a fluid (analogy), and electric force is equivalent to the buoyant force of that fluid. So, if we consider this space as non-empty space, then

- electric charge ≡ Highly dense (stable) point region of space fabric
- Electric potential ≡ Space fabric pressure
- Electric field ≡ Space pressure gradient
- Electric force ≡ Space buoyant force

Charge, when moves in this non-empty space, doesn't experience any resistance or oppose in it because there is not any actual transfer or motion of material but only the stabilized disturbance (highly dense region (charge) and low dense region (field)) moves from one position to another. Hence, no resistance acts on moving charges, as space itself is not moving but it transfers that stable disturbance.
When a charge (q_1) is placed in the electric field of some other charge (q_2), it experiences force not because the field line of q_2 pulls or pushes it, but it is the space fabric surrounding the charge (q_1), which pushes or exerts force (space buoyant force) on it because of the pressure gradient created near it by the local charge q_2.
In figures 25 and 26, Newton's third law is not violating because the action-reaction force is acting between charge and surrounding space but not in between the charges, i.e., force on charge (action force) is equal and opposite to the force experienced by its surrounding space (reaction force).
Same thing is happening in case of rotating homopolar motor as electric drag force also is applied by this non-empty space and hence, the action and reaction force acts between the charge and space (but not between the charges directly), which always remains equal and opposite. So the angular momentum of two charge system is seems to be non-conserved because we are not including the space fabric into the system. For the entire or complete system (charges + non-empty space), angular momentum remains conserved i.e., it is same before and after the experiment.

Similarly, an EM wave coming from an infinite distance applies force on charge through field particle interaction (the field is important, not the corresponding charge), where it makes the charge to oscillates in direction, perpendicular to its direction of propagation. So here also, it seems like Newton's law is violating (as light doesn't contain any momentum perpendicular to it's direction), but not actually, as an EM wave is the propagation of disturbances (pressure gradient) in this non-empty space, and when it interacts with any charge, it is that space that applies the force on the charge (due to that pressure gradient).

Note: Matter and anti-matter when forms, it seems like it is generated from empty space (nothing to something), which is not actually true as it is also the phenomena of this non-empty space or the space fabric i,e when it get sufficient energy, it results into stable high and low density region, which further acts like particles and so (i) they act like the complementary particles (ii) when comes together, they annihilates and again converts to the space fabric (changes to normal density) and leads to the emission of energy.

13.2 Existence of field line

The concept of field lines was introduced into physics in the 1830s by Michael Faraday, who considered magnetic and electric effects in the region around a magnet or electric charge as a property of the region rather than an effect taking place at a distance from a cause. But, as we saw, the magnetic field doesn't exist, and so the magnetic field lines also can't exist.

But what about electric field lines, i.e., does this really exist or is it just the imaginary lines of force? Light is a transverse wave, and it is proven (sec-10.3) that it travels on a primary electric field. A transverse wave can travel either on a 1-dimensional quantity (e.g., string wave) or a 2-dimensional surface (e.g., water wave), but not through a 3-dimensional quantity if it is uniform or homogeneous in every direction (even not possible to generate in it). It means an oscillating charge can produce an EM wave in its field if and only if field lines exist, i.e., its field exists as a bunch of field lines but not like a uniform or homogeneous space.

Also, Sec-13.1 mentions that an electric field is nothing but the stretch of space fabric that gets produced when compression or squeeze of space fabric takes place. If we compare it with a real-life situation, when a small portion of rubber sheet is squeezed to a point, the space around that point is not uniformly stretched, but some discrete, radial stretched line forms there, and that is equivalent to field lines.

13.2.1 Non-decaying of EM wave over primary electric field

When charge oscillates, it creates wave pulses on its field line, which travel to infinity. The strength of these field lines decays with distance but the strength of an EM wave pulse doesn't decays to infinity, and the reason is energy conservation. Energy of a wave pulse $(U_E + U_B)$ flows through the field line, which is a one-dimensional quantity, and so it remains conserved over the field line to infinity as it doesn't distribute over any area or volume. Hence

$$\underbrace{(U_E + U_B)}_{\substack{\text{at the point}\\ \text{of generation}}} = \underbrace{(U'_E + U'_B)}_{\substack{\text{at any point P}\\ \text{on the field line}}}$$
$$2U_E = 2U'_E \qquad (\because U_E = U_B) \tag{92}$$
$$2.\frac{1}{2}\epsilon E^2 = 2.\frac{1}{2}\epsilon E'^2$$
$$E = E'$$

It means that, in order to conserve the energy of the wave pulse, additional stretching happens in the field line during the propagation of the wave pulse to maintain the same value of E. Hence, it becomes independent of the strength of the primary electric field of charge and doesn't decay to infinity due to the additional stretching of the field. If any charge oscillates sinusoidally, then the resultant field will looks like as shown in Fig. 28, and mathematically, it can be written as (along the x-axis i.e., $E(x,t)$)

$$E = E_0 \sin(kx - \omega t + \theta) \tag{93}$$

where E is neither the primary electric field nor the secondary electric field, but it is the resultant electric field (strength of primary electric field line after stretching) and E_0 is its peak value.

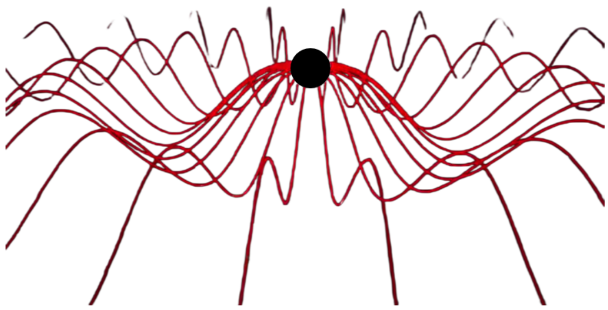


Figure 28: Oscillating charge

It follows traveling wave equation

$$\nabla^2 \vec{E} = \frac{1}{v^2}\,\frac{d^2\vec{E}}{dt^2} \tag{94}$$

where $v = \frac{1}{\sqrt{\mu\epsilon}}$ (experimental value). Putting it in above equation, it becomes

$$\nabla^2 \vec{E} = \mu\epsilon\,\frac{d^2\vec{E}}{dt^2} \tag{95}$$

Now, it will follow Helmholtz equation and all those equation on which our communication system is based on.

14 Static electron atomic model

All the failures of the atomic model which is mentioned before has been arose only due to the electron's high revolving speed around the nucleus. The concept of this revolving electron was introduced by Rutherford because of the gold foil alpha particle scattering experiment, which proved that (i) atoms are almost empty, (ii) they have a highly dense positively charged nucleus at the center, and (iii) electrons reside outside the nucleus (and so the nucleus is positively charged). To explain these three points, Rutherford made the assumption that the atomic model is like our solar system, where electrons revolve around the nucleus with suitable speed and so they don't fall into the nucleus. The only reason behind this assumption is to make electrons somehow stable outside the nucleus. But we don't have any proof of this; instead, all the failure (sec-12) has arisen because of

this assumption, which clearly proves that there is something wrong with it. So, these all failures and the Rutherford's alpha particle golf foil experiment indicates that that the electrons are stable outside the nucleus without any revolving speed (i.e., electrons are stationary inside the atoms), but how? All atomic models proposed further are based on the same assumption of Rutherford, with the addition of a few more assumptions to overcome the failures.
So, how can an electron be stable outside the nucleus without revolution? In sec-13.2, it is proved that electric fields are not homogeneous in space but exist as discrete field lines, as shown in fig-29. But there is a problem with this fig-29, as the primary electric field is a conservative field, but the field shown in fig-29 isn't. If a coil is placed in this field along the path ABC, it will induce a current in it for infinite time because of $_{ABC}\oint \vec{E}\cdot d\vec{l} \neq 0$, which is not possible as it is against the law of conservation of energy. Hence the actual field of charge can't be like this.

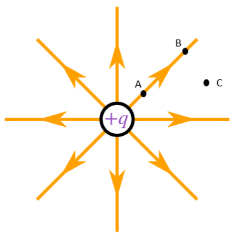


Figure 29: Fiels lines of charge

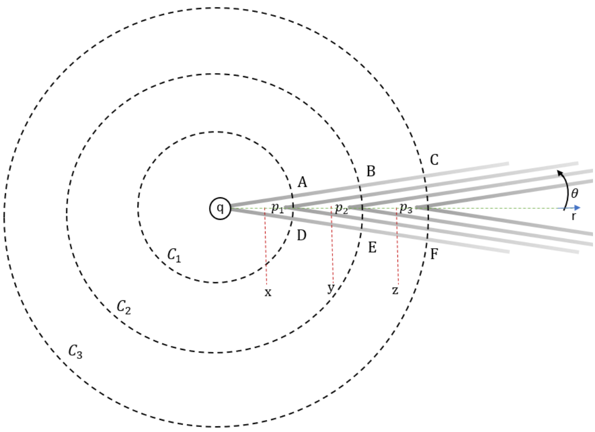
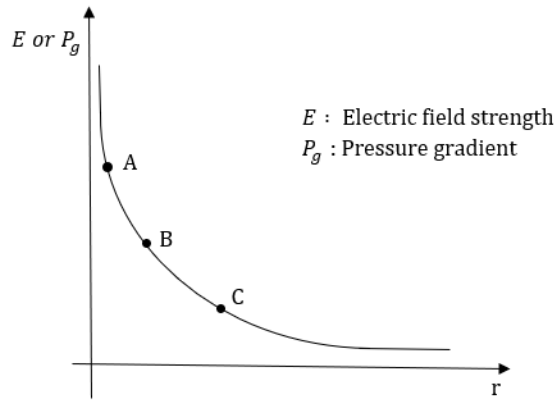
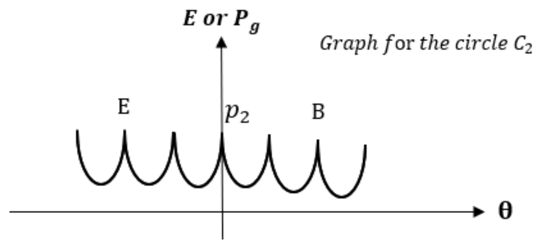


Figure 30: Actual structure of field line of charge

It means there must be extra field lines in the region between the field lines emerging from the charge so that $\oint \vec{E}\cdot d\vec{l} = 0$. The possible solution we can have is figure 30 (balancing concept of existence of field line and conservative nature of field). All the field lines can't emerge from the





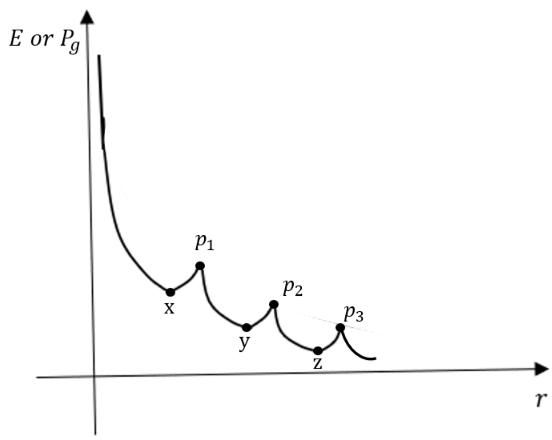


Figure 31: Graph of strength of electric field (E) vs distance (r) or angle θ

source charge as it can radiate a finite number of field lines only. Here, points p_1, p_2, p_3... p_n acts as a point of generation of lateral field lines (field lines that are not emerging directly from the charge).
Using $\oint \vec{E} \cdot d\vec{l} = 0$ along path ABC, its pressure gradient can be drawn, which looked like fig-31. Now, we can clearly see that points p_1, p_2, p_3,... p_n are the stable points for electrons to reside (stable equilibrium). In this, an electron doesn't need any velocity for its stability, and in this way, a stationary electron can be stable outside the nucleus without any motion.
It is valid at atomic scale only as in case of bulk charge, these stable points (P_i) will disappear due to superimposition of multiples of fields from the different sources, and the overall equation will reduces to $\vec{E} = kq/r^2\,\hat{r}$ (Coulomb's law). Note that Coulombs is also an experimental law, developed from experiments with bulk charges. So it is not valid at the atomic scale (as field exist in the forms of discrete lines) .
These points have their own characteristic oscillation constant at which electrons can oscillate with some particular frequency only (any frequency is not allowed) with maximum amplitude A (where A is the distance between p_n and p_{n+1} or p_{n-1}).
This atomic model overcomes:
(1) 1st Failure: Drag force on an atom: According to this model, an electron is stable outside the nucleus without any revolution, i.e., its velocity is zero, and so if it is placed in an electric field, it will experience zero electric drag force.
(2) 2nd Failure: Collapsing of atom due to radiation loss: The electron isn't revolving inside the atom, and so the generation of the EM wave doesn't take place.
(3) 3rd Failure: Magnetic Phenomenon: In magnetic materials, there are some special paths inside the material that are formed due to the overlapping or sequential arrangement of the stable points (p_i) of multiple of atoms (groups of atoms) into a line (closed path) as shown in fig-32 (each point of the path is a stable point).

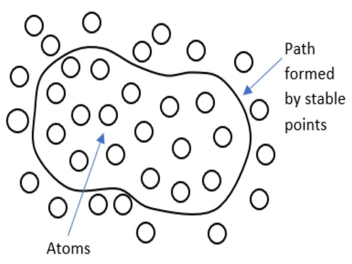


Figure 32: Special path inside magnetic materials

In this path, (i) the electron is stable, and (ii) it doesn't oscillate during its motion (due to the continuous presence of the stable points).
Not every material contains such type of paths, i.e., it is the property of the material. When material is magnetized, some electrons start moving in this closed path with low speed, which leads to the emergence of magnetic phenomena.
⇒ Due to low speed, the frequency of the revolution of an electron is very, very low, and so the generation of an EM wave takes place, but its frequency is negligible which leads to negligible power loss due to EM wave generation, and so magnetism retains for a long time.
⇒ Also, if such magnetic material is placed in an electric field, it will experience a very small electric drag force (almost zero) because of the lower speed of the moving electrons, as happens in the case of a current-carrying wire (another source of the magnetic field), where it is about 10^{-14} N.
Same thing happens in the case of superconductors, where these special paths are along the length of superconducting wire, having a larger range. So whenever a potential different is applied across it, many electrons start to travel in these paths, producing the magnetic field. In these paths, no power loss or almost zero loss power loss happens and so the magnetic effects retains for many years without any significant change.
But in the case of a non-superconductor permanent magnet, these paths are not very large but limited to a very small area (a small closed loop), and hence, when potential difference is applied, no such thing happens. But when it is magnetized (passing increasing or decreasing magnetic flux through the material), it leads the electrons to move in those smaller loops, where it shows a similar property like superconductor, i.e., almost zero loss of energy and retention of magnetic field for many years.
(4) Discrete lines in atomic spectra: When an electron of any stable point p_n gets energy from an external source, it jumps to higher stable points p_{n+i} (where n and i are positive integers), and when it gets disturbed, it falls back to lower stable points (p_{n-i}) and starts to oscillate there. During this oscillation, it loses its energy in the form of electromagnetic radiation. The frequency of the oscillation can't be anything. For the given point, an electron can oscillate with some fixed frequency only because of the characteristic oscillation constant of that point.
Hence, a material can emit radiation of some particular frequency only, but not the continuous frequency, which leads to discrete lines in atomic

spectra.
(5) Quantum nature of EM wave (discrete energy packet of light): Electromagnetic emission takes place when electrons fall from higher stable points to lower stable points during the process of electron oscillation. Due to continuous loss of energy, this oscillation becomes a damped oscillation, and so, after a few oscillations, it stops, and the radiated EM wave looks like Fig-33, i.e., as an energy packet.

Figure 33: Discretization of electromagnetic radiation

So, this was just an attempt to counter all the failure of atomic model by proposing another model of an atom.

15 Conclusion

This article proved that magnetic field does not exist and all the phenomena corresponding to the magnetic field is basically the effect of electric drag force. Using this drag property of electric field, Lorentz law and Faraday law is derived. Furthermore, our findings challenge the conventional view of space as an empty void. We have shown that space is not truly empty. Additionally, we have disproved the long-held notion that electrons revolve around the nucleus in atoms, providing new insights into atomic structure. These revelations not only refine our theoretical models but also open the door to further research and exploration .

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