Electric Charges as Energy Pairs

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.

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.

Also, this article suggests the following:

1. Analogous to the equation:

   \[ E = m \ c^2 \]

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

   derived by the special theory of relativity, which describes the relation between the energy embedded in mass and mass magnitude, this article suggests several options of equations that might describe the relation between the energy embedded in charge and charge magnitude. These suggestions are based only on assumptions and must be supported by additional findings.

2. Because 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)

\[ E = mc^2 \]

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

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.

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.

Also, this article suggests the following:

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2. Because 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**

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

$$u_e = \varepsilon_0 |E^\to|^2/(2).$$

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

Since, for a non moving point charge $q_0$,

$$|E^\to| = (1/(4\pi \varepsilon_0))(q_0/r^2)$$

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

$$u_e = (K q_0^2)/ r^4$$

Because $K$ is a constant and $r^4$ is dependent only on the unit volume in space where $E^\to$ 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 $E^\to$.

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

$$u_m = |B^\to|^2/(2 \mu_0).$$

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

Since, for a moving point charge $q$,

$$|B^\to| = (\mu_0/(4\pi))(q\sin \alpha/r^2)$$

(Ref 4).

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

then,
\[ u_m = \left( \frac{\mu_0}{32 \pi r^2} \right) q^2 v^2 \sin^2 \alpha / r^4 \]  
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 \( \mathbf{v}_1 \) then

\[ u_m = \left( \frac{1}{32 \varepsilon_0 \pi r^2} \right) q^2 \left( \mathbf{v}_1^2 / c^2 \right) / r^4 \]

since we already denoted \( K = \left( \frac{1}{32 \varepsilon_0 \pi r^2} \right) \) then,

\[ u_m = (K q^2 (\mathbf{v}_1^2 / c^2)) / r^4. \]  
Denoting \( x = (\mathbf{v}_1^2 / c^2) \), 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 \( q^2 x \) 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 \( q^2 \) because \( x \) 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 \( q^2 \). Because, 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.
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 the 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 provide 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 \( q^2 \) (the square of the charge magnitude) 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, because 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 as the square of the mass magnitude.

Thus, analogous 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 \( q^2 \), (the square of the charge magnitude) might 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, modern physics sees the detection of magnetism by a spectator external of a charge moving at a constant velocity, as a combination of maxwell equation and special relativity. And, analogous to the detection of magnetism by a spectator external to such a moving charge, a spectator external to a mass moving at a constant velocity 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.
Indeed, there are also differences between mass and charge.

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 $P = mV$ or $F = ma$ do not exist in the case of charges.

However, these differences 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.

At this point, a few words about the validity of the claim that charge might be also considered as being a form of energy, might be helpful.

Indeed, the above arguments are reasonable but are not a proof that charge might be also considered as being a form of energy.

But the strong structural similarity (or even structural identity) between a point mass and a point charge, and the structural identity between the coulomb force law and the universal gravitation force, strongly implies that if one entity (mass) was already discovered to be energy, the other entity (charge) might also be energy, because the basic equations governing the forces they create have identical structure.

Moreover, the assumption that charge might be energy is strengthened if it provides explanations to several unresolved issues concerning charge energy, as will be shown later in this article.
Suggestons for a relation between Charge and Energy

In the previous section we provided arguments that charge might also be considered as a form of energy.

In this section we provide several suggestions of the equation that might describe the relation between charge and its embedded energy.

Although the arguments for considering charge as a form of energy might be reasonable, the differences between charge and mass might provide additional difficulties for finding the exact relation between charge and its embedded energy, analogous to the equation $E = mc^2$ found for mass.

Our first suggestion for such an equation is as follows:

Because Energy is proportional to mass by a constant factor ($c^2$), then, analogous to the equation:

$$E = mc^2$$

this article suggests the equation:

$$E = Kq$$

where $K$ is a constant factor and $q$ is the charge magnitude.

This equation might describe the relation between the energy embedded in charge and charge magnitude.

This is one suggestion for an equation that might describe the relation between the energy embedded in charge and charge magnitude.

Another suggestion is presented as follows:

Ref 13 relates to Larmor Equation that describes the power dissipated by an accelerating charge, which is manifested as electromagnetic radiation.

The equation is:

$$P = \frac{2q^2a^2}{3c^3}$$

where $q$ is the charge magnitude, $a$ is the constant acceleration and $c$ is the speed of light.
$q^2$ is the only component in the equation that can be considered to contain energy, because all other components are constants (including the constant acceleration $a$).

We already argued, in a previous section of this article, that because of the structural similarities between a point mass and a point charge, the fact that $q^2$ is the only component that can be considered to contain the energy in the electric or magnetic fields, and $m^2$ is the only component that can be considered to contain the energy in the gravitational field, and mass is energy, than this might imply that charge is also energy.

Then, because $q^2$ is also the only component that can be considered to contain the energy in Larmor equation, (as it is also the only component that can be considered to contain the energy in the electric or magnetic fields), this might also imply that $q^2$ in Larmor equation is also a manifestation that charge might be energy.

Thus, the energy emitted in the radiation generated by an accelerated charge might be considered to be a manifestation of the energy embedded in the charge itself.

However, analysis of the energies related to mass movements are different than analysis of the energies related to charge movements.

And, this might imply that the relation between charge and its embedded energy does not necessarily rely on the structure of the relation between mass and its embedded energy, as our first suggestion imply.

When a mass is moving at constant velocity, a spectator external to this mass sees a mass increase which is also the manifestation of the kinetic energy of this moving mass. And, this mass increase is proportional to the mass magnitude.

Then, to accelerate a mass a force must be applied according to $F = m a$. This force produces more energy when applied over some length, and this energy increase is manifested in an additional increase in the mass magnitude (or the kinetic energy) but this energy is still proportional to the mass magnitude.
On the other hand, when a charge moves its magnitude never increases according to the charge invariance principle.

When the charge moves at a constant velocity, an external spectator to the charge sees an additional magnetic field, in addition to the electric field he saw when the charge was stationary relative to this spectator.

But this additional magnetic field is explained only as a combination of maxwell equations and special relativity. And, this external spectator sees a different mixtures of fields (a magnetic and an electric field), but the energies embedded in those fields is the same as the energy embedded in the electric field, when the charge was stationary.

So, in the case of a charge moving at a constant velocity, no additional energy is detected, contrary to the case of the mass moving at a constant velocity, where an increase in mass (or an additional kinetic energy) is detected.

However, when a charge accelerates, additional energy is detected in the form of radiation, whose power is provided by Larmor equation.

For accelerating a charge, because additional energy is generated in the form of radiation, this implies that energy must be applied to the accelerating charge. It seems that there is no exact model against what resistance this energy is applied (which eventually results in the electromagnetic radiation), because there is no analogous of $F = ma$ in the case of charges. But because charge does not increase, the additional energy supplied to the charge cannot be attributed to a charge increase.

It cannot also be the energy that was applied to the mass that carried the charge, because this energy was already manifested in the mass increase (or the kinetic energy of the mass that was generated), so it cannot be manifested also in the energy generated in the resulting radiation.

Also, infinite cases can be devised, each with a different mass but the same charge magnitude, so, each generates a different kinetic energy, but the same radiation energy.
So, when a charge accelerates, additional energy is generated, as in the case of an accelerating mass, and to generate this additional energy when a charge accelerates, a supply of energy was required to be provided to the charge, again, as in case of an accelerating mass.

But, according to Larmor equation this energy is proportional to $q^2$. While the additional energy generated in case of an accelerating mass, was still proportional to the mass magnitude and not its square magnitude.

To summarize, in case of mass, in all the situations that additional energy is generated, because of the mass movement, and, according to our arguments, this additional energy might be also considered to be a manifestation of the mass embedded energy, this additional generated energy is proportional to the mass magnitude (and not to the square of the mass magnitude).

And indeed, the embedded mass energy was found to be proportional to the mass magnitude (and not to the square of the mass magnitude).

On the other hand, in the case of an accelerating charge, which is the only situation of a charge movement which generates additional energy, in the form of radiation, which, according to our arguments, this additional energy might be also considered to be a manifestation of the charge embedded energy, this additional generated energy is proportional to the square of the charge magnitude.

Thus, this brings us to our second suggestion for an equation that might describe the relation between the energy embedded in charge and charge magnitude:

$$E = K q^2$$  where $K$ is a constant factor and $q$ is the charge magnitude.

Again, this is only an assumption, that must be supported by additional findings.
**The Energy Pairs Theory**

Because 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 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 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 masses in the whole universe and the energy embedded in the gravitational field in the whole universe belong also to an Energy Pair.

The concept of an Energy Pair that applies only to the set of all the masses in the universe does not apply to a single mass and its gravitational field.

Because, the energy embedded in the mass is proportional to the mass magnitude, and the energy embedded in the gravitational field is proportional to the square of the mass magnitude.

Only when we consider all the masses in the universe and assume that the masses are spread, on the average, uniformly in the universe, we can derive the conclusion that the energy embedded in all the masses in the whole universe might cancel the energy embedded in the gravitational field of the whole universe.

Analogous to the above, if we adopt the assumption that the charge is energy, then, the energy embedded in the positive charges in the whole universe and the energy in the electric fields and the magnetic fields of positive charges in the whole universe should also belong to an Energy Pair.

And, the energy embedded in the negative charges in the whole universe and the energy in the electric fields and the magnetic fields of negative charges in the whole universe should also belong to an Energy Pair.

The above described Energy Pairs must contain elements from the whole universe. On the other hand, this article assumes that if charge is considered energy, then, the energy embedded in any positive charge and the energy embedded in any negative charge, belong to an Energy Pair.

Also, energy belonging to any electric field generated by positive charges, and energy belonging to any electric field generated by negative charges, belong to an Energy Pair.

Also, energy belonging to any magnetic field generated by positive charges, and energy belonging to any magnetic field generated by negative charges, belong to an Energy Pair.

In a separate article titled "Energy Pairs and Energy Conservation Issues" that can be found at http://viXra.org/abs/1909.0149, the Energy Pairs Theory is used to explain some energy conservation issues related to electric and magnetic fields.

Also, as Ref 10 implies, modern physics is evaluating 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, as 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.

Thus, in regard to the above, the question why charge is still a distinct entity remains open.

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

Thus, if charge will be recognized as a special form of energy, 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, analogous to the equation:

\[ E = m \, c^2 \]

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

\[ E = m \, c^2 \]

derived by the special theory of relativity, which describes the relation between the energy embedded in mass and mass magnitude, this article suggests several options of equations that might describe the relation between the energy and charge magnitude. These suggestions are based only on assumptions and must be supported by additional findings.

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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