

Energy Analysis of a Null Electromagnetic Wave

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Abstract

The primary aim of this study was to evaluate if it is possible to detect the energy embedded in a Null electromagnetic wave, which is an electromagnetic wave that does not contain any electric or magnetic fields. In three different proposed experiments describing a production of a Null, or partly Null electromagnetic waves, energy loss in each of the processes was observed which seems as a violation of the energy conservation principle. The "Energy Pair Theory" (EPT) developed and proposed in the article, explains this energy loss. It states that certain energies can be accumulated and stored as "Energy Pairs" that disable each other, and therefore, the energy exists but is untraceable. The Energy Pair Theory puts the concept of Energy in a new and flexible framework that can be further applied and studied. For example, it can provide a possible explanation to the Dark Energy mystery. Other examples examined are the electron positron collision to produce a gamma photon, and the reversed process of a gamma photon producing an electron and a positron. Unexplained issues in these processes are also explained by the EPT theory. This explicit analysis leads also to the unexpected conclusion that electric charge is a form of energy, or in other words the entities of Charge and Energy are equated, as Mass is equated with Energy. This conclusion might also imply that the only distinct entity in Nature is Energy.



Visualization of two light waves that unify, continue together on the same direction and **disappear**.

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Keys: *Electromagnetic Waves; Energy Conservation Principle; Electric Charge; Energy; Dark Energy.*

1. Introduction

The issue of electromagnetic traveling wave's interference was already analyzed and presented extensively. Examples of such scenarios might be counter propagating one dimensional two source waves, or a single source wave propagating in two or more dimensions via scattering one portion of the wave into another portion, such as a double slit experiment with a single source. Analysis of these scenarios has shown that the interference between such waves always conserves the wave's energy [1].

The research presented in this paper describes a different scenario in which, a two source electromagnetic traveling waves, focused in a way that they can be considered as traveling only in one dimension, are colliding, then the two waves unify and continue to travel together in the same direction. If the two waves unify when they oscillate at exactly the same frequencies, have exactly the same intensities in their electric and magnetic fields, are exactly at a phase shift of 180 degrees relative to one another, and have proper polarization, the resultant electromagnetic wave will be a Null wave which does not contain any electric or magnetic fields. According to the latest knowledge, this kind of scenario has not been studied yet.

The present study provides a description of a possible lab experiment targeted to implement a Null Electromagnetic Wave. Then, analysis of possible results of such an experiment is discussed, and a new theoretical framework is developed to explain the results.

The conclusions drawn in this study are innovative and quite surprising, not only relating to the specific process examined, the Null Wave, but also in providing a better understanding of other unresolved scientific problems, as the disappearance of charge in an electron and a positron collision, and a possible explanation of the nature of the Dark Energy which affects the rate of expansion of the universe, which expands in a rate which is much bigger than the expected rate according to the current state of knowledge.

2. Implementation of a Null Electromagnetic Wave

Consider a traveling electromagnetic wave propagating along the x-axis. According to Maxwell's equations, the electric and magnetic fields associated with such a wave take the form of [2]:

$$E_y = E_0 \cos [2 \pi ((x / \lambda) - f t)]$$

$$B_z = B_0 \cos [2 \pi ((x / \lambda) - f t)]$$

Thus, an electromagnetic traveling wave contains two synchronized oscillating fields, an electric and a magnetic field, where each field oscillation occurs at a line in space which is perpendicular to the line of the oscillation of the other field, and both these oscillation lines are perpendicular to the line of traveling of this wave. All electromagnetic waves travel at the velocity of the speed of light.

A scenario of two one dimensional electromagnetic waves which unify and continue to travel together in the same direction can be described and implemented as shown in Figure 1.

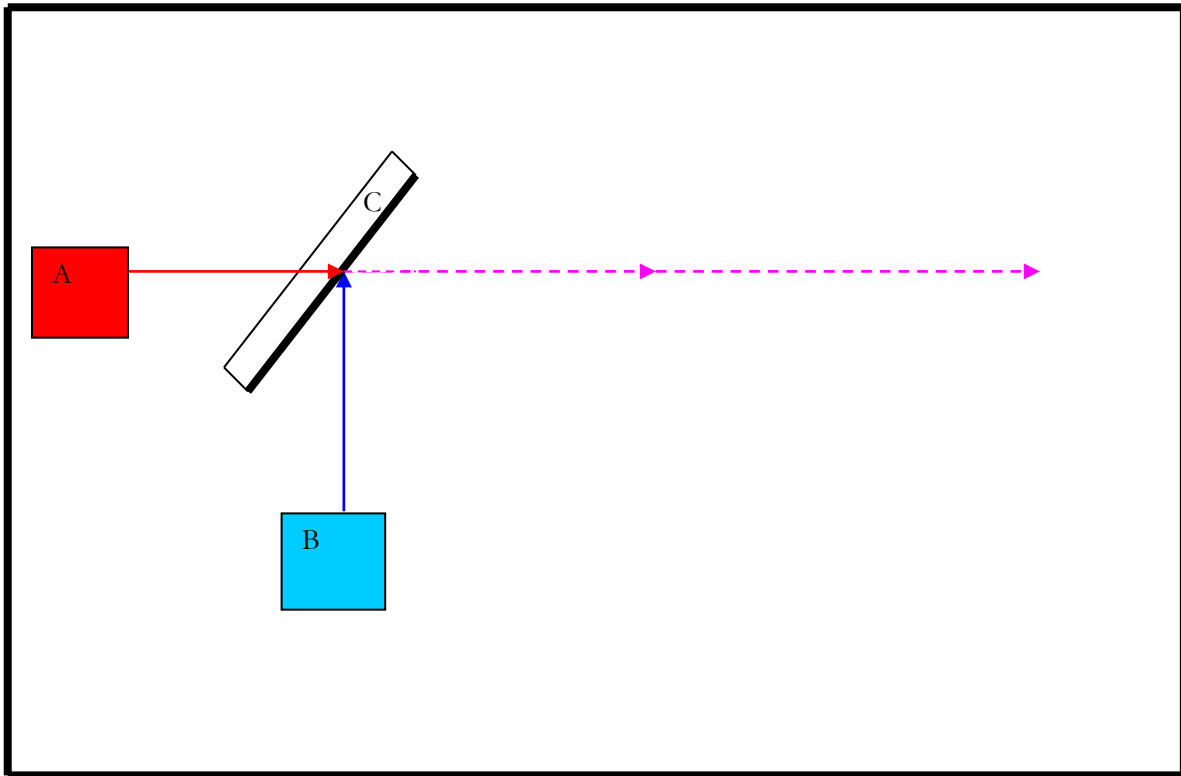


Fig 1 | suggested lab apparatus for experimental implementation of a Null Electromagnetic Wave

An Electromagnetic Wave Source A generates a much-focused one-dimensional electromagnetic traveling wave that passes through a half transparent mirror C, and continues to travel, as indicated by the dotted line. Another Electromagnetic Wave Source B generates a much-focused, one-dimensional electromagnetic traveling wave that is deflected by the mirror C, such that it continues to travel on the same line as the first wave A, as indicated by the dotted line.

From a Technical point of view, it might be difficult to implement such an experiment because of the requirement that the B wave should arrive at the mirror C at a time and at an angle that it will be deflected such as to consolidate completely with the A wave. Moreover, the waves should be much focused and one dimensional, which might present an additional difficulty in organizing the equipment needed. However, thinking about the above scenario and trying to analyze it theoretically (like a thinking exercise), provides the following possible result: If the two waves A and B unify when they oscillate at exactly the same frequencies, have exactly the same intensities in their electric and magnetic fields, are exactly at a phase shift of 180 degrees relative to one another, and have proper polarization, the resultant electromagnetic wave is a Null Wave that does not contain any electric or magnetic fields. Such a wave is described by Figure 2.

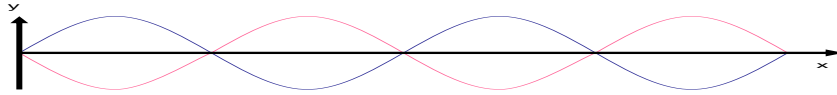


Fig 2 | Plot of the Electric or the Magnetic fields' intensities after the waves' unification

Figure 2 shows the electric fields' intensities of the two waves after their unification. Clearly, the electric fields of both waves will disappear after their unification, because each field's intensity cancels the respective field's intensity in the other wave, completely and continuously. The same applies for the magnetic fields of both waves. The magnetic fields intensities of these two waves can be also described by Figure 2, but the y-axis should be replaced by the z-axis, because the electric and magnetic fields are perpendicular to each other. So, the magnetic fields of both waves will disappear after their unification exactly as in the case of the electric fields.

Figure 3 is a picture that might provide a visualization of how two electromagnetic waves might consolidate, unify, continue to travel together in the same direction and **disappear** because they might annihilate each other. This picture displays two light sources, originating very close to each other, that spread their lights in two different directions. But it can be viewed differently: as two separate lights that approach each other, consolidate, unify, continue to travel together in the same direction and **disappear**, because they might annihilate each other completely. This picture is free does not require permission to use and is taken from:

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Fig 3 | Visualization of two light waves that unify, continue together on the same direction and **disappear**

It's important to add that the *original polarization of wave A* and the *original polarization of wave B*, should be such as to achieve the following result: the oscillations of the electric fields, of both waves A and B, after they pass the half transparent mirror C, must occur exactly on the same line in space. The same demand applies for the magnetic fields of waves A and B. This polarization demand of waves A and B validates that each field cancels the respective field in the other wave, completely and continuously, after the unification of the two waves.

As already mentioned, the requirement that both waves unify when they oscillate at exactly the same frequency, have exactly the same intensities in their electric and magnetic fields, are exactly at a phase shift of 180 degrees relative to one another, and have proper polarization (as described above), might create an extra complication in carrying out such a lab experiment.

The main question raised by this experiment is:

"Is it possible to detect a Null Electromagnetic traveling wave, which is a wave that does not contain any electric or magnetic fields?"

In order to answer this question, more experimental tools should be utilized in the described experiment: A tool that can be inserted at the wave's propagation line and is able to measure the energy embedded in each electromagnetic wave. For example, since electric charges are affected by electric and magnetic fields, inserting a detector that its measurements are based on the interactions between charges and electromagnetic fields might be appropriate. Any other technically suitable detector tool can also be devised and inserted in the propagation line of the two original electromagnetic waves A and B (Figure 1), and then in the Null Wave's propagation line and provide an indication whether the fields in the Null Wave exist. There are only two possible results: One, if the inserted tool will be affected by waves A and B, but will not be affected by the Null Wave, it will be an indication that the fields in the Null Wave, as shown in Figure 2, really do not exist and the Null wave energy is undetectable. Two, if the inserted tool will be affected by waves A and B, and by the Null Wave, then, some new conclusions about the characteristics of electromagnetic waves should be drawn. These two possible scenarios are analyzed in the following section.

3. Analysis of Two Possible Experiment's Results

Scenario (2) - A scenario in which a Null Wave is detected in the experiment

It is accepted by the science of Physics that the energy in an electromagnetic wave is embedded in the electric and magnetic fields it carries [3]. Since these fields do not exist in the Null Wave, but the lab-detector still measured energy according to scenario-2 of the experiment, it must be concluded that *the energy in electromagnetic traveling waves is not necessarily embedded in the electric and magnetic fields it carries*. If scenario-2 is really the case, this conclusion is surprising, and raises some questions: In what, then, the energy of an electromagnetic wave is embedded? Could it be that it is embedded in the photons existing in such a wave? And if so, is it possible that these photons remained intact when the electric and magnetic fields of the wave do not exist? It might be that there are more questions that should be asked and studied if a Null Wave can really be detected as scenario-2 of the lab-experiment shows.

This study's base view is that the assumption that the energy of an Electromagnetic Null wave is embedded in its photons and can be detected when the electric and magnetic fields of the wave do not exist is unacceptable. The current scientific knowledge indicates that both manifestations of a traveling electromagnetic wave, its wave and its photons or particles, are two manifestations of a single phenomenon. Thus, one cannot exist without the other. Photons are both manifestation of energy and particles, which are believed to carry the electromagnetic field force. As such, photons can't exist in the absence of an electromagnetic field. Moreover, if photons are the particles that carry the electromagnetic fields, then, their energy patterns should coincide with the energy patterns that these fields carry. But since the fields in the Null Wave disappeared and their energy cannot be detected, it is reasonable to assume, that the energy of the photons will not be detected either.

At this point, it might be assumed that any experimental attempt to detect the Null Wave will fail, because according to the basic physical laws, it is impossible to detect energy in a wave that doesn't have electric or magnetic fields.

Scenario (1) - A scenario in which a Null Wave is not detected in the experiment

According to scenario-1 of the experiment, the Null Wave is not detected by the experimental devices. If the Null Wave does not contain energy, clearly, this results in a violation of the ***Energy Conservation principle***. Since the Null wave was created from two electromagnetic waves, A and B, that unified and each contained energy, the accumulated energy of these two waves should be manifested in the Null Wave. If this doesn't happen, then, it is simply a violation of the energy conservation principle. Thus, a conclusion that the Null wave is really "Null" and does not contain energy seems as an unacceptable conclusion.

The following section introduces a ***new theory*** relating the energies embedded in electromagnetic fields that will provide an appropriate explanation to the results obtained in scenario-1 of the experiment.

4. The "Energy Pairs Theory" (EPT)

"Energy Pair" is a novel theoretical construct representing a physical state in which certain energies can be accumulated and stored together, and at the same time disable each other in a way that these energies exist but are untraceable.

To resolve what seems as a violation of the *energy conservation principle* discussed above, and to show that energy conservation in the creation of a Null Wave still exists, we'll introduce the *"Energy Pairs Theory"* and the novel construct of *Energy Pairs* to explain the experimental results obtained in scenario-1 above. Accordingly, the energies in the Null Wave are not annihilated; they still ***exist*** together after the unification of waves A and B as *"energy pairs" that disable each other*, such that it only appears that the Null Wave does not have any energy

and the energy conservation principle is violated. The Null Wave's embedded energies disable each other and therefore this energy is untraceable.

Following is a detailed description of "*The Energy Pairs Theory*", and a detailed explanation of how the energies accumulating in it disables each other:

The energy embedded in an electric field generated by a **positive charge**, and the energy embedded in an electric field generated by a **negative charge**, are assigned to one set of "Energy Pairs". The same is applied for the energies embedded in magnetic fields generated by moving charges: The energy embedded in a magnetic field generated by a **moving positive charge**, and the energy embedded in a magnetic field generated by a **moving negative charge**, are assigned to another set of "Energy Pairs". Energies belonging to an **Energy Pair** that exist together in the same location in space and have equal intensities can still **exist** together but disable each other, a disabling that **seems** as a violation of the *energy conservation principle*.

In each set of "*Energy Pairs*" the energies of the electromagnetic waves that unified and created the Null Wave, were accumulated and continued to be stored into that *Energy Pair*. The mutual annihilation of the fields or the waves that was seen and measured as a mutual annihilation of energies belonging to these fields, and a violation of the energy conservation principle, can be viewed now as a **mutual disabling of the energies** that continue to be stored into each *Energy Pair*.

The idea of "*Energy Pairs*", can be better understood by examining an analogue situation: *A rope in a rope pulling game (tug-of-war)*: Two people pull a rope each holding one edge of the rope and each in a direction exactly opposite to the other; if their pulling force is exactly equal, the rope does not move; this does not mean that the pulling energies that are exerted on the rope annihilate each other or disappear; The energies are accumulated and stored as a potential latent energy in the rope tension. The fact that the rope does not move, does not mean that the energies disappeared; they seem to be undetectable. The same applies when two electric or magnetic fields forces of the same intensity, but **opposite polarity** annihilate each other. The energies of these fields are not annihilated or disappear; they are accumulated and stored into two sets of "*Energy Pairs*", one that was created by the unification of the electric component of the waves, and the other by the unification of the magnetic component of the waves. The energies in each set of these "*Energy Pairs*" disable each other; as a result, the Null Wave cannot be detected.

The "Energy Pairs Theory" Related to Photon

The novel idea of "*Energy Pairs*" that exists in a Null Electromagnetic Wave is related to accumulation and storage of energy that *cannot* be detected because its components disable each other. This new concept should be expanded to the particle manifestation of an Electromagnetic Wave, namely, the Photon.

If a Null Wave cannot be detected, then the energies embedded in the photons that are carried by the Null Wave, **continue to exist but should be disabled** in a way that the wave cannot be detected, exactly as the energies embedded in the electric and magnetic components of the Null Wave cannot be detected. How can photons continue to exist in a disabled state? The resolution of this question is based on the "*Energy Pairs Theory*";

Photons should be capable of being in two different states in order to disable each other. When the wave's electric and magnetic *fields polarity is positive*, photons exist in one state (state 1). When the wave's electric and magnetic *fields polarity is negative*, photons exist in a second state (state 2). State 1 (the positive state) and state 2 (the negative state) are opposing each other. So, two photons that *exist together* in the same place in space but are at *opposite states* as related to one another *disable each other*. This, of course, is analogous to the conclusions derived relating the energies embedded in the electric and magnetic fields carried by the Null Wave. Photons can exist in two opposing states only if they have the capability to oscillate between these two states (1 and 2) synchronized with the oscillation frequency of the wave that carries them. So, photons should be always *physically oscillating* between two states. Since the two photons' states are synchronized with the frequency of oscillation of the wave that carry them, and the two unified waves that created the Null Wave are at a phase shift of 180 degrees as related to one another, then photons in the Null Wave ***exist but disable each other all the time*** such that the Null Wave cannot be detected.

The assumption that a photon physically oscillates between two states, also explains why the energy embedded in each photon is proportional to the frequency of oscillation of the electromagnetic wave that carries this photon. As far as photons have a manifestation of particles too, when they oscillate between two states, the frequency of the oscillation must be proportional to the energy embedded in them.

Thus, photons in the "*Energy Pairs Theory*" framework can be manifested as *Energy Pairs* that have the capability to disable each other and therefore, could be undetectable.

5. Expansion of the Experimental Implementation of a Null Wave

In order to expand and generalize the Energy Pairs Theory, the Null wave experimental implementation described in Figure 1 is now expanded to two more scenarios: One in which two electromagnetic waves unified, and continue to travel together in the same direction, but they had ***a phase shift relative to one another*** before the unification, and a second in which the two waves had ***different frequency of oscillation*** before the unification.

(1) The two electromagnetic waves had a phase shift before their unification

Figure 4 represents two electric fields waves' oscillations, as a function of time, which had a phase shift relative to one another before their unification. After their unification, they still have a phase shift relative to one another. However, there are portions of time such as: a-b, c-d, in each oscillating cycle, where one wave has opposite polarity relative to the other wave. In these portions of the oscillating cycle, ***one wave's intensity annihilates part of the other wave's intensity***, which results in reducing the electric fields' intensity of the unified wave so that ***the energy*** of the unified wave in these portions of the oscillation cycle is reduced. This may ***seem*** again as an energy loss after the unification of the two waves; more than that, because all waves have the same velocity along the one-dimensional x-axis (that represents time), this ***seemingly energy loss*** will occur continuously. Figure 4 plots the electric or magnetic fields'

intensities of the unifying waves. So, similar arguments apply also in the case of the magnetic fields of the unified wave. In this case the unified wave is a Partly Null Wave.

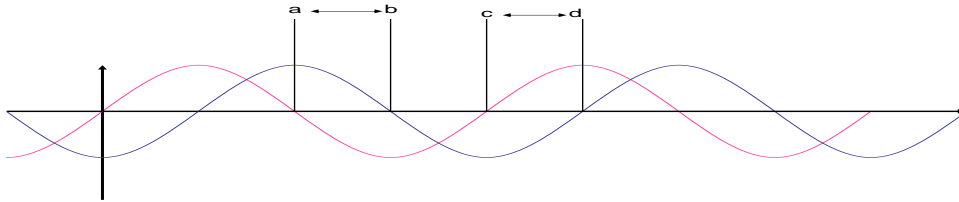


Fig 4 | Plot of the Electric or Magnetic fields of two unified waves that had a phase shift relative to one another

(2) The two waves had different frequency of oscillation before their unification

Figure 5 shows the electric fields of two waves that had different frequency of oscillation before their unification. After their unification they still have different frequency of oscillation. Because waves A and B oscillate at different frequencies, after unification between these two waves, there are portions of time, such as a-b, in each oscillating cycle of the unified wave, in which one wave has opposite polarity relative to the other wave. In these portions of the oscillating cycle, one wave will annihilate only **part** of the other wave's intensity, which results in reducing the electric fields' intensity of the unified wave and the energy carried by the unified wave in these portions of the oscillation cycle. This result may **seem again as an energy loss** following the unification. This **seemingly** energy loss will occur continuously because all electromagnetic waves have the same velocity along the one-dimensional x-axis that represents time. Figure 5 plots the electric or magnetic fields' intensities of the unifying waves. So, similar arguments apply also in the case of the magnetic fields of the unified wave. In this case, again, the unified wave is a Partly Null Wave.

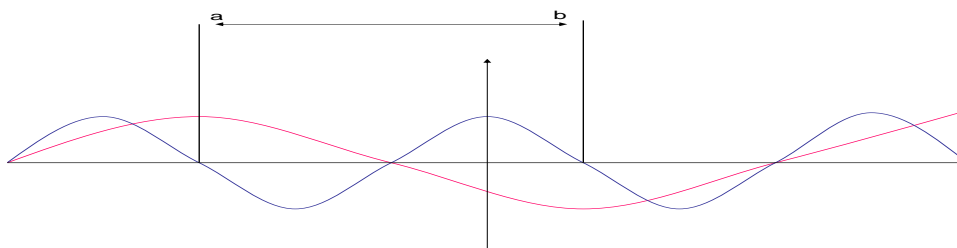


Fig 5 | Plot of the Electric or Magnetic fields of two unified waves that had different frequencies of oscillation

At this point, it can be concluded that for electromagnetic waves that consolidate and become unified, and continue to travel together in the same direction, the ***Energy Conservation Principle seems*** to be violated almost always and almost in any constellation.

It should be noted that the initial related polarization conditions of the two unified waves, that had been necessary in order to create a ***completely*** Null Wave in the first experiment, is no longer required in a creation of a Partly Null Wave, which will always present a ***seemingly*** energy loss after unification. If the polarization of the two consolidating waves is arbitrary, then, the electric or magnetic fields of one wave, which are vectors, can always be considered as being composed of two perpendicular vector components. One of these components can be aligned on the same line in space as the other wave's component, which will, almost always, generate ***some seemingly energy loss***, when the two waves unify, and continue to travel together in the same direction.

Thus, it can be concluded that for electromagnetic waves that consolidate and become unified, and continue to travel together in the same direction, the Energy Conservation Principle ***seems*** to be violated almost always, and almost in any constellation; even if the waves oscillate at different frequencies, have phase shifts as related to one another, have different fields' intensities and also *arbitrary polarization*.

In the *Energy Pairs Theory* framework, portions of the energy that *seems* to be lost exist as latent potential ***energy pairs*** in the photons, which carry these energy pairs, therefore, the energy is conserved.

6. Unified Electromagnetic Waves and the Entities of Dark Energy and Complete Emptiness

"*Dark Energy*" is a theoretical energy component that is assumed to exist in the universe and is supported by several cosmology observations. The nature of this energy is unknown, but it is used to provide an explanation to the rate of the universe expansion. The "*Dark Energy*" is untraceable but cosmology observations have shown that it makes up about 70% of the energy in the Universe [4].

In all of the scenarios described above (Figures 1, 2, 4, 5), where two electromagnetic waves unify and continue to travel together in the same direction, in case they have a phase shift relative to one another, different frequency of oscillation, different intensities of their electric and magnetic fields, or arbitrary polarity, all or some of the energy they initially carried, ***seems*** to disappear after their unification. If such scenarios occur in outer space, at least some of the produced waves will be Null or Partly Null, and, at least part of their energy would not be traceable. In the "*Energy Pairs Theory*" framework developed in this study, Null and Partly Null Electromagnetic Waves are composed of "*Energy Pairs*" that are packed up in the wave's photons, disable each other, and cause the waves energy to be untraceable or partly untraceable. It is possible then, that the "*Dark Energy*" might be composed of a significant

amount of Null or Partly Null waves. Since a huge portion of the energy in the universe is composed of electromagnetic waves that might be bended, scattered and deflected, the probability that scenarios of unification of electromagnetic waves, like those described in Figures 1, 2, 4, 5 occur in the universe, is high. Therefore, it is probable that many undetectable Null or Partly Null electromagnetic waves are traveling in the universe. Such waves might compose at least part of the **"Dark Energy"**.

If it is assumed that after some time that a Null Wave or a Partly Null Wave is traveling in the universe, for some reason or specific condition that might occur in the universe, this wave might be able to undergo the reversed process of *energy pairs* creation, or a split of the energies embedded in the *energy pairs* such that the energies become separated and traceable again, it will seem as if energy is generated out of nothing. The concept of **"Nothing"** might be named in Physics: **"Complete Emptiness"**.

It can be concluded that electromagnetic waves which consolidate and become unified, and continue to travel together in the same direction, is a possible source of both the *Dark Energy* and the *Complete Emptiness*. In other words, these entities might be a space in the universe in which *Energy Pairs* reside, but because they disable each other the energy embedded in them cannot be traced. Thus, the concept of *Energy Pairs* that was developed in this study might view the state of *Complete Emptiness* as containing combinations of *Energy Pairs* that disable each other. In other words, it can view the *Complete Emptiness* as the steady state of the existence that was, is and will be eternal, and, might transform into other states of existence, in which energy is created out of nothing, or converted to nothing.

7. Electron - Positron Collisions and the Energy Pairs Theory

In this part of the study the interrelationships between charge and energy will be discussed based on physics well-known observations relating to the Electron – Positron collisions (also known as Electron-Positron annihilation): When an electron and a positron collide, neutral gamma ray photons are emitted, with energy equal to the sum of the energies embedded in the *masses* of the electron and the positron [5]. In the reversed process (also known as Pair Production), a gamma photon that passes near a heavy atom, in appropriate conditions, is converted into a **negative charged electron** and a **positive charged positron** [6]. Each of these two elementary particles, a positron and an electron, has two fundamental features: *mass* and *charge*. According to the results given by the experiments the energy embedded in the photon, which converted to an electron and a positron, is converted to the sum of the energies embedded in the electron's and the positron's *masses*, and the question of how the charges of the electron and the positron were created remains unanswered. And, in the process of an electron and a positron collision the energy of the newly created photon is equal to the sum of the energies embedded in the *masses* of the colliding electron and positron, and the negative electric charge of the electron and the positive electric charge of the positron are assumed to annihilate each other and disappear. Obviously, all conservation principles, including the energy conservation principle, were obeyed in both processes. However, no analysis was ever made about the

disappearance or creation of charges in these processes. This study is concerned with the behavior of the charges in these two processes in the framework of "*The Energy Pairs Theory*". In this view it is required to ask some basic questions about these two processes: In the process of the electron-positron collision where a gamma photon is created from an electron and a positron: "How could the electron's and the positron's charges disappear? How could a fundamental feature of basic particles disappear without leaving any trace of their previous existence?" In the reversed process, where a photon converts to an electron and a positron: "Since photons are not considered containing mass or charge, how the charges of the electron and the positron that were emitted in this process evolved?" "Were these charges created out of nothing?" Although the charge disappearance in the electron - positron collision process and the charge creation in the reversed process, obey the charge conservation principle, whether charges can disappear or be created in physical processes is important to be asked and analyzed. The novel "*Energy Pairs Theory*" framework is used in further discussing charge characteristics and their essence in physical processes, and to provide reasonable answers to the above questions.

The fact that photons are composed of energy only and do not contain mass or charge, but still, a gamma photon in the reversed process discussed above and observed in a lab experiment, converted into two particles that do contain charge, a negative charged electron and a positive charged positron, implies that **energy is capable to be converted into charge**. This surprising conclusion is further analyzed and elaborated.

Previously, in the part discussing "*The Energy Pairs Theory Related to Photons*", the possibility that **photons might exist as Energy Pairs** that disable each other and therefore cannot be traced, was presented. Thus, the electron's and the positron's charges that were generated from a gamma photon in the reversed process discussed above might be a result of a split of an *Energy Pair* embedded in the gamma photon, that transformed into a negative charge of the electron and a positive charge of the positron. It is important to distinguish between this specific process and the process in which the traceable energy embedded in the photon was converted into the electron's and the positron's masses which obeyed the energy conservation principle. Actually, it can be summarized that in the "*Energy Pairs Theory*" framework a photon might be built out of two different "kinds" of energy: One is the traceable energy embedded in the photon that obeys the energy conservation principle by saving its energy into the electron's and the positron's masses that were produced in the process. Second is the untraceable "*Energy Pair*" carried by the photon, which is converted into negative and positive electric charges. This specific "kind" of energy is latent undetectable energy that manifested as two electric charges. Thus, it can be concluded that energy, not only can be converted to charge, but Energy *is equated with Charge*. This surprising and revolutionary conclusion is central in this study and might have far-reaching consequences and implications in both science and technology.

The conclusion that *Energy is equated with Charge* can also be used to explain the charge disappearance in the process of the electron-positron collision where a gamma ray photon was emitted (the first process discussed above). The gamma photon produced in this process, embeds an *Energy Pair* that contains disabled energies that originated from the negative electron and the positive positron charges before their collision so that the electron's and the positron's charges does not disappear, they converted into a latent untraceable *Energy Pair* embedded in the created gamma photon.

To conclude this part of the study and its revolutionary findings, a further elaboration of the concept of energy would be made:

A very basic view of the concept of "Energy" of a particle (like electron and positron), may be equated to the *ability of the particle to generate activity in its environment*.

Particles containing only mass can generate activity in their environment by creating gravitational fields that interacts with all masses in the environment.

Particles containing both mass and charge, like electron and positron, generate both gravitational and electric fields (and magnetic fields in case the charges are in movement) that have the capability to interact with both masses and charge in their environments. So, particles containing both mass and charge can generate more activity in their environments. In other words, they embed more energy.

In a case of a gamma photon transformed into an electron and positron, the charges created in the process, and added to the environment where they were created; contribute additional energy to the environment, in comparison to the energy that would be contributed to same environment if particles that contain same amount of mass and no charge at all were added to same environment. In this basic and simple point of view charges are also equated with energy.

This implies that when a photon converts into an electron and a positron this increases the energy of the environment more than the traceable energy embedded in the photon itself, whose energy was converted *only* to the energy embedded in the *masses* of the electron and the positron. This implies that the *charges created are energy*.

According to the "Energy Pair Theory", that new energy, was created from a latent and untraceable *Energy Pair* that was embedded in the photon. This implies that such latent *Energy Pairs* can evolve and become detectable energy. This conclusion was already used in this study when the "Energy Pair Theory" was applied to explain the entities of the "Dark Energy" and "Complete Emptiness".

Thus, this analysis presented above clearly leads to a possible surprising conclusion that basically *Charge and Energy are equal entities*. (The same as *Mass is equated with Energy* according to Einstein's analysis in his *Special Relativity Theory* [7]). If so, the only entity that exists and governs the natural world is *Energy*. This conclusion has tremendous implications both on research and technology.

The *Energy Pair* built of the energy embedded in two charges, a negative and a positive charge, resembles the *Energy Pair* that was built out of two electromagnetic unified waves, by the fact that in both cases an *Energy Pair* is created out of two entities that might annihilate each other. Second, in both cases the *Energy Pair* is built out of two components that disable each other and therefore the *Energy Pair* is undetectable, and in both cases the *Energy Pair* might be created and might split again into traceable energy. Thus, *Energy Pair* is a flexible theoretical construct that might be useful in other lab experiments and scientific observations.

8. Summary and Conclusions

The initial aim of this study was to analyze the **energy loss** in a process of creation of a Null Electromagnetic Wave from consolidation of unified electromagnetic waves that continue to travel together in the same direction, which was shown to be incompatible with the "*Energy Conservation Principle*". The first step towards fulfilling this goal was to provide an explanation to this unacceptable energy loss. It was carried out by developing a new theoretical framework named "**Energy Pair Theory**" (EPT). The central idea in the EPT is that certain "kinds" of energies in certain circumstances can be accumulated and stored together in a state called: "**Energy Pair**", in which they disable each other so that their energies *exist* but cannot be detected. According to this theoretical framework, the energy that was seemingly lost in the Null Wave's creation was conserved into an "*Energy Pair*" that exists as latent energy in the Null Wave because its two components disable each other.

A second step in the EPT development was to answer the question: "Where do the *Energy Pairs* in a Null or a partly Null Electromagnetic wave reside?" Expanding the EPT to include photon's energy indicated that photons might carry *Energy Pairs*. In other words, photons in the unification of electromagnetic waves carry two "kinds" of energy: the photon *traceable energy* and **in addition** a photon might carry an *untraceable Energy Pair* of the Null or partly Null Electromagnetic Wave. In the process of creation of a complete Null wave, the photons energy is conserved as *Energy Pairs* only that disable each other and therefore a complete Null Wave's energy is totally undetectable.

In the third step of the study an attempt was made to examine other undetectable energies, such as the "*Dark Energy*", in the "*Energy Pairs*" theoretical framework. The following assumption was made: As far as the universe consists of a huge amount of electromagnetic waves that can be bended, scattered and deflected, there is a solid base to assume that a high probability exists that some of these waves might create Null or partly Null Waves that carry untraceable or partly untraceable energy. These untraceable waves or *Energy Pairs* might compose, at least, part of the *Dark Energy* entity. A further assumption added at this point related to the EPT framework was that in suitable conditions that might occur in the universe, the reversed process of the creation of a Null Wave that might compose the *Dark Energy* might split back into traceable energies. An example of such a split of *Energy Pairs* into traceable energy might be the conversion of a gamma photon into an electron and a positron in appropriate conditions. This process is also analyzed in the article in a separate section.

The fourth and final phase of this study was to apply the "*Energy Pair Theory*" framework to understand better the following two well-known observations: a collision of an electron and a positron to obtain a gamma neutral Photon, and the reversed process of a gamma neutral photon producing an electron and a positron in appropriate conditions. Though all conservation laws are obeyed in these two processes, this study was concerned with the disappearance of the electric charges in the first process, and the creation of negative and positive electric charges out of a neutral gamma photon, in the reversed process. These two processes raise crucial questions relating the nature of the electric charge: How electric charges are obtained out of a neutral gamma photon that does not contain any charge, while all the energy of the photon was converted only to the energies embedded in the **masses** of the created electron and positron? And in the electron positron collision process, how could elementary electric charges of a negative electron

and a positive positron disappear? Electric charges are basic feature of these elementary particles therefore it is hard to believe that these charges could disappear just like that. To our best knowledge these basic questions have not been studied yet.

Examination of the above two processes in the "*Energy Pairs Theory*" framework, provided a surprising explanation to these questions: In the collision between an electron and a positron, the electron's negative charge and the positron's positive charge combined to create an untraceable "*Energy Pair*" that is embedded in the gamma photon created and carried by it. In the reversed process, a splitting of the "*Energy Pair*" that is embedded in the gamma photon occurs and creates the electric charges embedded in the two basic elementary particles: the negative charge of the electron, and the positive charge of the positron. In the "*Energy Pairs Theory*" view the original charges have not disappeared but were manifested as "*Energy Pairs*" that were carried by the gamma photon created. So, analysis of these two well-known processes in the "*Energy Pairs Theory*" framework resulted in a surprising and revolutionary conclusion that **energy is equated with electric charge**. In other words, *Electric Charge* might be a manifestation of *Energy*. Considering that another elementary feature of particles, **Mass**, is also equated with **Energy** according to Einstein's *Special Relativity Theory*, then, a wider and a very significant conclusion can be drawn: ***Mass and Electric Charges are both a form of Energy.***

This study contributes to the energy concept a new and a deeper meaning or a new "state of energy" called: "*Energy Pair*" that establishes a robust and useful theoretical framework to study untraceable energies like the *Dark Energy*. It also provides new theoretical tools to better analyze and understand the basic entities of nature: **Mass, Charge and Energy**, and the interrelationships between them.

Following is a brief summary of the main features of the concept of *Energy Pairs* as developed in the "*Energy Pairs Theory*" in this study:

1. *Energy Pairs* can be created from both, either two electromagnetic unified waves, or the energies embedded in negative and positive charges. In both cases an *Energy Pair* is created out of two entities that might annihilate each other.
2. *Energy pairs* are built out of two components that disable each other and therefore their energy *exists* but is undetectable.
3. *Energy pair* might be created from traceable energies, and might be split again into traceable energy, like in the case of a gamma photon splits into a negative charged electron and a positive charged positron.
4. *Energy pairs* can be carried by photons. Moreover, photons themselves have been shown in this study as *Energy Pairs*.

It is important to add a concluding note: The most unexpected and revolutionary conclusion that the "*Energy Pairs Theory*" contributed to this study was that ***Electric Charge is equated with Energy***, or, in other words, electric charges can be manifested as energy and vice versa. Further elaboration of this conclusion with Einstein's *Special Relativity Theory* equating *Mass* with *Energy*, implies that *Energy* is the only entity that governs the natural world.

Mass and Electric Charges are manifestations of Energy. This conclusion might lead to a novel paradigm in studying science. It also may provide new ideas and perspectives relating future technological implications.

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