Charge - another form of Energy

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Abstract

The kinetic energy of a moving mass is attributed to the mass increase because of its velocity. Thus, mass is recognized as a special form of energy. In contrast to mass, charge is believed to be a constant entity, not affected by its velocity. From the above, two questions might be asked:

1. Why charge remains a distinct entity while mass was discovered to be another form of energy.

2. If mass increase by velocity is recognized to be the cause of the kinetic energy embedded in a moving mass, what is the cause for the generation of a magnetic field while the charge is moving?

This article deals with these questions by claiming that charge is also another form of energy, as mass turned to be. This claim makes Energy as the only distinct entity (in addition to time and space), a simpler and cleaner view of nature.

Moreover, this article claims that the charge magnitude value is not a constant entity and it increases by the charge velocity and that increase of the charge magnitude because of its velocity is the cause for the generation of the magnetic field of a moving charge.

This article derives theses claims by analyzing the existing energy density equations of electric and magnetic fields.

Then, by analyzing the existing experimental results related to charges and the fields they create from a new point of view, and applying these claims, the article tries to evaluate if these claims lead also to additional new insights.

The result is the following four conclusions:

1. Charge magnitude increase because of its velocity is described by the following formula: 
   \[ q = q_0 / (1 - \frac{v_1^2}{c^2})^{1/2} \]  
   very similar to the equation: 
   \[ m = m_0 / (1 - \frac{v^2}{c^2})^{1/2} \]  
   that describes the increase in mass when the mass is moving.

2. Magnetic and electric fields which are generated by the same moving charge are always perpendicular to each other, thus, these fields have the structure of the electromagnetic emission from accelerating moving charges.
3. This article derives the equation $\Delta u = K (\Delta q^2)$ where $\Delta u$ is the energy density in the magnetic field of a moving charge, $\Delta q^2$ is the increase in the magnitude of the square of the charge $q$ when it is moving, and $K$ is a factor that is dependent only on the location of the unit volume where $\Delta u$ resides.

4. Since charge comes in two types, a positive charge and a negative charge, then the energy embedded in charge also comes in two energy types. The article assigns these energy types to one set of Energy Pairs.

This Energy Pairs Theory is used to explain why in electron positron collisions the charges completely disappear, and this Energy Pairs Theory is also used to explain magnetic and electric fields energy conservation paradoxes.
Introduction

Mass is recognized as a special form of energy. It is not constant and mass increases by velocity according to: (Ref 1)

\[ m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \]

where \( c \) is the speed of light.

And it can be converted to energy according to: (Ref. 2)

\[ \Delta E = (\Delta m)c^2 \]

where \( E \) is energy, \( m \) is mass and \( c \) is the speed of light.

Thus, before the presentation of the special theory of relativity, the science of physics recognized actually three distinct entities: energy, mass and charge, (apart from time and space).

After the presentation of the special theory of relativity, the mass ceased to be a distinct entity, and it is recognized as a special form of energy. So, now there are only two distinct entities (apart from time and space): energy and charge.

In contrast to the mass, the existing science of physics views the charge as an entity whose magnitude value is constant and not affected by its velocity.

From the above, two questions might be asked:

1. Why charge remains a distinct entity while mass was discovered to be another form of energy.

2. Because the increase in mass is understood to be the cause of the kinetic energy embedded in a moving mass, what is the cause for the generation of a magnetic field while the charge is moving?

These two questions are viable questions.

Before the introduction of the special theory of relativity, nobody was bothered with the question what causes the kinetic energy embedded in a moving mass. Now, since it is clear that there is such a cause, and it is the increase of the mass because of its velocity, it is only normal to ask what is the cause for the magnetic field generated by a moving charge.

It cannot be the kinetic energy of the moving body which contains the electric charge because infinite cases can be devised, each with a body with a different mass but containing the same amount of charge, thus, each such body has a different kinetic energy but creates the same magnetic field.

Also, after mass was discovered to be a special form of energy. It is only natural to wonder now, if charge might be also a special form of energy.

This article deals with these questions by claiming that charge is also another form of energy, as mass turned to be. This claim makes Energy as the only distinct entity (in addition to time and space), a simpler and cleaner view of nature.
Moreover, this article claims that the charge magnitude value is not a constant entity and it increases by the charge velocity and that increase of the charge magnitude because of its velocity is the cause for the generation of the magnetic field of a moving charge.

This article derives these claims by analyzing the existing energy density equations of electric and magnetic fields.

Then, by analyzing the existing experimental results related to charges and the fields they create from a new point of view, and applying these claims, the article tries to evaluate if these claims lead also to additional new insights.

The result is the following four conclusions:

1. Charge magnitude increase because of its velocity is described by the following formula:

\[ q = \frac{q_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \]

very similar to the equation:

\[ m = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \]

that describes the increase in mass when the mass is moving.

The equation

\[ q = \frac{q_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \]

is derived using two different methods:

Once, by using the existing experimental results and equations for the energy density of electric and magnetic fields, and applying the above claims.

Secondly, by analyzing the existing experimental results related to charges and the fields they create, and applying the above claims.

2. An accelerating charge emits electromagnetic emission in which the electric and magnetic fields are perpendicular to each other. This is a direct result from Maxwell's equations. On the other hand, a moving charge which is not accelerating, according to the existing knowledge, generates electric and magnetic fields which are not necessarily perpendicular to each other.

However, by using the above claims, when analyzing the existing experimental results related to charge and the fields they create, it turns out that the magnetic field generated by a moving point charge is always perpendicular to the existing electric field. Thus, it turns out that the magnetic and electric fields generated by the same moving charge, always has the structure of the electromagnetic emission from accelerating moving charges.

3. Analogous to the equation \( \Delta E = (\Delta m) c^2 \), derived from the special relativity theory, when applying the above claims, it can be shown that \( \Delta \mathbf{u} \), the energy density in the magnetic field of a moving charge, is dependent and directly proportional only to \( \Delta q^2 \), which is the increase in the magnitude of the square of the charge \( q \) when it is moving.
4. Since charge comes in two types, a positive charge and a negative charge, then the energy embedded in charge also comes in two energy types. The article assigns these energy types to one set of Energy Pairs.

This Energy Pairs Theory is used to explain why in electron positron collisions the charges completely disappear, and this Energy Pairs Theory is also used to explain magnetic and electric fields energy conservation paradoxes.

When an electron and a positron collide they annihilate each other and gamma ray photons are emitted, with energy equal to the sum of the energies embedded in the masses of the electron and the positron.

However, the charges of the electron and the positron are not converted to any new substance (such as energy) and they simply disappear without leaving any trace of their previous existence.

This charge disappearance seem to be an unusual, strange and unexpected mystery, although this charge disappearance obey the charge conservation principle. This charge disappearance is strange, because charge seem to be a basic element in physics, and such basic elements should not disappear.

The Energy Pairs mentioned above provides a reasonable and logic explanation to this charge disappearance mystery. This is done by assuming that Energies belonging to Energy Pairs, cancel each other if they coexist in the same space volume, such that only the net energy intensity of the energy type in the Energy Pair that had initially more intensity, remains in the space volume where the two Energy Pairs coexist.

Magnetic and electric fields energy conservation paradoxes are also resolved using the above concept of Energy Pairs. Thus, energy conservation exists only when the total amount of energy in a specific volume in space contains only the net amount of one member of the energies which belong to an Energy Pair.
Energy densities equations reveal new Charge feature

The embedded energy per unit volume in the electric field \( u_e \) is provided by the following formula: (Ref. 7)

\[
u_e = \varepsilon_0 |E^>|^2/(2).
\]

Where \( E^> \) is the electric field magnitude in the unit volume, and \( \varepsilon_0 \) is the vacuum permittivity and is equal to: 8.854187817…x 10^{-12} \text{ F/m (Farad per meter)}

Since \( |E^>| = (1/(4\pi \varepsilon_0))(q_0/r^2) \) Where \( q_0 \) is the non moving charge magnitude. and \( r \) is the distance from the charge to the location of the unit volume. (Ref 3), then,

\[
u_e = (1/(32 \varepsilon_0 \pi^2))(q_0^2/r^4)
\]

If we denote \( K= 1/(32 \varepsilon_0 \pi^2) \) then

\[
u_e = (K(q_0^2))/r^4
\]

Since \( K \) is a constant and \( r^4 \) is dependent only on the unit volume in space where \( E^> \) resides, then, \( u_e \), the embedded energy per unit volume in the electric field, is directly dependent and is directly proportional only to the square of the magnitude of the non moving charge \( q_0 \) that generated \( E^> \).

Similarly, the embedded energy per unit volume in the magnetic field \( u_m \) is provided by the following formula: (Ref. 6)

\[
u_m = |B^>|^2/(2 \mu_0).
\]

Where \( B^> \) is the magnetic field in that volume unit and \( \mu_0 \) is the vacuum magnetic permeability and is equal to: 4\pi 10^{-7} \text{ H/m (Henry per meter)}.

Since \( |B^>| = (\mu_0/(4\pi))(qvsin \alpha)/r^2 \) (Ref 4).

Where \( q \) is the moving charge magnitude that generated the magnetic field \( B^> \), moving at the velocity \( v \), and \( \alpha \) is the angle between \( v \) and the line connecting that moving charge to that volume unit.

then,

\[
u_m = (\mu_0/(32\pi^2))(q^2v^2\sin^2 \alpha)/r^4
\]

and since \( \mu_0 = 1/(\varepsilon_0 c^2) \) (Ref 4), then

\[
u_m = (1/(32 \varepsilon_0 \pi^2))(q^2(v^2/c^2)\sin^2 \alpha)/r^4
\]

since we already denoted \( K= 1/(32 \varepsilon_0 \pi^2) \) then,
\[ u_m = (K (q^2 (v^2/c^2) \sin^2 \vartheta))/r^4. \]  

Denoting \( x = (v^2/c^2) \sin^2 \vartheta, \) then,

\[ u_m = (K (q^2 x))/r^4 \]

and as shown above \( u_e = (K (q^2_0))/r^4. \)

It turns out that what generates \( u_e \) is \( q^2_0 \) and what generates \( u_m \) is a fraction of \( q^2 \) since \( x \) spans from 0 for \( v=0 \) to a maximum of 1 when \( v=c. \)

Also, both equations, \( u_m \) and \( u_e, \) have exactly the same structure, only \( u_m \) contains \( q^2 x \) as its generation source and \( u_e \) contains \( q^2_0 \) as its generation source.

If \( q = q_0, \) as the current knowledge dictates, a paradox exists. Since the full magnitude of \( q_0 \) already was used to generate the electric field energy density \( u_e, \) what is left for generating the magnetic field energy density \( u_m? \) The only other feature the charge \( q \) has is its velocity.

Indeed, the magnetic field is generated because the charge is moving, but if this movement does not affect the charge magnitude, where the extra \( q^2 x \) required for generating the magnetic field came from?

It cannot be the kinetic energy resulting from the velocity \( v, \) since that kinetic energy is already manifested in the mass increase, so it cannot be manifested also in the energy of the magnetic field. Moreover, as already mentioned in the previous chapter, infinite cases can be devised, each with a body with a different mass but containing the same amount of charge, thus, each such body has a different kinetic energy but creates the same magnetic field.

Thus, it seems that the solution to that paradox should be to establish that \( q \) is greater than \( q_0, \) which means that a moving charge magnitude increases by its movement, and, this increase is the cause to the generation of the magnetic field by a moving charge, and, thus, charge is another form of energy.

Thus, our initial claims turns to be a direct result from analyzing the existing equations for the energy density in electric and magnetic fields.

Thus, if \( u_m, \) is directly dependent and is directly proportional only to a fraction \( x \) of the square of the increased moving charge magnitude \( q, \) and \( u_e \) is directly dependent and is directly proportional only to the square of the magnitude of the non moving charge \( q_0, \) then it can be argued that the total energy density \( (u_m + u_e) \) should be directly proportional only to the square of the full magnitude of the moving charge \( q, \) and should also be expressed by an equation that has the same structure as \( u_m \) and \( u_e \) but its generation source should be \( q^2. \)

Thus, it can be argued that

\[ u_m + u_e = (K (q^2 x))/r^4 + (K (q^2_0))/r^4 = (K (q^2))/r^4. \]
Thus,

\[ q^2 + q^2 x = q^2 \]

which results in

\[ q^2 = q_0^2 / (1-x) \]

since

\[ x = (v^2/c^2) \sin^2 \alpha \]

this results in:

\[ q^2 = q_0^2 / (1 - (v^2/c^2) \sin^2 \alpha) \] or

\[ q = q_0 / (1 - (v^2/c^2) \sin^2 \alpha)^{1/2} \]

Very similar to:

\[ m = m_0 / (1 - v^2/c^2)^{1/2} \]

Which describes the increase in mass when the mass is moving.

It will be shown in a next chapter that \( v \sin \alpha \) is the component of the velocity \( v \) perpendicular to the line that connects the charge to the unit volume and also to the spectator that monitors the charge movement. This component is denoted \( v_1 \) which turns the relationship between \( q \) and \( q_0 \) to

\[ q = q_0 / (1 - (v_1^2/c^2) )^{1/2} \]

\( q^2 x \) can be denoted also as \( \Delta q^2 \), since when it is added to \( q_0^2 \) the result of this addition is the full \( q^2 \).

Also, since in the relation of \( u_m \) shown above, \( K \) is constant and \( r^4 \) and \( \sin^2 \alpha \) (which exists in \( x \)) are dependent only on the unit volume in space where \( B \) resides, then \( K/r^4 \) can be denoted \( K_1 \).

Thus, from the above

\[ u_m = (K (q^2 x)) / r^4 \]

can be written as \( K_1 (\Delta q^2) \)

Thus,

\[ u_m = \Delta u = K_1 (\Delta q^2) \]

Where:

\( \Delta u \) is the energy density in the magnetic field of a moving charge, which is also the additional energy density a moving charge creates, in addition to the electric field it creates when it is not moving.

\( K_1 \) is a factor dependent only on the unit volume in space where \( B \) resides.
And $\Delta q^2$ is the increase in the magnitude of the square of the charge $q$ when it is moving, which, when added to the square of the magnitude of the non moving charge $q_0$ results in $q^2$.

This is analogous to the equation:

$$\Delta E = (\Delta m) c^2$$

presented in the special relativity theory.

In a following chapter (Analysis) we will derive again the relationship

$$q = q_0 / \left(1 - \left(v_1^2 / c^2 \right)\right)^{1/2}$$

from another point of view, by analysing the existing equations of charges and the fields they create and applying our claims about charge being a new form of energy, charge increasing by velocity, and that this charge increase is the cause of the generation of the magnetic field.

But, before, a review of the existing formulae will be presented.
Review of existing formulae

First, we will review the existing formulae related to point charges and the fields they create.

1. A point charge \( q \) induces an electric field \( E^\rightarrow \) at a distance \( r \) from the charge as shown in Fig. 1:

The induced electric field is a vector \( E^\rightarrow \) as expressed by the formula:

\[
E^\rightarrow = \frac{(1/(4\pi\varepsilon_0))(qr^\rightarrow)}{r^2}
\]

Where \( \varepsilon_0 \) is the vacuum permittivity and is equal to:

\[8.854187817 \times 10^{-12} \text{ F/m (Farad per meter)}\]

And \( r^\rightarrow \) is a unit vector in the direction of the line \( xy \), indicating that \( E^\rightarrow \) is also a vector in that direction.

The magnitude of \( E^\rightarrow \) is expressed by the formula:

\[
|E^\rightarrow| = \frac{(1/(4\pi\varepsilon_0))(q/r^2)}
\]
2. A moving point charge $q$ moving at a constant velocity $v \rightarrow$ induces a magnetic field $B \rightarrow$ at a distance $r$ from the charge, as shown in Fig. 2.

The magnetic field $B \rightarrow$ is expressed by the formula:
(Ref 4)
$$B \rightarrow = \left( \frac{\mu_0}{4\pi} \right) (q ( v \rightarrow \times r \rightarrow ) / r^2)$$

Where $\mu_0$ is the vacuum magnetic permeability and is equal to:
$4\pi \times 10^{-7}$ H/m (Henry per meter).

Where $B \rightarrow$ is a vector which is the result of the vector multiplication of $v \rightarrow$ and $r \rightarrow$, where $v \rightarrow$ is the charge velocity vector and $r \rightarrow$ is a unit vector in the direction of $xy$.

The result of the vector multiplication of $v \rightarrow$ and $r \rightarrow$ also give the magnitude of $B \rightarrow$ which is given by the following formula:
$$|B \rightarrow| = \left( \frac{\mu_0}{4\pi} \right) \left( \frac{q v \sin \alpha}{r^2} \right)$$

Where $v$ is the magnitude of $v \rightarrow$ ($|v \rightarrow|$).

3. The force $F \rightarrow_\text{E}$ exerted on a point charge $q$ residing in an electric field $E \rightarrow$ is expressed by the following formula:
(Ref 3)
$$F \rightarrow_\text{E} = E \rightarrow q$$

Where $F \rightarrow_\text{E}$ is a vector in the direction of the electric field $E \rightarrow$ whose magnitude is:
$$|F \rightarrow_\text{E}| = |E \rightarrow| q$$
4. The force $\mathbf{F} \times \mathbf{B}$ exerted on a point charge $q_2$ moving in a magnetic field $\mathbf{B}$ at a constant velocity $\mathbf{v}$ is shown in Fig. 3:

$\mathbf{B}$ is a vector perpendicular to this page coming upwards.

Here, point charge $q_1$ moving at velocity $\mathbf{v}$ to the right generates the magnetic field $\mathbf{B}$ that affects the non-moving charge $q_2$. However, relative to the magnetic field $\mathbf{B}$, $q_2$ is moving at a velocity $\mathbf{v}$ to the left, because the magnetic field $\mathbf{B}$ is moving at a velocity $\mathbf{v}$ to the right. This relative velocity of $q_2$ is denoted $v_x$.

![Fig. 3](image)

As already shown (Ref 4) $$\mathbf{B} = \frac{\mu_0}{4\pi} q_1 (\mathbf{v} \times \mathbf{r})/r^2$$

The force $\mathbf{F} \times \mathbf{B}$ is expressed by the following formula:

(Ref 5) $$\mathbf{F} \times \mathbf{B} = q_2 (\mathbf{v} \times \mathbf{B})$$

where $\mathbf{F} \times \mathbf{B}$ is a vector resulting from the vector multiplication of $\mathbf{v}$ and $\mathbf{B}$.

The magnitude of $\mathbf{F} \times \mathbf{B}$ is given by the following formula:

$$|\mathbf{F} \times \mathbf{B}| = \frac{\mu_0}{4\pi} \left(\frac{q_1 q_2 \mathbf{v}^2 \sin \alpha}{r^2}\right)$$

where $\alpha$ is the angle between $\mathbf{v}$ and $\mathbf{xy}$.

Where $q_1$ is the point moving charge generating the magnetic field $\mathbf{B}$, the charge $q_1$ is moving at constant velocity $\mathbf{v}$ to the right from point $y$. $q_2$ is a point charge at point $x$ at a distance $r$ from $y$. $q_2$ is actually moving at a constant velocity $\mathbf{v}$ to the left relative to the magnetic field $\mathbf{B}$, since $\mathbf{B}$ is a magnetic field moving at a velocity $\mathbf{v}$ to the right since it is generated by the point charge $q_1$ moving at constant velocity $\mathbf{v}$ to the right.
Analysis

Now we can continue and add our claims that the magnetic field of a moving charge is a result from an increase of the charge magnitude because of its velocity.

It should be noted that direct measurement of mass increase by velocity is actually impractical, because it requires movement of the mass at very high speed (about or more than 0.1 the speed of light), and executing direct measurement of the mass magnitude while it is travelling at that speed.

Similarly, the measurement of charge magnitude was done for non moving charges, and direct measurement of charge magnitude while it is travelling at very high speed is not practical. So, the findings that charge magnitude increases by velocity, should not contradict the known knowledge today.

To derive the formula for the charge increase because of the charge velocity we will refer to Fig. 4:

The charge \( q_1 \) at point \( y \) in space is a moving point charge, moving at a constant velocity \( v \) to the right. The charge \( q_2 \) is a point charge at point \( x \) in space, such that the line \( xy \) is at a distance \( r \) from \( y \).

We will also give the notation \( q_{10} \) to the charge magnitude of \( q_1 \) when it is not moving and \( q_1 \) to its charge magnitude when it is moving, relative to an external spectator to the charge. In a similar way the notation \( q_{20} \) will be given to the charge
magnitude of $q^2$ when it is not moving and $q^2$ to its charge magnitude when it is moving, relative to an external spectator to the charge.

The field $\mathbf{E}^\rightarrow$ is a vector in the direction of the line $xy$. The force $\mathbf{F}^\rightarrow_\mathbf{E}$ is also a vector in the direction of the line $xy$ and its magnitude is:

$$\left|\mathbf{F}^\rightarrow_\mathbf{E}\right| = \left(1/(4\pi\epsilon_0)\right)(q_{10}q_{20}/r^2)$$

The field $\mathbf{B}^\rightarrow$ is a vector perpendicular to the plane where $v^\rightarrow$ and the line $xy$ reside and pointing upwards.

The force $\mathbf{F}^\rightarrow_\mathbf{B}$ resides in the plane where $v^\rightarrow$ and the line $xy$ reside, is perpendicular to $v^\rightarrow$ and points upward. The magnitude of $\mathbf{F}^\rightarrow_\mathbf{B}$ is given by:

$$\left|\mathbf{F}^\rightarrow_\mathbf{B}\right| = \left(\mu_0/(4\pi)\right)((q_1q_2v^2\sin \alpha)/r^2)$$

In the equations of the force $\mathbf{F}^\rightarrow_\mathbf{B}$ the moving point charges magnitudes $q_1$ and $q_2$ appear, which are bigger than $q_{10}$ and $q_{20}$ (for the non moving charges) which appeared in the equation for $\mathbf{F}^\rightarrow_\mathbf{E}$, because $q_1$ is the moving charge that generated the magnetic field, and $q_2$ is a moving charge relative to the magnetic field that exerts forces on it.

The force $\mathbf{F}^\rightarrow_\mathbf{B}$ can be disassembled into its two components, the one $\mathbf{F}^\rightarrow_\mathbf{B1}$ parallel to $\mathbf{F}^\rightarrow_\mathbf{E}$ and another, $\mathbf{F}^\rightarrow_\mathbf{B2}$, perpendicular to $\mathbf{F}^\rightarrow_\mathbf{E}$.

The magnitudes of these forces are:

$$\left|\mathbf{F}^\rightarrow_\mathbf{B1}\right| = \left(\mu_0/(4\pi)\right)((q_1q_2v^2\sin^2 \alpha)/r^2)$$

$$\left|\mathbf{F}^\rightarrow_\mathbf{B2}\right| = \left(\mu_0/(4\pi)\right)((q_1q_2v^2\sin\alpha \cos \alpha)/r^2)$$

Since $\mathbf{F}^\rightarrow_\mathbf{B1}$ is parallel to $\mathbf{F}^\rightarrow_\mathbf{E}$ it can be argued that it represents an increase to the electric force caused by an increase of the magnitude of the moving point charge $q_1$.

Thus, it can be argued that on point charge $q_2$ a bigger electric field exerts a bigger electric force $\mathbf{F}^\rightarrow_\mathbf{E}(\text{bigger})$ by the moving charge at $q_1$.

Also, since it is an electric force, it can be expressed by the formula that describes the forces exerted by electric fields on charges.

$\mathbf{F}^\rightarrow_\mathbf{E}(\text{bigger})$ is a bigger force, since it is a force generated by a moving charge $q_1$, and thus has a bigger magnitude compared to a non moving charge $q_{10}$, and it is exerted on a moving charge $q_2$, moving relative to the magnetic field generated by point charge $q_1$, and thus, $q_2$ is also a bigger charge, as compared to the non moving charge $q_{20}$. 

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So, it can be argued that:
\[ F_{\text{E(bigger)}} = \frac{1}{(4\pi\varepsilon_0)}(q_1q_2 \frac{r}{r^2}) \]

Then

Since \( F_{\text{E(bigger)}} = F_{\text{E}} + F_{\text{B1}} \)

And since \( F_{\text{E}} \) is parallel to \( F_{\text{B1}} \), then
\[ |F_{\text{E(bigger)}}| = |F_{\text{E}}| + |F_{\text{B1}}| \]

Then
\[ \frac{1}{(4\pi\varepsilon_0)}(q_1q_2/r^2) = \frac{1}{(4\pi\varepsilon_0)}(q_{10}q_{20}/r^2) + \frac{\mu_0}{(4\pi)}((q_1q_2v^2 \sin^2 \alpha)/r^2) \]

Since \( \mu_0 = 1/\epsilon_0 c^2 \) (Ref 4) then
\[ \frac{1}{(4\pi\varepsilon_0)}(q_1q_2/r^2) = \frac{1}{(4\pi\varepsilon_0)}(q_{10}q_{20}/r^2) + \frac{1}{(4\pi \epsilon_0 c^2)}((q_1q_2v^2 \sin^2 \alpha)/r^2) \]

This results in:
\[ q_1q_2 (1 - (v^2 \sin^2 \alpha / c^2)) = q_{10}q_{20} \]

From which \( q_1 \) and \( q_2 \) are derived from \( q_{10} \) and \( q_{20} \) as:
\[ q_1 = q_{10}/\left(1 - (v \sin \alpha)^2/c^2\right)^{1/2} \]
\[ q_2 = q_{20}/\left(1 - (v \sin \alpha)^2/c^2\right)^{1/2} \]

Now, \( v \sin \alpha \) is the component of \( v \) which is perpendicular to the line \( xy \) which connects \( q_1 \) and \( q_2 \). This component is denoted \( v_{\text{1}} \).

So, the equations for \( q_1 \) and \( q_2 \) become:
\[ q_1 = q_{10}/(1 - v_1^2/c^2)^{1/2} \]
\[ q_2 = q_{20}/(1 - v_1^2/c^2)^{1/2} \]

The same equation that connects \( q \) to \( q_0 \) that was already derived before from the existing equations of energy densities in electric and magnetic fields.

This equation is also very similar to the equation that describes the increase of mass by velocity:
\[ m = m_0/(1 - v^2/c^2)^{1/2} \]
It should also be noted that the line \( xy \) is the line that connects each of the point charges \( q_1 \) and \( q_2 \), to the specific charge spectator. Thus, when we talk about external spectators, the external spectators for the charges \( q_1 \) and \( q_2 \) are different spectators. The spectator of point charge \( q_1 \) reside where \( q_2 \) resides, and the spectator of point charge \( q_2 \) resides where \( q_1 \) resides.

The external spectator for the point charge \( q_1 \) at point \( y \) in space is a spectator at point \( x \) in space where \( q_2 \) reside. This spectator measures the \( q_1 \) point charge by evaluating the fields and the forces \( q_1 \) creates at point \( x \) in space. For this spectator \( q_1 \) is moving with a constant velocity \( v \) to the right.

The external spectator for the point charge \( q_2 \) at point \( x \) in space is a spectator at point \( y \) in space where \( q_1 \) resides. This spectator measures the \( q_2 \) point charge by evaluation the motion of the \( q_2 \) point charge in the fields that \( q_1 \) created at point \( x \) in space. For this spectator \( q_2 \) is moving with a constant velocity \( v \) to the left relative to the magnetic field \( B \rightarrow \) generated by \( q_1 \).

In addition to the above, apart from increasing the forces exerted by the electric field by the component \( F \rightarrow B_1 \), the moving point charge \( q_1 \) also generates another force \( F \rightarrow B_2 \), as already noted, which is perpendicular to \( F \rightarrow B_1 \) (and thus, perpendicular to the increased electric field) and whose magnitude is : (as noted before)

\[
|F \rightarrow B_2| = (\mu_0/(4\pi))((q_1 q_2 v^2 \sin\alpha \cos\alpha)/r^2)
\]

Thus, it should be noted that, from the above, the velocity of a point charge \( q_1 \) actually creates not just a single field, which is called today "the magnetic field", but two moving field components.

One of these moving field components is a moving electric field component, which exerts the force \( F \rightarrow B_1 \) on point charge \( q_2 \).

Another moving field component is the one that exerts the force \( F \rightarrow B_2 \) on point charge \( q_2 \) and it can be seen as the actual magnetic field created.

These two moving field components are moving since they are created by the moving \( q_1 \) point charge. Also, these two moving field components are perpendicular to each other.

Thus, it turns out that the **magnetic and electric fields generated by the same moving charge are always perpendicular to each other, and, thus, always has the structure of the electromagnetic emission from accelerating moving charges**.
The Energy Pairs Theory

The claims that charge is another form of energy can be used to provide an explanation to the following:

When an electron and a positron collide they annihilate each other and gamma ray photons are emitted, with energy equal to the sum of the energies embedded in the masses of the electron and the positron. However, the charges of the electron and the positron are not converted to any new substance (such as energy) and they simply disappear without leaving any trace of their previous existence. This charge disappearance seem to be an unusual, strange and unexpected mystery. In interactions of particles that do not contain any charge, sometimes parts of the masses are converted to energy, but nothing disappears.

A logical explanation to that paradox might be the assumption, that certain energies, such as the energy embedded in charges, come in an Energy Pair form, such that the member in that pair that has smaller intensity, can cancel the the amount of energy of the other member in that pair which is equal to its energy intensity, if both happen to coexist in the same space volume.

From the above, it is obvious that the Energy Pair embedded in charges contains the following two energy types: one type is the energy embedded in positive charges, the other type is the energy embedded in negative charges.

The Energy Pairs assumption is actually derived from the findings that charge is another form of energy, because such energy must have two values, one for the energy attributed to positive charges, and one for the energy attributed to negative charges.

The Energy Pairs theory also provides an explanation to magnetic and electric fields potential energy conservation paradoxes.

The magnetic field potential energy conservation paradox is described as follows:

When a body is charged with electric charges of a certain polarity (such as positive electric charges) and a certain amount of charge, and the body is moved at a specific constant speed in a certain direction, it creates a magnetic field $B^{>}$ around it whose embedded energy per unit volume $u$ is provided by the following formula:

$$u = \frac{|B^{>}|^2}{2\mu_0}$$

Where $\mu_0$ is the vacuum magnetic permeability and is equal to: $4\pi10^{-7}$ H/m (Henry per meter).
While the magnetic field $B^\rightarrow$ was already shown in this article to be described by:

$$B^\rightarrow = (\frac{\mu_0}{4\pi})(q( v^\rightarrow \times r^\rightarrow )/r^2)$$

(Ref. 4)

When a second body is charged with electric charges of the opposite polarity (negative electric charges) but with the same amount of charge, and that body is also moved at the same constant speed in the same direction, it creates a magnetic field in the same space volume, whose magnitude is still expressed by the same formula that describes the magnetic field $B^\rightarrow$ created by the first body when it was moved, but its direction (or polarity) is inverse to the polarity of the magnetic field $B^\rightarrow$ that the first body created when it was moved. But, the embedded energy per unit volume of the magnetic field created by that second body is still expressed by the formula presented before for energy per unit volume in a magnetic field. (Ref. 6)

When both bodies are tied to an apparatus that keeps them very close to each other, (but inhibits them from being attracted completely to each other), and both bodies are moved together, at the same speed, in the same direction, no magnetic field is created around them (or a negligible magnetic field, because the bodies are not exactly at the same point in space).

The reason why in that third case scenario basically no magnetic field was created is well understood.

Magnetic fields obey the superposition rule. Since the first body creates a magnetic field which has the same intensity, but inverse polarity compared to the magnetic field the second body creates, and both magnetic fields occupy the same volume in space, they cancel each other, and basically no magnetic field is created in that volume in space.

However, there is still a paradox, concerning the conservation of the energy embedded in these two magnetic fields.

The first body does not "know" that a second, inverse magnetic field is created, and it still creates its own magnetic field. This magnetic field embeds an energy per unit volume described by the formula above (Ref. 6). The same is true for the second body. So, the fact that each field cancels the other, contradicts the energy conservation principle, since the energies of both fields also disappear.

The Energy Pairs theory provides also an explanation to this energy conservation paradox.

From the above, it is obvious that the Energy Pair for magnetic fields contains the following two energy types: one type is the energy embedded in magnetic fields created by positive charges, the other type is the energy embedded in magnetic fields created by negative charges.
Similarly to the explanation of the magnetic field energy conservation paradox, the Energy Pairs Theory provides a similar explanation to a similar electric field energy conservation paradox.

This electric field energy conservation paradox is very similar to the magnetic field energy conservation paradox. Thus, it will be described here more briefly, since its description is very similar to the description of the magnetic field energy conservation paradox.

When a body is charged with electric positive charges it creates an electric field around it whose embedded energy per unit volume \( t \) is provided by the following formula: (Ref. 7)

\[
u_e = \varepsilon_0 |E^→|^2/(2).\]

Where \( E^→ \) is the electric field magnitude in the unit volume, and \( \varepsilon_0 \) is the vacuum permittivity and is equal to: \( 8.854187817 \times 10^{-12} \) F/m (Farad per meter)

When a second body is charged with same amount of negative charges, it creates an electric field whose polarity is inverse to the polarity of the electric field that the first body created.

But, the embedded energy per unit volume of the electric field created by that second body is still expressed by the formula presented before for energy per unit volume in an electric field. (Ref. 7)

When both bodies are tied to an apparatus that keeps them very close to each other, (but inhibits them from being attracted completely to each other), no electric field is created around them (or a negligible electric field, because the bodies are not exactly at the same point in space).

As before, the paradox is, again, the fact that the energies also disappear, although, each charge is not "aware" of the other charge, and, thus, is supposed to create still its own electric field.

This brings about another conclusion which implies that energy conservation exists only when the total amount of energy in a specific volume in space contains only one member of energies which belong to an Energy Pair.

Although the Energy Pairs assumption is actually derived from the findings that charge is another form of energy, the assumption that equal sizes of both energies belonging to the same Energy Pair annihilate each other, might be seen as a mere speculation.

However, since it provides reasonable explanations to the mysteries and paradoxes described above, it seems also as a reasonable assumption and not just a speculation.
Equating Emptiness to Substance

Since Energy Pairs of equal intensities residing in the same space volume annihilates to nothing, then, the Energy Pairs concept can be extrapolated to predict that Energy Pairs can be also generated out of nothing.

This extrapolation is indeed a mere speculation, but it is based on the assumption that if things annihilate each other to nothing, they can also emerge together from nothing.

This concept attributes to the nothing (or complete emptiness) concept the same validity as the validity attributed to the existence (or substance) concept, and since this concept assumes that something can evolve from nothing, it discards the need for the concept of creation.

The prediction that Energy Pairs can be generated out of nothing provides also a connection between the Quantum Mechanics physics and rest of physics, because also Quantum Mechanics physics predicts that there is no such thing as complete emptiness (or absolute nothing), and it always contains random quantum fluctuations in which negative energy annihilates same amounts of positive energy.
Summary, Results and Conclusions

Before the presentation of the special theory of relativity, the science of physics recognized actually three distinct entities: energy, mass and charge (apart from time and space).

After the presentation of the special theory of relativity, the mass ceased to be a distinct entity, and it is recognized as a special form of energy. So, now there are only two distinct entities: energy and charge (apart from time and space).

Also, the special theory of relativity provided the explanation to the question what caused the kinetic energy of a moving mass. Its answer was that the increase in mass because of the mass velocity, is actually the kinetic energy of that mass.

Thus, in regard to the above, the questions why charge is still a distinct entity, and what cause the creation of the magnetic field created by a moving charge, remain open.

This article deals with these questions, by deriving that charge is also a special form of energy, that charge magnitude is not constant and increases by charge velocity, and that charge magnitude increase is the cause for the creation of the magnetic field.

Thus, if these claims turns to be proved by experiments, the energy remains the only distinct entity (apart from time and space), which turns to be a much simpler and cleaner view of nature.

Also by using these claims and by conducting a "thinking exercise" while analyzing the current equations from a new point of view, this article arrives at the following formula for the charge increase by velocity:

\[ q = \frac{q_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \]

This is very similar to the equation:

\[ m = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}} \]

Which describes the increase in mass when the mass is moving.

Also, analogous to the equation \( \Delta E = (\Delta m) c^2 \), derived from the special relativity theory, when applying the above claims, it can be shown that \( \Delta u \), the energy density in the magnetic field of a moving charge, is dependent and directly proportional only to \( \Delta q^2 \), which is the increase in the magnitude of the square of the charge \( q \) when it is moving.

Also, by applying these claims it turns out that the magnetic and electric fields generated by the same moving charge are always perpendicular to each other, and, thus, always has the structure of the electromagnetic emission from accelerating moving charges.

Also the claims that charge is a special form of energy brought about another concept, the concept of Energy Pairs.
This concept states that certain potential energies, such as the potential energies embedded in magnetic fields, should exist as pairs of energies, such that the member in that pair that has smaller intensity cancels an energy portion equal to its energy amount of the other member in that pair, if both happen to coexist in the same space volume.

Moreover, the Energy Pairs concept was used to provide an explanation to magnetic and electric fields potential energy conservation paradoxes and an explanation to an unresolved mystery of charge disappearance in electron positron collisions.

This brought about also another conclusion, which implies that energy conservation exists only when the total amount of energy in a specific volume in space contains only one member of energies which belong to an Energy Pair.

The concept of Energy Pairs also can be extrapolated to predict that Energy Pairs can be generated from nothing (or complete emptiness) which, in turn, equivalents Emptiness to Substance. This also provides a connection between the Quantum Mechanics physics and rest of physics, because also Quantum Mechanics physics predicts that there is no such thing as complete emptiness (or absolute nothing), and it always contains random quantum fluctuations in which negative energy annihilates same amounts of positive energy.

Finally, a few comments about the methodology used in this article, and comments about possible future activities regarding the content of this article:

The claims that charge is a special form of energy, that charge increases by velocity and it is the cause for the creation of the magnetic field of a moving charge were derived from the existing energy density equations of electric and magnetic fields.

Then, the results of theses claims brought about new insights.

It should be noted that even if the derivation of these claims from the existing energy density equations of electric and magnetic fields, is found to be problematic, leaving these claims as claims still brings about new important insights. It should be noted that similar approach, of using claims, was used before. For example, the special relativity theory was also based on the claim that nothing can travel faster than the speed of light, and based on that claim, the theory brought about new insights.

Thus, the article states that energy is another form of energy, and it brings new insights that indicates that that might be the case. This should trigger further investigations in this matter, which might either discard this idea or strengthen it.

Although direct proof that charge increases by velocity might be impractical, if a single polarity charge (such as an electron) can be annihilated completely to energy, and the resulting energy intensity will be greater than the mass converted to energy in this case, this might turn to be such a proof.
Such result was not demonstrated yet, although the annihilation and full conversion to energy of pairs of opposite polarities charges was demonstrated (such as converting pairs of electron and positron to energy). But such conversion is not expected to generate additional energy, above the energy embedded in the converted masses, since they belong to one Energy Pair as assumed in this article.

Also, in regard of what can be done to prove or disprove the claims presented in this article, it is worthwhile to mention the following:

Although direct measurement of charge magnitude while it is travelling at very high speed seems to be not practical, it is worthwhile to analyze such measurements, since, as technology advances, such measurements might become practical.

Thus, if measurements of the intensities of the energy densities of the electric and magnetic fields, generated by charged particles, travelling at velocities greater than \((1/2^{1/2})c\), will be found to be practical, an experiment that proves or disproves that charge increases by velocity, can be devised.

Since, if charge does not increase by velocity, then, from the energy density equations of electric and magnetic fields follows, that at any point in space, the magnetic field energy density intensity must be smaller than the electric field energy density intensity.

This results from the fact that, as shown before, the electric field energy density is proportional to \(q^2\) and the magnetic field energy density is proportional (with exactly the same proportion) to \(q^2 (v^2/c^2) \sin^2 \alpha\) and \((v^2/c^2) \sin^2 \alpha\) is a fraction less than 1.

Thus, the sum of the energy density intensities of the electric and magnetic fields is less than twice the energy density intensity of the electric field generated by the non moving charge.

On the other hand, if charge does increases by velocity according to

\[
q = q_0/(1 - v_1^2/c^2)^{1/2}
\]

then, if the charge travels at a velocity greater than \((1/2^{1/2})c\), there are points in space where \(q^2 (v^2/c^2) \sin^2 \alpha\) is greater than \(q_0^2\), and thus, at these points in space the sum of the energy density intensities of the electric and magnetic fields will be more than twice the energy density intensity of the electric field generated by the non moving charge.
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