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.

As will be shown in this article, there are similarities between mass and charge which might lead us to conclude that charge should also be considered as a special form of energy.

From the above, the following question might be asked:

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

Thus, this article does claim that **Charge might also be recognized as another form of Energy, as mass turned to be**. This claim, if found viable, and supported by additional findings, will make Energy as the only distinct entity (in addition to time and space), **a simpler and cleaner view of nature**.

This article suggests this claim by using the important similarities that exist between mass and charge, as will be further explained in this article, and 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, the article tries to evaluate if this leads also to additional insights.

The results are the following conclusions:

1. 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.

   Actually, this article shows that a moving charge generates not just a single additional field referred to as the magnetic field generated by the moving charge.

   This article shows that a moving charge generates two additional field components, additional to the electric field it generated when it was not moving.

   One of them is an **increase of the electric field intensity** generated when the charge was not moving. The other is a **field perpendicular to the electric field** and might be considered as the actual additional magnetic field.

This resolves the mystery why only in electromagnetic emissions the magnetic and electric fields are always perpendicular to each other, while in other cases, the current knowledge of physics imply that they are **not necessarily perpendicular to each other**.

Actually, this finding might not be a new finding. It might be a result of explaining magnetism as being a combination of maxwell equations and special relativity. But the way it is evaluated here might be new.

2. It should be emphasized that it might be impossible to derive an equation which describes the relation between charge and the energy embedded in charge, analogeous to the equation $E = m\,c^2$, or arrange an experiment that measures that. This might be because the charge conservation principle inhibits us to convert only charge of one polarity (say positive charge) to energy, without converting a same amount of the other polarity charge (say negative charge), also to energy. And, as the Energy Pairs theory, presented later in this article, implies, by converting same amounts of negative and positive charges to energy results in an untraceable and undetectable Energy Pair, which cannot be measured.

3. 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.

   This might be one of the crucial reasons why it was difficult to recognize charge as another form of energy.

   However, the article provides a logical explanation to this issue. The article also assigns these energy types to one set of Energy Pairs.

   This Energy Pairs Theory is also used to explain why in the electron and positron collisions the charges completely disappear.

Introduction

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

$$m = m_0/(1 - v^2/c^2)^{1/2}$$ where c is the speed of light.

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

$$E = m\,c^2$$ 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, according to the charge invariance principle, the science of physics views the charge as an entity whose magnitude value is constant and not affected by its velocity.

However, a spectator, monitoring a **moving charge**, sees an **increase in the charge density**, because of the Lorentz Length Contraction factor.

Also, modern physics already recognizes that this increase in the charge density is the reason that this spectator detects also a magnetic field because of this moving charge.

From the above, the following question might be asked:

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

Since, 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.

Moreover, as will be shown in this article, there are similarities between mass and charge that might lead us to conclude that charge should be also considered as a special form of energy.

Thus, this article does claim that **Charge might be 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.

This article derives this claim by using the important similarities that exist between mass and charge, as will be further explained in this article, and 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, the article tries to evaluate if this leads also to additional new insights.

The results are the following conclusions:

1. 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 **<u>not necessarily perpendicular to each other</u>**.

However, this article shows , that the magnetic field generated by a moving 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 have the structure of the electromagnetic emission from accelerating moving charges.

Actually, this article shows that a moving charge generates not just a single additional field referred to as the magnetic field generated by the moving charge.

This article shows that a moving charge generates two additional field components, additional to the electric field it generated when it was not moving.

One of them is an increase of the electric field intensity generated when the charge was not moving. The other is a field perpendicular to the electric field and might be considered as the actual additional magnetic field.

This resolves the mystery why only in electromagnetic emissions the magnetic and electric fields are always perpendicular to each other, while in other cases, the current knowledge of physics imply that they are **<u>not necessarily perpendicular to each other</u>**.

Actually, this finding might not be a new finding. It might be a result of explaining magnetism as being a combination of maxwell equations and special relativity. But the way it is evaluated here might be new.

2. It should be emphasized that it might be impossible to derive an equation which describes the relation between charge and the energy embedded in charge, analogeous to the equation $E = m c^2$, or arrange an experiment that measures that. This might be because the charge conservation principle inhibits us to convert only charge of one polarity (say positive charge) to energy, without converting a same amount of the other polarity charge (say negative charge), also to energy. And, as the Energy Pairs theory, presented later in this article, implies, by converting same amounts of negative and positive charges to energy results in an untraceable and undetectable Energy Pair, which cannot be measured.

3. 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.

This might be one of the crucial reasons why it was difficult to recognize charge as another form of energy.

However, the article provides a logical explanation to this issue. The article also assigns these energy types to one set of Energy Pairs.

This Energy Pairs Theory is also used to explain why in the electron and positron collisions the charges completely disappear.

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, might, in certain situations, cancel each other if they coexist in the same space volume.

Review of Energy densities equations

According to the charge invariance principle, charge is a constant entity, not affected by its velocity.

However, because of the Lorentz Length Contraction factor, an external spectator to a **moving charge**, sees an **increase in the charge density** by the inverse of the Lorentz Length Contraction factor

$$1/(1 - v_1^2/c^2)^{1/2}$$

where v_1 is charge velocity component which is perpendicular to the line that connects the external spectator to the moving charge, and c is the speed of light.

In this section we will first review why modern physics claims that this increase in the charge density is the reason that this spectator also detects a magnetic field because of this moving charge.

However, we will focus in this explanation on point charges, since we refer to point charges throughout this article, because we want to refer to the single charge, and point charges seem as the most straightforward way to do this.

Point charges are an idealization, they don't really exist.

However, if we assume that a charge Q is spread over a length L, and we denote L1 as a minimum length, such that a charge Q1 spread over the length L1 is short enough as to be considered as a point charge, then, we can use the equations relating to point charges when dealing with this charge Q1.

Then, a non moving charge Q spread over a length L can be divided into L/L1 non moving point charges, each spread over a length L1 and each with a charge magnitude of

$$q_0 = Q*(L1/L).$$

Then, an extrernal spectator to the charge Q, (the charge Q being spread over a length L when it is not moving), sees a contraction of the length L, when the charge Q is moving relative to this external spectator, according to the Lorentz Length Contraction factor.

Thus if we denote as q the magnitude of each point charge that the external spectator sees now, when the charge Q is moving, then

$$q = Q*(L1 / (L*(1 - v_1^2/c^2)^{1/2}))$$

It should be noted that L1 can be always choosen such that, on one hand, it is short enough so that q_0 and q can be considered point charges, and, on the other hand L/L1 and $(L*(1 - v_1^2/c^2)^{1/2}) / L1$ are both whole numbers.

Thus, the relation between q and q_0 is such that q is bigger than q_0 by the inverse of the Lorentz Length Contraction factor :

$$q / q_0 = 1/(1 - v_1^2/c^2)^{1/2}.$$

Thus, an external spectator to a moving charge Q **which is not a point charge** sees less **point** moving charges of length L1 as compared to the number of **point** charges of length L1 that he saw when the charge Q was not moving. But, each such **point** moving charge is bigger in its charge magnitude than any **point** charge he saw when the charge was not moving, by a factor of: $1/(1 - v_1^2/c^2)^{1/2}$.

But this spectator still sees the same charge magnitude Q, although the charge is moving, as the charge invariance principle dictates.

In the following paragraphs we will deal with the embedded energy per unit volume (or energy density) in electric and magnetic fields, but we will use the equations of point charges, when presenting the electric field $E^{->}$ and the magnetic field $B^{->}$ that these energy density equations contain.

Since the equations of point charge are considered to be viable, the discussion does not violate any existing knowledge of electromagnetism, and should be consistent also with what maxwell's equations provide.

Since in the real world, a charge Q which is not a point charge can be considered to be composed of a number of point charges q_0 (or q, if Q is moving) , and the effects of the charge Q can be evaluated as superpositions of all the effects of all the point charges q_0 (or q), it is enough to restrict the arguments only to the effects of the point charges q_0 (or q).

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 ε_0 is the vacuum permittivity and is equal to: 8.854187817…x 10^{-12} F/m (Farad per meter)

Since, for a non moving point charge q_0,

$|E^{->}| = (1/(4\pi\ \varepsilon_0))(q_0/r^2)$ Where q_0 is the non moving point charge magnitude and r is the distance from the non moving point 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 point 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 μ_0 is the vacuum magnetic permeability and is equal to: $4\pi 10^{-7}$ H/m (Henry per meter).

Since, for a moving point charge q,

$|B^{->}| = (\mu_0/(4\pi))(qv\sin\alpha/r^2)$ (Ref 4).

Where q is the moving point charge magnitude that generated the magnetic field $B^{->}$ moving at the velocity v, and α 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), and, $v\sin\alpha$ is the velocity component that is perpendicular to the line that connects the external spectator to the moving point charge q, and thus, can be denoted v_1

then

$u_m = (1/(32\varepsilon_0\pi^2))(q^2(v_1^2/c^2)/r^4)$

since we already denoted $K = 1/(32\varepsilon_0\pi^2)$ then,

$u_m = (K q^2(v_1^2/c^2))/r^4$. Denoting $x = (v_1^2/c^2)$, then,

$u_m = (K q^2 x)/r^4$ and as shown above $u_e = (K q_0^2)/r^4$

Both equations, u_m and u_e , have exactly the same structure, only u_m contains q^2x as its generation source and u_e contains q^2_0 as its generation source.

Also, 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. Thus, these equations already imply that charge should be the energy embedded in the electric and magnetic fields. Because, the only components in these equations that can be considered as containing the energy are q^2_0 and q^2. Since, all the other components in these equations are either constants, or components that depend only on the location in space where these energy densities reside.

Now, instead of the point charges q_0 and q we refer now to a charge Q **which is not a point charge**. Then, when the charge Q is moving its charge magnitude does not change, according to the charge invariance principle.

But, when Q is moving, if we evaluate its effects by analyzing the point charges (of length L1) it is composed of (as shown in previous paragraphs), then, as already explained in a previous paragraph, each of the moving point charges q, that Q is composed of, when the charge Q is moving, has a bigger charge magnitude than each of the non moving point charges q_0, that Q is composed of, when the charge Q is not moving, by a factor equal to the inverse of the Lorentz Length Contraction factor (as shown in previous paragraphs).

Thus, each such moving point charge will generate a bigger energy density, as compared to the energy density any non moving point charges generated.

Also, from the point of view of the external spectator of the moving charge, all it sees is a bigger magnitude point charge which generates a bigger energy density. Thus, this bigger energy density, that can be denoted u_{total} , that is generated by any of the moving point charges q that Q is composed of, should be expressed by the same formula structure as the structure of the formula of the energy density of any of the non moving point charges q_0 that Q is composed of.

Thus, since $u_e = (K\, q_0^2)/ r^4$ it can be argued that $u_{total} = (K\, q^2)/ r^4$

Then, if we sustract the electric energy density u_e , of any of the non moving point charges that Q is composed of, from the total energy density u_{total} , of any of the moving point charges that Q is composed of, we get

$$u_{total} - u_e = (K\, q^2)/ r^4 - (K\, q^2{}_0)/ r^4 . \quad \text{since } q^2 = q_0^2 / (1- (v_1^2/c^2))$$
$$u_{total} - u_e = (K\, q_0^2 / (1- (v_1^2/c^2))/ r^4 - (K\, q_0^2)/ r^4 =$$
$$= (K\, q^2(v_1^2/c^2))/ r^4 = (K\, q^2 x)/ r^4 = u_m .$$

which is the energy density of the magnetic field u_m detected because of any of the moving point charges q that Q is composed of.

Thus, since the energy density in the magnetic field detected because of the moving charge Q (**which is not a point charge**), is the superposition of all the energy densities in the magnetic fields detected because of all the moving point charges it is composed of, then, **the energy density in the magnetic field of the moving charge Q**, which is additional to the electric energy density detected because of the non moving charge Q, is a result of **the charge density increase that a spectator extrernal to the moving charge Q** sees.

This concludes the review why modern physics recognizes that the increase of the charge density because of the charge velocity, which is detected by a spectator external to a moving charge, is the cause that this spectator detects also a magnetic field because of this moving charge.

Arguments why charge might be also Energy

At this point we can refer to the reasons why we claim that charge might also be considered as another form of energy.

In a previous paragraph we already claimed that the only components in the energy densities equations of the electric and magnetic fields u_e and u_m that can be considered as containing the energy, are $q^2{}_0$ and q^2.

Indeed, u_e and u_m are the energy density embedded in the electric and magnetic fields and not in the charges that generated these fields.

But, according to Ref 8 "The gravitational field of a point mass and the electric field of a point charge are structurally similar" and when analyzing "the energy density for the electric field, and a similar expression" which "represents the energy density for the magnetic field, no such energy density term has ever been defined for the gravitational field. But one suspects that it could be, and possibly even should be".

Also, Ref 8 does provides an expression for the energy density in the gravitational field in which m^2 (the square of the mass magnitude) can be considered as the only component containing the energy, as $q^2{}_0$ and q^2 are the only components that can be considered as containing the energy densities u_e and u_m in the energy density equations for the electric and magnetic fields.

And, since mass is already recognized as being another form of energy, it implies that the energy in the mass is also manifested in the energy density of the gravitational field.

Thus, analogeous to the above, the fact that the only components in the energy densities equations of the electric and magnetic fields u_e and u_m that can be considered as containing the energy, are $q^2{}_0$ and q^2, should also imply that this energy density is a manifestation of the energy embedded in the charge, and that the charge is also another form of energy.

In addition to that, the fact that was already derived above, that the detection of the energy density u_m manifested by any moving point charge q, which a moving charge Q is composed of, is a result of the increase in the charge density a spectator external to Q sees, is another reason why the charge might be seen as energy.

This result is a manifestation that modern physics sees the detection of magnetism by a spectator external of a moving charge, as a combination of maxwell equation and special relativity. And, analogeous to the detection of magnetism by a spectator external to a moving charge, a spectator external to a moving mass sees a phenomenon denoted as gavitational electromagnetism (GEM), which is the analogy of magnetism in gravitation (Ref 12).

Thus, structural similarities between mass and charge extends beyond the case of stationary masses and stationary charges, as described above.

These strong similarities between mass and charge, strongly implies that charge might also be a form of energy, as mass turned to be.

However, it should be emphasized, that although the above arguments can be considered as providing reasonable arguments for claiming that **<u>Charge might be indeed Energy</u>**, they do not yet indicate what should be the equation that provides the exact relation between charge and energy, as the equation $E = m c^2$ is providing the exact relation between mass and energy.

This is because of the following:

It should be emphasized, as already explained, that the external spectator sees less point moving charges q, that Q is composed of, when Q is moving, as compared to the number of non moving point charges q_0 , that Q is composed of, when Q was not moving.

But the total amount of energy density, this external spectator sees when that charge Q is moving, over the period of time it moves over this spectator**, <u>is the same</u>** as it was when the charge Q was not moving.

This is because, when the charge Q was not moving, the external spectator saw more non moving point charges generating the energy density u_e related to only to the electric field energy density.

When the charge Q was moving, the external spectator saw a smaller number of moving point charges, but now, each such moving point charge generates the energy density u_{total} which is the sum of u_e and u_m. Or in other words, the sum of the electric field energy density and the magnetic field energy density.

Thus, although the external spectator sees a **<u>different mixture of energies</u>** when the charge is moving as compared to when the charge was not moving, he still sees **<u>the same amount of energy</u>** generated when the charge is moving as compared to when the charge was not moving, although, **<u>among this energy mixture</u>**, this spectator **<u>detects</u>** also a magnetic field.

This also complies with the charge invariance principle.

And, since when the charge is moving each moving point charge generates an energy density of $(K q^2)/ r^4$, the total energy density in the electric and magnetic fields the external spectator sees is $(K Q^2)/ r^4$ where Q is the moving charge, which is not a point charge, which does not change because of the charge movement, and is the only component that contains the energy in the equation.

On, the other hand, when a spectator monitors a moving mass, the **<u>mass does increase</u>**, and M^2 (the square of the increased mass magnitude) is now the only component that contains the energy density in the gravitational field.

Thus, from the point of view of the **<u>mixture of the energies detected</u>**, the **<u>increase in the charge density</u>** for a moving charge is analogeous to the **<u>increase of the mass</u>** for a moving mass.

But, since the **charge does not increase, and its square value** is manifested in the energy density of the electric and magnetic fields, and the **mass does increase, and its increased square value** is manifested in the energy density of the gravitaional field, the energy embedded in charge should be proportional to the **charge magnitude**, as the energy embedded in mass is proportional to the **mass magnitude**.

It should also be emphasized that there are also differences between mass and charge.

As already mentioned above, an external spectator to a moving mass sees an increase of this mass. On the other hand, because of the charge invariance principle, charge does not increase by velocity.

Also, masses are usually positive entities and always attract each other, while charge comes as positive and negative charges and different signed charges attract each other while similar signed charges repel each other.

Also, masses can be converted to energy, while, according to the charge conservation principle, the total number of positive and negative charges must balance each other, such that only one type of charges cannot be eliminated alone.

Also, equations such as $P = m V$ or $F = m a$ do not exist in the case of charges.

However, these diferences do not cancel the similarities between charge and mass presented before, and do not cancel the possibility that charge might be also another form of energy, implied by the similarities between charge and mass described above.

In a next section (Analysis) we will evaluate the issue from another point of view. We will analyse it from the point of view of the electric and magnetic fields and electric and magnetic forces.

We will show that the moving charge actually generates by its movement not a single magnetic field and a single magnetic force, but two components of fields and forces which are perpendicular to each other.

One of them can be considered as the actual magnetic field and the actual magnetic force. The other is an increase of the electric field and the electric force. And both are detected by an external spectator to the moving charge, again, as a result of the increase of the charge density that this spectator sees.

Since these two fields are perpendicular to each other, it turns out that, 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. Which resolves the mystery why only in electromagnetic emission the magnetic and electric fields are always perpendicular to each other, while in other cases, the current knowledge of physics imply that they are **not necessarily perpendicular to each other**.

Actually, this finding might not be a new finding. It might be a result of explaining magnetism as being a combination of maxwell equations and special relativity. But the way it is evaluated here might be new.

But, first a review of existing formulae for point charges will be presented, to assist in the discussion presented in the coming Analysis section.

Review of existing formulae for Point charges

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-> at a distance r from the charge as shown in Fig. 1:

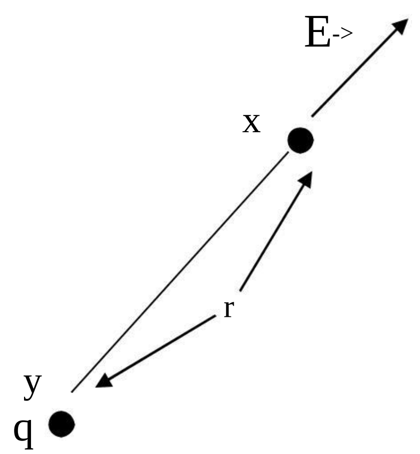

Fig. 1

The induced electric field is a vector E-> as expressed by the formula:
(Ref 3)

$$\vec{E} = (1/(4\pi\varepsilon_0))(q\vec{r}/r^2)$$

Where ε_0 is the vacuum permittivity and is equal to:
8.854187817…x 10^{-12} F/m (Farad per meter)

And r -> is a unit vector in the direction of the line xy, indicating that E-> is also a vector in that direction.

The magnitude of E-> is expressed by the formula:

$$|\vec{E}| = (1/(4\pi\varepsilon_0))(q/r^2)$$

2. A moving point charge q moving at a constant velocity $v^{->}$ induces a magnetic field $B^{->}$ at a distance r from the charge, as shown in Fig. 2.

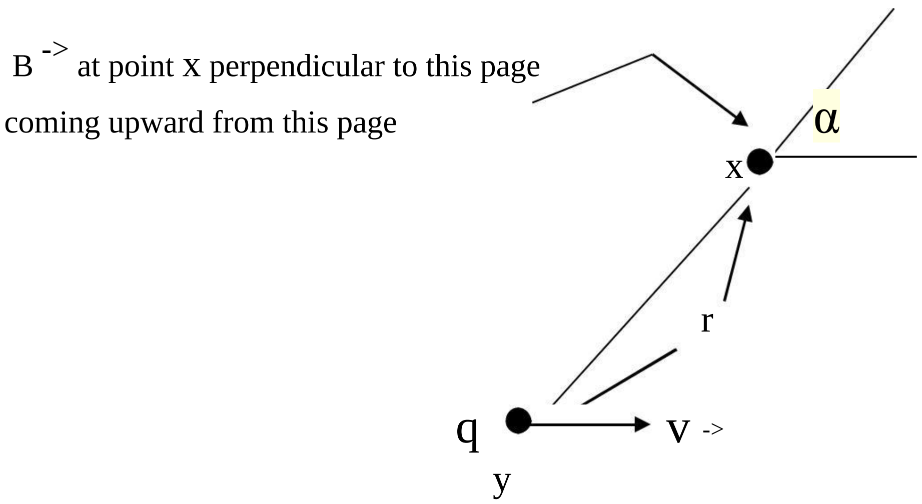

Fig. 2

The magnetic field $B^{->}$ is expressed by the formula:
(Ref 4)

$$B^{->} = (\mu_0/(4\pi))(q(v^{->} X\ r^{->})/r^2)$$

Where μ_0 is the vacuum magnetic permeability and is equal to:
$4\pi 10^{-7}$ H/m (Henry per meter).

Where $B^{->}$ is a vector which is the result of the vector multiplication of $\mathbf{v}^{->}$ and $r^{->}$, where $\mathbf{v}^{->}$ is the charge velocity vector and $r^{->}$ is a unit vector in the direction of xy

The result of the vector multiplication of $\mathbf{v}^{->}$ and $r^{->}$ also give the magnitude of $B^{->}$ which is given by the following formula:

$$| B^{->}| = (\mu_0/(4\pi))((qv\sin \alpha)/r^2)$$

Where v is the magnitude of $v^{->}$ ($|v^{->}|$)

3. The force $F^{->}_E$ exerted on a point charge q residing in an electric field $E^{->}$ is expressed by the following formula:
(Ref 3)

$$F^{->}_E = E^{->} q$$

Where $F^{->}_E$ is a vector in the direction of the electric field $E^{->}$ whose magnitude is:

$$|F^{->}_E| = |E^{->}| q$$

4. The force $\vec{F}_B$ exerted on a point charge q_2 moving in a magnetic field $\vec{B}$ at a constant velocity $\vec{v}_x$ is shown in Fig. 3:

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

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

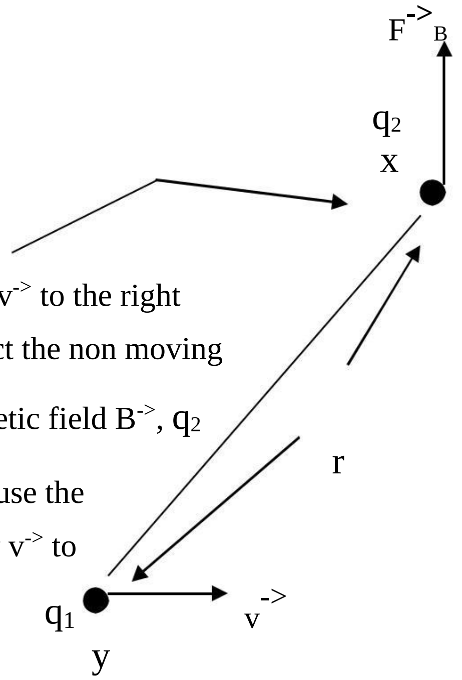

Fig. 3

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

The force $\vec{F}_B$ is expressed by the following formula:
(Ref 5)

$$\vec{F}_B = q_2 (\vec{v}_x \times \vec{B})$$

where $\vec{F}_B$ is a vector resulting from the vector multiplication of $\vec{v}_x$ and $\vec{B}$.

The magnitude of $\vec{F}_B$ is given by the following formula:

$|\vec{F}_B| = (\mu_0/(4\pi))((q_1 q_2 v^2 \sin \alpha)/r^2)$ where α is the angle between $\vec{v}$ and xy

Where q_1 is the point moving charge generating the magnetic field $\vec{B}$, the charge q_1 is moving at constant velocity 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 v to the left relative to the magnetic field $\vec{B}$, since $\vec{B}$ is a magnetic field moving at a velocity v to the right since it is generated by the point charge q_1 moving at constant velocity v to the right.

Analysis

Now we will evaluate, our claim, that a moving charge generates not just a single additional field referred to as the magnetic field generated by the moving charge.

We will now show that a moving charge generates two additional field components, additional to the electric field it generated when it was not moving.

One of them is an **increase of the electric field intensity** generated when the charge was not moving. The other is a **field perpendicular to the electric field** and might be considered as the actual additional magnetic field.

And this results, again, is derived from the fact that a spectator external to the moving charge, sees an increase of the charge density.

It should be emphsized, that this finding does not contradict the current experimental results relating to magnetic fields and magnetic forces. It only shows that the same magnetic field magnitude, and the same magnetic force magnitude that are derived by the current viable equations, can be shown to be presented also as two fields components, as just described above.

we will refer to Fig. 4:

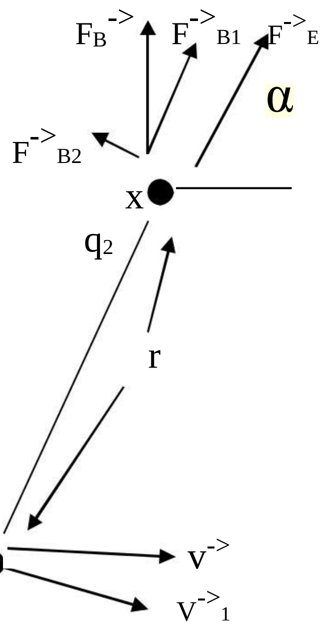

Fig.4

The point charge q_1 at point y in space is a moving point charge, moving at a constant velocity v to the right.

The point charge q_2 is a point charge at point x in space, such that the line xy is at a distance r from y.

q_1 is also the magnitude of any of the moving point charges (of length L1) that a charge Q_1, at point y in space, **(which is not a point charge)** is composed of, when Q_1 is moving at a constant velocity v to the right, relative to an external spectator to Q_1.

We will also give the notation q_{10} to the magnitude of any of the non moving point charges (of length L1) that composes the charge Q_1, when Q_1 is not moving relative to an external spectator to Q_1.

As already shown in a previous chapter, because of the increase in the charge density detected by a spectator external to the charge Q_1 , q_1 is bigger as compared to q_{10} by the inverse of the Lorentz Length Contraction factor, although the magnitude of Q_1 is the same when it is moving, as compared to its magnitude when it is not moving, relative to an external spectator to Q_1.

similarly, q_{20} denotes the magnitude of any of the non moving point charges (of length L1) that a charge Q_2 , at point x in space, **(which is not a point charge)** is composed of, when Q_2 is not moving relative to an external spectator to Q_2.

And, q_2 denotes the magnitude of any of the moving point charges (of length L1) that a charge Q_2 is composed of, when it is moving relative to an external spectator to Q_2.

Again, as already shown in a previous chapter, because of the increase in the charge density detected by a spectator external to the charge Q_2 , q_2 charge magnitude is bigger as compared to q_{20} by the inverse of Lorentz Length Contraction factor, although the magnitude of Q_2 is the same when it is moving, as compared to its magnitude when it is not moving, relative to an external spectator to Q_2.

The field $E^{->}$ is a vector in the direction of the line xy. The force $F^{->}{}_E$ is also a vector in the direction of the line xy and its magnitude is:

$$|F^{->}{}_E| = (1/(4\pi\varepsilon_0))(q_{10}q_{20}/r^2)$$

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

The force $F^{->}{}_B$ resides in the plane where $v^{->}$ and the line xy reside, is perpendicular to $v^{->}$ and points upward. The magnitude of $F^{->}{}_B$ is given by:

$$|F^{->}{}_B| = (\mu_0/(4\pi))((q_1q_2v^2\sin\alpha)/r^2)$$

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

The force $\vec{F}_B$ can be disassembled into its two components, the one $\vec{F}_{B1}$ parallel to $\vec{F}_E$ and another, $\vec{F}_{B2}$, perpendicular to $\vec{F}_E$.

The magnitudes of these forces are:

$$|\vec{F}_{B1}| = (\mu_0/(4\pi))((q_1 q_2 v^2 \sin^2\alpha)/r^2)$$

$$|\vec{F}_{B2}| = (\mu_0/(4\pi))((q_1 q_2 v^2 \sin\alpha\cos\alpha)/r^2)$$

Since $\vec{F}_{B1}$ is parallel to $\vec{F}_E$ it can be argued that it represents an increase to the electric force caused by the movement of q_1.

Thus, it can be argued that on point charge q_2 a bigger electric field exerts a bigger electric force $\vec{F}_E$(bigger) by the moving point 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.

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

So, it can be argued that:

$$\vec{F}_E(\text{bigger}) = (1/(4\pi\varepsilon_0))(q_1 q_2\, \vec{r}/r^2)$$

As already shown in a previous chapter, (because of the charge density increase) :

$$q_1 = q_{10}/(1 - (v \sin\alpha)^2/c^2)^{1/2}$$

$$q_2 = q_{20}/(1 - (v \sin\alpha)^2/c^2)^{1/2}$$

Then

$$\vec{F}_E(\text{bigger}) = (1/(4\pi\varepsilon_0))\, (q_{10}\ q_{20} / (1 - (v \sin\alpha)^2/c^2)\, \vec{r}/r^2)$$

if we substract $\vec{F}_E$ from $\vec{F}_E$(bigger) we get:

$$\vec{F}_E(\text{bigger}) - \vec{F}_E =$$

$$= (1/(4\pi\varepsilon_0))\, (q_{10}\ q_{20} / (1 - (v \sin\alpha)^2/c^2)\, \vec{r}/r^2) - (1/(4\pi\varepsilon_0))\, (q_{10}\ q_{20}/r^2) =$$

$= (1/(4\pi\varepsilon_0)) ((q_{10}\ q_{20} / (1 - (v \sin\alpha)^2/c^2))) (v^2 \sin^2\alpha) / r^2) =$

$= (1/(4\pi\varepsilon_0)) ((q_1\ q_2\ v^2 \sin^2\alpha)/r^2).$

Since $\mu_0 = 1/(\varepsilon_0 c^2)$ (Ref 4) then

$F^{->}_E(\text{bigger}) - F^{->}_E = (\mu_0/(4\pi))((q_1\ q_2\ v^2 \sin^2\alpha)/r^2) = |F^{->}_{B1}|$

Thus, $F^{->}_{B1}$, which is the component of the magnetic force parallel to $F^{->}_E$, that the moving point charge q_1 exerts on the point charge q_2, is a result of the moving point charge magnitude q_1 being bigger by the inverse of the Lorentz Length Contraction factor as compared to the non moving point charge magnitude q_{10}. And, this is because an external spectator to charge Q_1 sees an increase of the charge density because Q_1 is moving relative to this spectator.

It should also be noted that the line xy is the line that connects each of the moving point charges q_1 and q_2, to the specific charge spectator. Thus, when we talk about external spectators, the external spectators for the moving point charges q_1 and q_2 are different spectators. The spectator of moving point charge q_1 reside where q_2 resides, and the spectator of moving point charge q_2 resides where q_1 resides.

The external spectator for the moving 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 moving 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 moving 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 moving 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 $B^{->}$ generated by q_1.

In addition to the above, apart from increasing the forces exerted by the electric field by the component $F^{->}_{B1}$, the moving point charge q_1 also generates another force $F^{->}_{B2}$, as already noted, which is perpendicular to $F^{->}_{B1}$ (and thus, perpendicular to the increased electric field) and whose magnitude is : (as noted before)

$|F^{->}_{B2}| = (\mu_0/(4\pi))((q_1 q_2 v^2 \sin\alpha\cos\alpha)/r^2)$

Thus, it should be noted that, from the above, that the velocity of a moving 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 $\vec{F}_{B1}$ on point charge q_2.

Another moving field component is the one that exerts the force $\vec{F}_{B2}$ 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 have the structure of the electromagnetic emission from accelerating moving charges**.

The Energy Pairs Theory

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.

This might be one of the crucial reasons why it was difficult to recognize charge as another form of energy.

However, the claim 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 existance. 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 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 assumption that certain energies can cancel each other is not a new concept in physics. According to Ref 9, the energy embedded in the gravitational fields, in the whole universe, is now considered to be a negative energy, such that it offsets completely the energies embedded in the masses, in the whole universe, such that the net energy of the universe which relates to masses and gravitational fields is zero.

This fits with the assumption that the energies embedded in charges belong to one set of Energy Pairs, and, if the charge conservation principle holds, the net energy embedded in charges, in the whole universe, is again zero.

On the other hand, according to Ref 8, we already showed that Ref 8 defined an equation for the energy density in the gravitational field. If we adopt the idea presented in Ref 9 that this energy density is a negative energy, then, we should conclude also that the energy embedded in the mass and the energy embedded in the gravitational field belong also to an Energy Pair.

Also, the energy in the charge and the energy in the electric field or magnetic field should also belong to an Energy Pair.

Also, as Ref 10 implies, modern physics is evaluting the concept of negative mass. Ref 11 even informs that it may be that physicists created "negative mass". If the notion of negative mass is found to be a viable concept, it further increases the similarities between mass and charge, as related to energy. Then, since mass is already recognized as a special form of energy, this increases the possibility that charge should also be recognized as a special form of 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, there are similarities between mass and charge which might lead us to conclude that charge should also be considered as a special form of energy. Thus, in regard to the above, the question why charge is still a distinct entity remains open.

This article deals with this question, by claiming that **Charge might also be a special form of Energy**.

Thus, 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, this article shows that the **magnetic and electric fields generated by the same moving charge are always perpendicular to each other**, and, thus, always have the structure of the electromagnetic emission from accelerating moving charges. **This resolves the mystery why only in electromagnetic emission the magnetic and electric fields are always perpendicular to each other, while in other cases, the current knowledge of physics imply that they are not necessarily perpendicular to each other**.

It should be emphasized that it might be impossible to derive an equation which describes the relation between charge and the energy embedded in charge, analogeous to the equation $E = m c^2$, or arrange an experiment that measures that. This might be because the charge conservation principle inhibits us to convert only charge of one polarity (say positive charge) to energy, without converting a same amount of the other polarity charge (say negative charge), also to energy. And, as the Energy Pairs theory, presented later in this article, implies, by converting same amounts of negative and positive charges to energy results in an untraceable and undetectable Energy Pair, which cannot be measured.

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 energies, such as the energies embedded in charges, should exist as pairs of energies, such that energies belonging to an Energy Pair might, in certain cases, annihilate each other, if both happen to coexist in the same space volume.

Moreover, the Energy Pairs concept was used to provide an explanation to an unresolved mystery of charge disappearance in electron positron collisions.

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