

Nine New Fundamental Laws Are Proposed for Electromagnetism

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Abstract: This study aims to propose new fundamental laws for electromagnetism, challenging conventional understanding and revealing novel insights into the nature and logic of electromagnetic phenomena. Key contributions include the identification of the minimum physical unit indispensably required for electromagnetic phenomena, the necessary and sufficient conditions for their generation, and the nature of electromagnetic force, et cetera. More specifically, the nature and logic of electromagnetic phenomena were investigated, and nine new fundamental laws are proposed for electromagnetism. They are: the fundamental law on what is the minimum physical unit indispensably required to generate electromagnetic phenomena, the fundamental law on what are the necessary and sufficient conditions for generating electromagnetic phenomena, the fundamental law on how electromagnetic phenomena are interacted with each other, the fundamental law on what is the nature of electromagnetic force, the fundamental law on what is the nature of the electromagnetic magnetic force, the fundamental law on what is the nature of electric field flux, the fundamental law on what is the logic of the mutually-inducing process between a changing magnetic field and a changing electric field, the fundamental law on what is the prerequisite for the application of superposition principle in electromagnetism, and the fundamental law on is there interaction in the direction perpendicular to physical field lines. All the discoveries in this research are very encouraging, disruptive and critically important. However, what has to be specially announced in this abstract section is that: electromagnetic force is self-balanced within the current envelope (/electric field envelope) of current-carrying closed loop, and is the internal force inside the current envelope of current-carrying closed loop; at each point of the current envelope of current-carrying closed loop, the electromagnetic force per unit length of the current envelope is the same; although the magnitude and direction of electromagnetic force are affected by external magnetic field, the electromagnetic force has no force on the external magnetic field; electromagnetic force has totally different nature in contrast with the force between magnetic fields, and they are not the force of same kind.

Keywords: The nature and logic of electromagnetic phenomena; Nine new fundamental laws being proposed for electromagnetism; Electromagnetic force being without interaction force on the external magnetic field.

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1. Introduction

The Ampère force law which states that a current-carrying conductor experiences a force in a magnetic field, the Faraday's law of motional electromotive force which states that a conductor cutting through magnetic field lines generates an electromotive force, the Oersted's law of electromagnetism which states that a current-carrying conductor generates a circular magnetic field surrounding the conductor, and the Lorentz force law which states

that an independent moving charge experiences a force in a magnetic field have been disproven^[1]. That is, the edifice of electromagnetic theory has collapsed, and Maxwell's equations must collapse with it. However, electromagnetic theory, especially Maxwell's equations, is not only related to the problems of electricity and magnetism, but also to many major problems in the fields of classical physics and quantum physics, and is the key cornerstone for human to understand and interpret the natural world. Therefore, there is an urgent need to create a new system of fundamental laws for electromagnetism as soon as possible, filling in the gaps created by the falsification of the fundamental laws of electromagnetism. In other words, the fact that existing theories of electromagnetism, such as Ampère's force law and Faraday's law of motional electromotive force, have been disproven, is necessitating the development of a new framework. This study addresses this need by proposing nine fundamental laws that provide a more accurate and comprehensive understanding of electromagnetic nature of the natural world. Specifically, in this research, what is the minimum physical unit indispensably required to generate electromagnetic phenomena, what are the necessary and sufficient conditions for generating electromagnetic phenomena, how electromagnetic phenomena are interacted with each other, what is the nature of electromagnetic force, what is the nature of the electromagnetic magnetic force, what is the nature of electric field flux, what is the logic of the mutually-inducing process between a changing magnetic field and a changing electric field, what is the prerequisite for the application of superposition principle in electromagnetism, and is there interaction in the direction perpendicular to physical field lines were examined and nine new fundamental laws were proposed for electromagnetism.

2. The First Fundamental Law of Electromagnetism: The fundamental law on what is the minimum physical unit indispensably required to generate electromagnetic phenomena, which is as follows:

The whole of a closed loop (that is, the entire closed loop) of one turn is the minimum physical unit indispensably required to generate an electromagnetic phenomenon, any part of this minimum physical unit cannot generate any electromagnetic phenomenon, electromagnetic phenomena are all generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop.

Metalogic and facts: Based on the previous research work^[1], it is concluded that: The whole of a closed loop (that is, the entire closed loop) of one turn is the minimum physical unit indispensably required to generate an electromagnetic phenomenon, any part of this minimum physical unit cannot generate any electromagnetic phenomenon, electromagnetic phenomena are all generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop. The closed loop here can consist of medium of some kind, such as conductor, insulator, dielectric, the independent moving charge beam, displacement currents, and vacuum, as long as there is movable charge or oscillatory charge contained in part of the medium. Electromagnetic phenomena refer to the appearance and disappearance of magnetic fields, electric fields, electromotive forces, electric current and electromagnetic forces, etc., for example, the so-called Ampère force, the so-called motional electromotive force, the so-called Oersted's magnetic field and the so-called Lorentz force all are electromagnetic phenomena. The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation). Therefore, changing magnetic fields and changing electric fields can generate changing electromagnetic forces and changing electromagnetic magnetic forces with some kind of matter, including insulator, and can interact with the matter.

Conventional electromagnetism holds that electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , electric charge, and independent moving charges (/charge beam) themselves. It reveals a fundamentally different electromagnetic nature of the world, depending on whether the electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , and independent moving charge, as the fundamental laws of conventional electromagnetism stated, or the electromagnetic phenomena are generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop. This is a major scientific question of decisive significance, a major technical question of decisive significance, and a major engineering question of decisive significance. As a result, human understanding of the natural world will be completely different because of this.

3. The Second Fundamental Law of Electromagnetism: The fundamental law on what are the necessary and sufficient conditions for generating electromagnetic phenomena, which is as follows:

The whole of a closed loop (that is, the entire closed loop) of one turn with a change in magnetic flux and/or in magnetic induction intensity within the closed loop is the necessary and sufficient conditions for generating an electromagnetic phenomenon.

Metalogic and facts: Based on the previous research work ^[1], it is concluded that: The whole of a closed loop (that is, the entire closed loop) of one turn with a change in magnetic flux and/or in magnetic induction intensity within the closed loop is the necessary and sufficient conditions for generating an electromagnetic phenomenon. A constant magnetic field, a constant electric field, a constant electromotive force, a constant electric current, a constant electromagnetic force, a constant magnetic flux within a closed loop, and a constant magnetic induction intensity within a closed loop all do not generate electromagnetic phenomena, but can only maintain the electromagnetic phenomena that have already been generated. The closed loop here can consist of medium of some kind, such as conductor, insulator, dielectric, the independent moving charge beam, displacement currents, and vacuum, as long as there is movable charge or oscillatory charge contained in part of the medium. Electromagnetic phenomena refer to the appearance and disappearance of magnetic fields, electric fields, electromotive forces, electric current and electromagnetic forces, etc., for example, the so-called Ampère force, the so-called motional electromotive force, the so-called Oersted's magnetic field and the so-called Lorentz force all are electromagnetic phenomena. The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation). Therefore, changing magnetic fields and changing electric fields can generate changing electromagnetic forces and changing electromagnetic magnetic forces with some kind of matter, including insulator, and can interact with the matter. Conventional electromagnetism holds that electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , electric charge, and independent moving charges (/charge beam) themselves. It reveals a fundamentally different electromagnetic nature of the world, depending on whether the electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , and independent moving charge, as the fundamental laws of conventional electromagnetism stated, or the electromagnetic phenomena are generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop. This is a major scientific question of decisive significance, a major

technical question of decisive significance, and a major engineering question of decisive significance. As a result, human understanding of the natural world will be completely different because of this.

4. The Third Fundamental Law of Electromagnetism: The fundamental law on how electromagnetic phenomena are interacted with each other, which is as follows:

The nature of electromagnetic processes is the induction among changing magnetic fields, changing electric fields and changing electromagnetic forces through the whole of a closed loop (that is, the entire closed loop) of integer turns with a change in magnetic flux and/or in magnetic induction intensity within the closed loop, any and all electromagnetic processes are the result of the coexistence of these five.

Metalogic and facts: Based on the previous research work^[4], it is concluded that: The nature of electromagnetic processes is the induction among changing magnetic fields, changing electric fields and changing electromagnetic forces through the whole of a closed loop (that is, the entire closed loop) of integer turns with a change in magnetic flux and/or in magnetic induction intensity within the closed loop, any and all electromagnetic processes are the result of the coexistence of these five. The closed loop here can consist of medium of some kind, such as conductor, insulator, dielectric, the independent moving charge beam, displacement currents, and vacuum, as long as there is movable charge or oscillatory charge contained in part of the medium. Electromagnetic phenomena refer to the appearance and disappearance of magnetic fields, electric fields, electromotive forces, electric current and electromagnetic forces, etc., for example, the so-called Ampère force, the so-called motional electromotive force, the so-called Oersted's magnetic field and the so-called Lorentz force all are electromagnetic phenomena. The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation). Therefore, changing magnetic fields and changing electric fields can generate changing electromagnetic forces and changing electromagnetic magnetic forces with some kind of matter, including insulator, and can interact with the matter. Conventional electromagnetism holds that electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , electric charge, and independent moving charges (/charge beam) themselves. It reveals a fundamentally different electromagnetic nature of the world, depending on whether the electromagnetic phenomena are generated by conductor segment Δl , differential conductor segment dl , current element Idl , and independent moving charge, as the fundamental laws of conventional electromagnetism stated, or the electromagnetic phenomena are generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop. This is a major scientific question of decisive significance, a major technical question of decisive significance, and a major engineering question of decisive significance. As a result, human understanding of the natural world will be completely different because of this.

5. The Fourth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of electromagnetic force, which is as follows:

The nature of electromagnetic force is the force generated by the current envelope (electric field envelope) of a current-carrying closed loop to change its own area to lower the magnetic induction intensity within the current envelope of the current-carrying closed loop that generated the electromagnetic force; electromagnetic force is self-balanced within the current envelope of the current-carrying closed loop, that is, it

is self-balanced within the current-carrying closed loop; electromagnetic force is the internal force inside the current envelope of the current-carrying closed loop, that is, it is the internal force inside the current-carrying closed loop; at each point of the current envelope of the closed loop, the electromagnetic force per unit length of the current envelope is the same, and the direction of the electromagnetic force on the current envelope is perpendicular to the tangent at each point of the current envelope; although the magnitude and direction of electromagnetic force are affected by external magnetic field, the electromagnetic force does not force on the external magnetic field.

Metalogic and facts: The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation). As shown in Figure 1, under the premise that the external magnetic field is ignored, the electromagnetic force on the current envelope (/electric field envelope) of a square shaped closed loop is an inflating force regardless of the current direction of the closed loop, because the current direction does not cause any change in the form of action of the closed loop. And in this process, if the electromagnetic forces at different points of the current envelope are measured or logically analyzed, it is clear that the magnitude of the electromagnetic force on the current envelope per unit length of the current envelope are equal at every points of it. And the direction of the electromagnetic force on the current envelope is perpendicular to the tangent at every point of the current envelope.

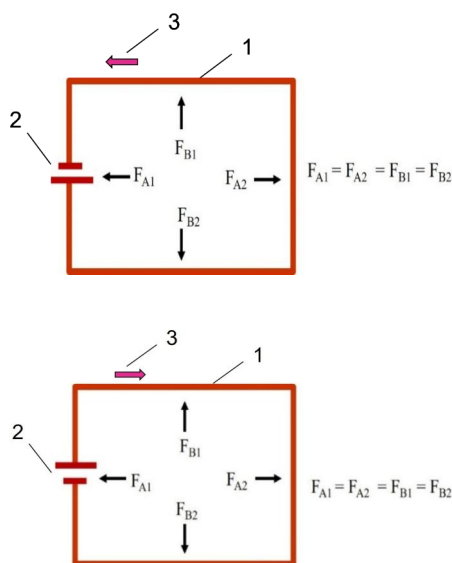


Figure 1. A schematic illustration of the direction of the electromagnetic forces generated by square shaped closed loops loaded with currents of different directions. 1. The closed loop, 2. The battery. 3. The direction of electric current.

As shown in Figure 2, under the premise that the external magnetic field is ignored, the electromagnetic force on the current envelope of a long oblong shaped closed loop is an inflating force. And if the electromagnetic forces at different points of the current envelope are measured or logically analyzed, it is clear that the magnitude of the electromagnetic force on the current envelope per unit length of the current envelope are equal at every points of the current envelope. That is, $F_{B1} = F_{B2} = F_{A1} = F_{A2}$, but not $(F_{B1} = F_{B2}) >> (F_{A1} = F_{A2})$ which is as explained by the existing fundamental laws of electromagnetism. And the direction of the electromagnetic force on the current envelope

is perpendicular to the tangent at the measuring point of the current envelope.

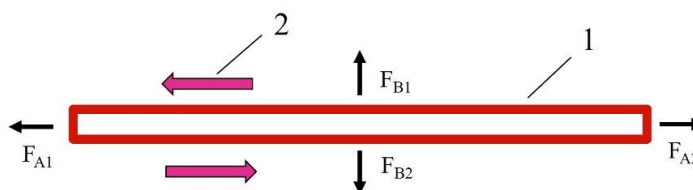


Figure 2. A schematic illustration of the direction of the electromagnetic forces generated by a long oblong shaped closed loop loaded with currents of different directions. 1. The long oblong shaped closed loop, 2. Current direction.

The above two cases illustrate that the electromagnetic force is always the force that inflates the current envelope and thus inflates the closed loop when the external magnetic field is ignored, and the magnitude of the electromagnetic force on the current envelope per unit length of itself are equal at every point of the current envelope. This shows that under the premise that the external magnetic field is ignored, the electromagnetic force acts in the direction of reducing the magnetic induction intensity within the current envelope that generates the electromagnetic force. This is because that the inflating force will increase the area of the current envelope of the closed loop, and the bigger this area is, the smaller the magnetic induction intensity within the current envelope is, when the closed loop is under the same current especially under the same voltage.

As shown in Figure 3, if the direction of the magnetic field generated by the current envelope of the closed loop is the same as that of the external magnetic field shown by B, the electromagnetic force generated by the current envelope is inflating force which inflates the current envelope of the closed loop. This is because that this is the only way that can make the magnetic induction intensity generated by the current envelope of the closed loop tend to be lower, since when the current especially the voltage is the same, the larger the area of the current envelope of the closed loop is, the lower the magnetic induction intensity within the current envelope of the closed loop is. Since the direction of the magnetic field generated by the current envelope of the closed loop is the same as that of the external magnetic field, therefore, the decrease in the increase in the magnetic induction intensity within the current envelope of the closed loop caused by the current carrying of the closed loop is the direction to resist the increase of the magnetic induction intensity within the current envelope of the current carrying closed loop. And within this case, this is the only thing that can be done by the current envelope to achieve the goal that the magnetic induction intensity within the current envelope of the closed loop is reduced, after the closed loop is loaded with a current.

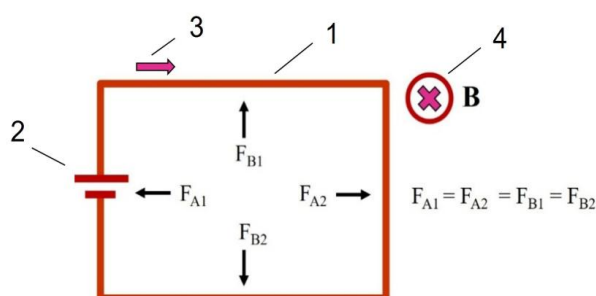


Figure 3. A schematic illustration of the direction of the electromagnetic forces generated by the current envelope of a closed loop loaded with current, which generates the magnetic field of same direction as that of the external magnetic field. 1. The closed loop, 2. The battery. 3. The direction of electric current, 4. The direction of the external magnetic field.

As shown in Figure 4, if the direction of the magnetic field generated by the current envelope of the closed loop is in the opposite direction in contrast with that of the external magnetic field shown by B , the electromagnetic force generated by the current envelope is deflating force which deflates the current envelope of the closed loop. This is because that this is the only way that can make the magnetic induction intensity generated by the current envelope of the closed loop tend to be higher, since when the current especially the voltage is the same, the smaller the area of the current envelope of the closed loop is, the higher the magnetic induction intensity within the current envelope of the closed loop is. Since the direction of the magnetic field generated by the current envelope of the closed loop is in the opposite direction in contrast with that of the external magnetic field, therefore, the higher magnetic induction intensity within the current envelope of the closed loop caused by the current carrying of the closed loop is in the direction to reduce the magnetic induction intensity within the current envelope of the current carrying closed loop. And in this case, this is the only way that can be done by the current envelope to achieve the goal that the magnetic induction intensity within the current envelope of the closed loop is lowered and even it is lowered to zero, after the closed loop is loaded with a current.

If the current on the closed loop is greatly increased while the area of the current envelope of the closed loop is reducing, the magnetic induction intensity within the current envelope of the closed loop will be reduced to zero, and then, if the current continues to increase, the electromagnetic force on the current envelope of the closed loop will change from deflating force to inflating force.

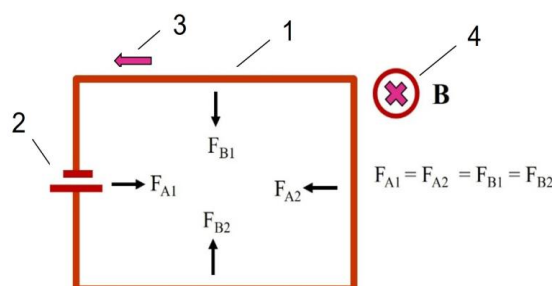


Figure 4. A schematic illustration of the direction of the electromagnetic forces generated by the current envelope of a closed loop loaded with current, which generates the magnetic field of opposite direction in contrast with that of the external magnetic field. 1. The closed loop, 2. The battery. 3. The direction of electric current, 4. The direction of the external magnetic field.

The analysis conducted above indicates that the nature of electromagnetic force is the force generated by the current envelope (electric field envelope) of a current-carrying closed loop to change its own area to lower the magnetic induction intensity within the current envelope of the closed loop that generated the electromagnetic force.

Furthermore, since the Ampère force law which states that a current-carrying conductor experiences a force in a magnetic field has been falsified [1], and it has been concluded that a current-carrying conductor itself does not experience a force in a magnetic field.

Therefore, it is concluded that there is no force interaction between the current-carrying edge of any current-carrying closed loop and the external magnetic field which the current-carrying edge is located in. This indicates that electromagnetic force is self-balanced within the current envelope of a current-carrying closed loop, that is, magnetic force is self-balanced within the current-carrying closed loop. This further indicates that electromagnetic force is the internal force inside the current envelope of the current-carrying closed loop, and is the internal force inside the current-carrying closed loop, and at each points of the current envelope of the closed loop, the electromagnetic force per unit length of the current envelope is the same. Although the magnitude and direction of the electromagnetic force are affected by the external magnetic field inside the current envelope of the current-carrying closed loop which generated the electromagnetic force, the electromagnetic force does not act on the external magnetic field.

Therefore, there are: The nature of electromagnetic force is the force generated by the current envelope (electric field envelope) of a current-carrying closed loop to change its own area to lower the magnetic induction intensity within the current envelope of the current-carrying closed loop that generated the electromagnetic force; electromagnetic force is self-balanced within the current envelope of the current-carrying closed loop, that is, it is self-balanced within the current-carrying closed loop; electromagnetic force is the internal force inside the current envelope of the current-carrying closed loop, that is, it is the internal force inside the current-carrying closed loop; at each points of the current envelope of the closed loop, the electromagnetic force per unit length of the current envelope is the same, and the direction of the electromagnetic force on the current envelope is perpendicular to the tangent at each point of the current envelope; although the magnitude and direction of electromagnetic force are affected by external magnetic field, the electromagnetic force has no force on the external magnetic field.

6. The Fifth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of the electromagnetic magnetic force, which is as follows:

Electromagnetic magnetic force is not the force between the current-carrying edge of a current-carrying closed loop and the other magnetic field, but it is the force between the magnetic field generated by the current envelope (electric field envelope) of a closed loop and the other magnetic field, it is the magnetic force between magnetic fields, such as the magnetic force between two permanent magnets; electromagnetic magnetic force obeys the rule that the same poles repel and the opposite poles attract; the direction of the action of electromagnetic magnetic force tends to increase the magnetic flux and to increase the magnetic induction intensity within the current envelope of the closed loop; the electromagnetic magnetic force is not self-balanced within the current envelope of a closed loop, but it acts on the external magnetic field.

Metalogic and facts: There are two completely different forces in the current-carrying closed loop, when it is set in the magnetic field, one is the electromagnetic force and the other one is the electromagnetic magnetic force.

Electromagnetic force and electromagnetic magnetic force have totally different natures. Electromagnetic magnetic force is actually magnetic force between magnetic fields, is the same kind of force as the force between two permanent magnetics. However, the electromagnetic force is totally different kind of force.

7. The Sixth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of electric field flux, which is as follows:

The net electric field flux through any closed surface is always equal to zero, that is:

$$\Phi_e = \oint_S \mathbf{E} \cdot d\mathbf{S} = 0$$

Metalogic and facts: The direction of the electric field that forces a positive charge Q^+ and a negative charge Q^- to separate from each other is in the direction from the negative charge Q^- towards the positive charge Q^+ , and the direction of the electric field resulted by the separated the positive charge Q^+ and the negative charge Q^- is in the direction from the positive charge Q^+ towards the negative charge Q^- . Therefore, these two electric fields must form closed loops of electric field. In other words, if the electric field that forces a positive charge Q^+ and a negative charge Q^- to separate from each other is named as E_x , and the electric field generated by the separated the positive charge Q^+ and the negative charge Q^- is named as E_y , then E_x and E_y are mutually dependent and inseparable. And therefore, the positive charge Q^+ , the negative charge Q^- , the electric field E_x and the electric field E_y must form closed loops of electric field. This implies that when a positive charge Q^+ and a negative charge Q^- are separated, both the positive charge Q^+ and the negative charge Q^- receive electric fields and output electric fields. Additionally, when a positive charge Q^+ and a negative charge Q^- are separated, the positive charge Q^+ outputs electric fields by itself, but it receives electric fields from the more positive electric field body, while the negative charge Q^- receives electric fields by itself, but it outputs electric field to the more negative electric field body, thus closed loops of electric field must be formed. As long as a positive charge Q^+ and a negative charge Q^- are in a separate state, the electric field E_x and the electric field E_y must exist. And as long as the electric field E_x and the electric field E_y exist, closed loops of electric field will inevitably be formed. Since there is no positive charge Q^+ or negative charge Q^- in the world that is not in a separate state, the existence and motion of any charge must be part of a closed loop of electric field. There is no charge in the world that is not part of a closed loop of electric field, and there is no electric field that is not part of a closed loop of electric field.

As shown in Figure 5, if we use mechanical force to increase the distance between the charged body X and the charged body Y, then the electric potential between the two charged bodies will increase, and more positive and negative charges will accumulate on the two surfaces corresponding to the two charged bodies. On the opposite side of each of the two charged bodies, more electrically opposite charges will be accumulated. This inevitably results in a closed loop of the stronger electric field as shown in this figure. Therefore, the following equation do hold true for electric field flux.

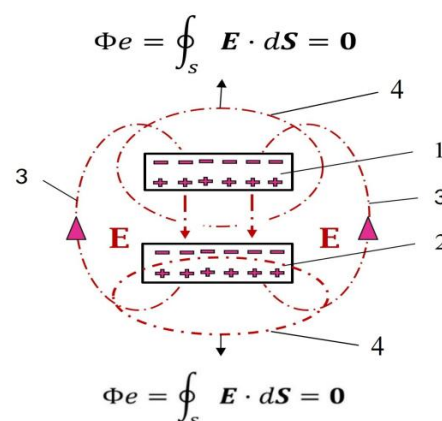


Figure 5. A schematic illustration of a logical experiment proving that there is a closed loop of electric field surrounding charged bodies. 1. The charged body X, 2. The charged body Y, 3. The closed loop of electric field, 4. The closed surface.

Additionally, If positive charge only emits electric fields, because electric fields are matter, then the mass of the positive charge must keep decreasing and eventually ceases to exist, otherwise, the law of conservation of energy and the law of conservation of matter are violated. Not only that, but if negative charge only accepts electric field, because electric fields are matter, then the mass of the negative charge must keep increasing and eventually become infinity, otherwise, the law of conservation of energy and the law of conservation of matter are violated. Therefore, it is not possible for a positive charge to only output electric fields and not accept them, and it is impossible for a negative charge to only accept electric fields and not to output them. Therefore, electric fields are also closed loop fields, they are not as explained by current electromagnetic theory, in which electric fields are only emitted by positive charges, partly reach infinitely far, and partly reach negative charges.

In fact, the existence of positive charge is due to the existence and action of negative charge, and is due to the existence and action of the more-positive charge. Similarly, the existence of negative charge is due to the existence and action of positive charge, and is due to the existence and action of the more-negative charge. Without the existence and action of a negative charge and more-positive charge, a positive charge cannot exist and cannot emit an electric field. Similarly, without the existence and action of a positive charge and more-negative charge, a negative charge cannot exist and cannot receive an electric field. Any charge and charge movement must be part of a closed loop, there is no charge in the world that is not part of a closed loop, there is no charge movement that is not part of a closed loop, and there is no charge beam that is not part of a closed loop.

The above statements are logically inevitable, and they are clearly true, therefore, the Gauss's theorem for electric field flux does not hold true.

This means that the net electric field flux through any closed surface is always equal to zero, that is, the following equation does hold true for electric field flux:

$$\Phi_e = \oint_S \mathbf{E} \cdot d\mathbf{S} = 0$$

This is called fundamental law on electric field flux.

This indicates that electric field is also a closed field, and the magnetic field is known to be a closed field. However, this indicates that the whole of one electric field closed loop is the indispensable minimum unit required to achieve the effect of electric field, and the whole of one magnetic field closed loop is the indispensable minimum unit required to achieve the effect of magnetic field. This study concludes that only the whole of integer turns closed loops can generate electromagnetic phenomena. All this indicates that electric fields, magnetic fields, and all other electromagnetic phenomena are not only generated by the whole of closed loops, but also their effects are achieved also by the whole of closed loops. Therefore, the integer turns and the integer number of closed loops are the core of the problem. This indicates that not only can the Hall effect and the anomalous Hall effect be quantized, but all electromagnetic phenomena can also be quantized.

8. The Seventh Fundamental Law of Electromagnetism: The fundamental law on what is the logic of the mutually-inducing process between a changing magnetic field and a changing electric field, which is as follows:

The formation and the propagation of electromagnetic waves can only take place where there is a closed loop consisting of a medium of some kind, which must contain movable charge or oscillatory charge; the propagation of a changing magnetic field in a vacuum environment will carry on in the form of a magnetic field itself, and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop, similarly, the propagation of a changing electric field in a vacuum environment will carry on in the form of an electric field itself and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop. Otherwise, there must be something in the vacuum environment, which can provide movable charge or oscillatory charge, or the vacuum environment is just a part of a closed loop.

Metalogic and facts: The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation). Therefore, changing magnetic fields and changing electric fields can generate changing electromagnetic forces and changing electromagnetic magnetic forces with some kind of matter, including insulator, and can interact with the matter. It has been discovered that nothing can act on itself, that is, a change of any kind must need an indispensable third party to interact with before it takes place, that is, a being x must need an indispensable third party to interact with before it becomes a non-being x ^[2]. This statement is termed as the second law of the isolated system. This is not Newton law of inertia which describes the state of object motion. The second law of the isolated system describes the nature of being. Newton law of inertia can be applied in all field of object-motion, the second law of the isolated system can be applied in whole and every part of the universe. For example, in field of cosmology, physics, chemistry, biology, and so on, the second law of the isolated system is all applicable. This is because that if a being can act on itself, there is no way for it to exist. Thus, as long as something exist, it definitely cannot act on itself. The second law of the isolated system can also be stated as: the attribute of being will not change by itself. It is an example of application of this law that a compound cannot change to be another subject unless it interacts with other parties, such as temperature, pressure, or other subjects. The statement that nothing can act on itself is equivalent to the statement that being cannot act itself. The attribute of being not only includes the state of present time, but also includes the started definite tendency. For example, the decay of radioactive elements, the automatic start of a timed system, the spoilage of a canned food and et cetera, which all have a started definite tendency, respectively. This is because that these changes are the results of their started process, but not new changes in the nature of them. Thus, these processes still comply with the second law of the isolated system. From another perspective, these changes are the results of that a part of being acts on another part of the same being. Therefore, these processes again still comply with the second law of the isolated system. According to the second law of the isolated system it can be concluded that a varying magnetic field must need something suitable as the indispensable third party to interact with before it induces a varying electric field, and vice versa. However, the consensus understanding on the same issue derived from Maxwell's equations contradicts this conclusion.

The discovery obtained in other research^[1] that the whole of a closed loop (that is, the

entire closed loop) of one turn is the minimum physical unit indispensably required to achieve an electromagnetic phenomenon and that the whole of a closed loop with a change in magnetic flux and/or in the magnetic induction intensity within the closed loop is the necessary and sufficient conditions for generating electromagnetic phenomena indicates that: A closed loop is the indispensable minimum unit that can convert an electric field into a magnetic field and convert a magnetic field into an electric field. Any part of this minimum unit cannot achieve these conversions. If this minimum unit does not exist, an electric field and a magnetic field, or a magnetic field and an electric field, all do not have interactive relations with each other.

This discovery further indicates that the mutually-inducing process between a changing magnetic field and a changing electric field can only take place where there is a closed loop consisting of a medium of some kind, which must contain movable charge or oscillatory charge. This closed loop is the indispensable third party to interact with in this mutually-inducing process. A changing magnetic field cannot induce a changing electric field earlier than a closed loop exists. A changing electric field cannot induce a changing magnetic field earlier than a closed loop exists. The propagation of a changing magnetic field in a vacuum environment will carry on in the form of a magnetic field itself, and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop. Similarly, the propagation of a changing electric field in a vacuum environment will carry on in the form of an electric field itself and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop. This indicates that the so-called electromagnetic waves are only electric field waves or magnetic field waves in some cases where there is no matter. Changing magnetic field and changing electric field are different things, a conversion or an induction between different things must need something suitable to interact with before it takes place. LC oscillating circuit makes the mutually-inducing process between a changing magnetic field and a changing electric field to take place. Here, LC oscillating circuit is the indispensable third party to interact with in each inducing in this mutually-inducing process and is the minimum physical unit indispensably required to achieve an electromagnetic phenomenon. LC oscillating circuit can be made to be any form such as the form of an antenna to more efficiently generate a changing electric field, but this electric field must need something suitable as the indispensable third party to interact with before a changing magnetic field being induced in the space where is no LC oscillating circuit. LC oscillating circuit is the indispensable third party to interact with in each inducing in the mutually-inducing process between a changing magnetic field and a changing electric field, when humans make electromagnetic waves. Why Maxwell's equations give the results that the mutually-inducing process between a changing magnetic field and a changing electric field will take place in a vacuum environment where is no LC oscillating circuit. Why the LC oscillating circuit is eliminated in Maxwell's equations. The eliminations of closed loop and LC oscillating circuit indicate that some of Maxwell's equations lack logical and physical foundation.

It is undeniably logical that nothing can act on itself. Thus, a change of any kind must need an indispensable third party to interact with before it takes place. That is, a being x must need an indispensable third party to interact with before it becomes a non-being x . This implies that a changing magnetic field must need something suitable as the third party to interact with before it induces a changing electric field, and vice versa. Therefore, it is sure that the mutually-inducing process between a changing magnetic field and a changing electric field will not take place in a vacuum environment, as long as the vacuum environment does not contain movable charges or oscillatory charges, which is

indispensable in forming closed loop of electric field.

It is undeniably logical that the whole of a closed loop of one turn is the minimum physical unit indispensably required to achieve an electromagnetic phenomenon and that the whole of a closed loop with a change in magnetic flux and/or in the magnetic induction intensity within the closed loop is the indispensable necessary and sufficient conditions for generating electromagnetic phenomena. And it is undeniably logical that: A closed loop is the indispensable minimum unit that converts an electric field into a magnetic field and convert a magnetic field into an electric field; any part of this minimum unit cannot achieve these conversions; if this minimum unit does not exist, an electric field and a magnetic field, or a magnetic field and an electric field, all do not have interactive relations with each other, and no electromagnetic phenomena achieved.

All these mean that the real ways of the formation and propagation of electromagnetic waves are different from the consensus understanding derived from Maxwell's equations. An electric field closed loop is the indispensable third party to interact with in the mutually-inducing process between a changing magnetic field and a changing electric field. And finally, all these mean that the real ways of the formation and the propagation of electromagnetic waves should contradict the consensus understanding derived from Maxwell's equations.

Conclusions obtained above indicates that the mutually-inducing process between a varying magnetic field and a varying electric field can only take place where there is a closed loop consisting of any medium, which must contain movable charge or oscillatory charge, not has to be conductor, because the magnetic field and the electric field are varying. This closed loop is the indispensable third party to interact with in this mutually-inducing process. This third party is just the third party indispensably required by the second law of the isolated system. All these mean that a varying magnetic field cannot induce a varying electric field earlier than a closed loop exists. The same, a varying electric field cannot induce a varying magnetic field earlier than a closed loop exists. The propagation of a varying magnetic field in a vacuum environment will carry on in the form of a magnetic field itself, and will only switch to the alternating propagation mode of a varying magnetic field and a varying electric field when it encounters a closed loop. Similarly, the propagation of a varying electric field in a vacuum environment will carry on in the form of an electric field itself and will only switch to the alternating propagation mode of a varying magnetic field and a varying electric field when it encounters a closed loop. All these mean that the ways of the formation and propagation of electromagnetic waves in a vacuum environment derived from Maxwell's equations contradict the second law of the isolated system, and contradict the fundamental law on what is the minimum physical unit indispensably required to generate electromagnetic phenomena stated above and must be wrong.

9. The Eighth Fundamental Law of Electromagnetism: The fundamental law on what is the prerequisite for the application of superposition principle in electromagnetism, which is as follows:

The prerequisite for the application of superposition principle is that the minimum unit the superposition starts from must indeed have the necessary characteristics to be superimposed, otherwise, the application of the superposition principle lacks logical and physical foundations.

Metalogic and facts: It is true that a change in magnetic flux within a closed loop generates

electromotive force. However, this does not imply that every part of the closed loop generates a portion of that electromotive force, nor that calculus can be performed on part of the windings of the closed loop to obtain the electromotive force generated by the whole of the closed loop, since the electromotive force is generated by the whole of the closed loop of integer turns, but not generated by any part less than one turn of the whole of the closed loop. The whole of the closed loop of one turn is the minimum unit indispensably required to generate electromotive force. In other words, calculus cannot be performed on any part less than one turn of the windings of the closed loop to obtain the electromotive force generated by the whole of the closed loop, since the electromotive force is generated by the whole of the closed loop of integer turns. For example, a drum's sound arises from the whole drum (that is, the entire drum), it cannot be assumed that each part of the drum skin and drum cavity independently produces some portion of the drum's sound and then use calculus on the drum skin and drum cavity to obtain the whole of the drum's sound, unless it is demonstrated that every part of drum skin and drum cavity independently produces drum's sound. However, it is indisputable that neither the drum skin nor the drum cavity can independently produce drum sound. In electromagnetism, the indispensable minimum unit indispensably required to generate an electromagnetic phenomenon is the whole of a closed loop of one turn. That is, the whole one turn of a closed loop is the indispensable minimum unit indispensably required to generate an electromagnetic phenomenon, and the whole one turn of a closed loop with a change in magnetic flux and/or in the magnetic induction intensity within the closed loop is the indispensable necessary and sufficient conditions for generating electromagnetic phenomena. The superposition principle is widely utilized in electromagnetism, but the prerequisite for its application is that the minimum unit the superposition starts from must indeed have the necessary characteristics to be superimposed. If the minimum unit which the superposition starts from have not been proved to possess the necessary characteristics to be superimposed, the calculation using the superposition principle lacks experimental and logical foundations. In fact, humans have never experimentally detected an electromagnetic force, an electromotive force or a magnetic field on objects smaller than the whole of a closed loop of one turn, such as conductor segments Δl , differential conductor segments dl , current elements Idl or the current (or beam) of independent moving charges, without the existence of the whole of a closed loop. Therefore, the calculation using the superposition principle for an electromagnetic force, an electromotive force, and a magnetic field on conductor segments Δl , differential conductor segments dl , current elements Idl or on the current (or beam) of independent moving charges lacks experimental and logical foundations.

The existence of the whole of a closed loop with a change in magnetic flux and/or in the magnetic induction intensity within the closed loop of one turn is the indispensable premise for achieving electromagnetic phenomena. This implies that the whole of a closed loop of one turn is the minimum physical unit indispensably required to achieve an electromagnetic phenomenon. Therefore, any calculus process on objects smaller than the whole of a closed loop of one turn to describe the electromagnetic phenomena lacks physical experimental and logical foundations. Logically, the characteristics of a whole are not equal to the superposition of the characteristics of its parts, and the characteristics of the constituent parts are not equal to the division of the characteristics of its whole. As illustrated in Figure 6, if there is a changing magnetic field in the iron core, and the main one turn closed loop for electricity generation will generate electromotive force. If the electromotive force generated by the main one turn closed loop is V_0 , and if the superposition principle is suitable for electromotive force calculation for a coil, then there must be an electromotive force relation: $V_0 > V_4 > V_3 > V_2 > V_1 > 0$. However, the generally and indisputably accepted fact (supported by physical measurement) is that the actual

electromotive force relation is: $V_0 > 0$ and $V_4 = V_3 = V_2 = V_1 = 0$. This implies that any part of a closed loop generating electromotive force does not generate electromotive force individually. In other words, the whole of a closed loop of one turn is the minimum physical unit indispensably required to generate an electromotive force, and any part of this minimum physical unit cannot generate any electromotive force on its own. This also indicates that a changing magnetic field cannot induce a changing electric field, and conversely, a changing electric field cannot induce a changing magnetic field, unless there is at least a one turn closed loop, as long as it is consisting of some matter of some kinds. This also indicates that the prerequisite for the application of superposition principle for any electromagnetic phenomena calculation in electromagnetism is the whole one turn closed loop.

Therefore, for any kind of application of superposition principle on electromagnetic phenomena, the starting unit must be a closed loop of one turn. Therefore, again, any calculation based on conductor segments Δl , differential conductor segments dl , current elements $I dl$ and the current (or beam) of independent moving charges for electromagnetic phenomena lacks logical and physical foundation.

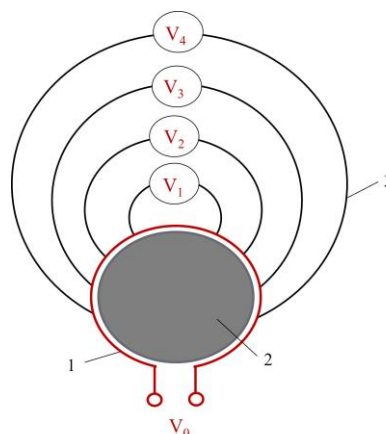


Figure 6. A schematic illustration of a physical experiment testing the validity of the superposition principle in calculating electromotive force. 1. Main one turn closed loop for electricity generation, 2. Iron core, 3. Measuring circuits.

10. The Ninth Fundamental Law of Electromagnetism: The fundamental law on is there interaction in the direction perpendicular to physical field lines, which is as follows:

It is impossible for a physical field to act in the direction perpendicular to itself, i.e., there is no interaction in the direction perpendicular to the physical field lines, therefore, there is no interaction force in the direction perpendicular to the physical field lines.

Metalogic and facts: If examine whether the interaction relation for the results stated by a physical law exists or not, and if the interaction relation for the results stated by a physical law does not exist, then the physical law is falsified by the falsification by the existence of the interaction relations, that is, the physical law is disproved. For example, if a physical law claims that Y moving in the direction perpendicular to the physical field X produces Z by the interaction of the physical field X, this physical law is obviously untenable. This is because that it is as absurd as saying that an object moving in the direction of the contour of the Earth's gravitational field does work on the gravitational field or gains energy from the gravitational field. This is also because that it is impossible for a physical field to act in its in the direction perpendicular to the physical field lines, which is here defined as the law of no interaction in perpendicular direction to physical

field lines. Therefore, the conclusions that a current-carrying conductor experiences a force in the direction perpendicular to the magnetic field lines, a conductor cutting through magnetic field lines in the direction perpendicular to the magnetic field lines generates an electromotive force, and an independent moving charge experiences a force in the direction perpendicular to the magnetic field lines are all wrong.

11. Discussion

The proposed laws offer new insights into the nature of electromagnetic phenomena, challenging conventional understanding of the natural world, and all electromagnetic technologies and electromagnetic equipment will undergo fundamental changes. Here are just a few examples stating the effects of the new fundamental laws proposed.

11.1. On the electron double-slit interference experiment

The discovery that the whole of a closed loop (that is, the entire closed loop) is the minimum physical unit indispensably required to achieve an electromagnetic phenomenon and that the whole of a closed loop with a change in magnetic flux and/or in the magnetic induction intensity within the closed loop is the indispensable necessary and sufficient conditions for achieving electromagnetic phenomena may offer deeper scientific insights into the electron double-slit interference experiment. Since if the moving charge is considered as a component of a closed electric field loop, the story will be totally different and the problem may become clearer. The electron beams used to be considered a kite without a string or bullets fired from a gun barrel in the electron double-slit interference experiments. However, as schematically illustrated in Figure 7, the electron beams are actually segments of closed electric field loops, but not a kite without a string or bullets fired from a gun barrel. In the electron double-slit interference experiments, observers cause changes in the form of the closed electric field loop consisting of the electron beam. This indicates that the presence or absence of the observer leads to changes in the form of the closed electric field loop, which in turn leads to a change in the expression of the electron beam. This may be the reason why the electron beams perform different when the observer exists or not.

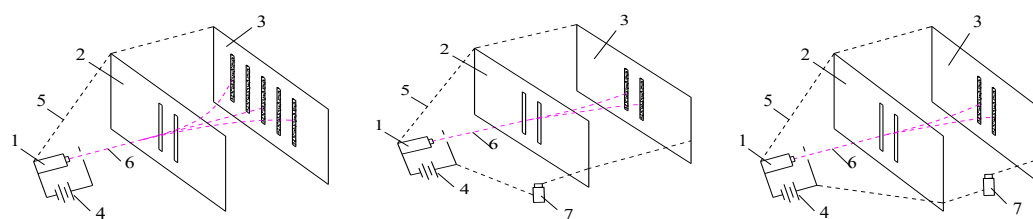


Figure 7. A schematic illustration of the electron double-slit interference experiment. 1. Electron gun, 2. Double slits, 3. Screen, 4. Electric source, 5. The closed electric field loop, 6. Electric beam, 7. Observer.

11.2. On Hall effects

The self-balanced nature of electromagnetic force within the current envelope of closed loops has implications for phenomena such as the Hall effects. As stated above, the electromagnetic force is the force generated by the current envelope (electric field envelope) of a closed loop to change its own area to lower the magnetic induction intensity within the current envelope of the closed loop that generated the electromagnetic force, it is self-balanced within the current envelope of the current-carrying closed loop, and within the current-carrying closed loop, and it is the internal

force inside the current envelope of the current-carrying closed loop, it is the internal force inside the current-carrying closed loop, and at each point of the current envelope of the closed loop, the electromagnetic force per unit length of the current envelope is the same. This conclusion implies that both the Hall effect and the anomalous Hall effect must exist. Because whenever a closed loop carries current, the current envelope of the conductor must inflate or deflate itself to reduce the magnetic induction intensity within the current envelope of the closed loop, thus giving rise to the Hall effect and the anomalous Hall effect. In fact, the Hall effect, the anomalous Hall effect, the quantum Hall effect, and the anomalous quantum Hall effect are generated by electromagnetic force. The Hall effect, the anomalous Hall effect, the quantum Hall effect, and the anomalous quantum Hall effect are nothing more than projections of the interaction between the electromagnetic force and the current envelope (/electric field envelope). The fundamental reason for the existence of the quantum Hall effect and the anomalous quantum Hall effect is the law discovered in this study that only the whole of integer turns closed loops can generate electromagnetic phenomena.

11.3. On the direct interaction between different fields

Different fields cannot interact with each other directly, field A and field B cannot interact with each other directly, and there must be a being X involved. The being X converts the field A into the field B, or converts the field B into the field A, or converts both the field A and the field B into field C, and eventually enable the field A and the field B to interact with each other. Different field A and different field B require different being X. This is because that if different fields can interact directly with each other, then there can be only one field in the world at most. Since there is more than one field in the world, then the different fields must not interact directly with each other. It is not possible to interact directly with each other between an electric field and a magnetic field. In other words, an electric field cannot interact directly with a magnetic field, and a magnetic field cannot interact directly with an electric field. They can only interact with each other through a closed-loop. An electric field must be converted into a magnetic field through a closed loop first before interacting with other magnetic fields, and a magnetic field must be converted to an electric field through a closed loop before interacting with other electric fields. A closed loop is the minimum unit that can convert an electric field into a magnetic field and convert a magnetic field into an electric field. Any part of this minimum unit cannot achieve these conversions. If this minimum unit does not exist, an electric field and a magnetic field, or a magnetic field and an electric field, all do not have interactive relations with each other, and no electromagnetic phenomena exist. Of course, the closed loop here is a closed loop which can be a conductor closed loop, a closed loop that includes a displacement current, a closed loop that includes an independent moving charge, or a closed loop that consists of some kind of matter.

11.4. On the skin effect and U-turn current

Clarification of the nature of electromagnetic forces will deepen the understanding of the common-sense knowledge of the skin effect. It is likely that the electromagnetic force is the fundamental driver of the skin effect. This means that the skin effect is not uniform on the surface of the current-carrying conductor, but on the side of the conductor that changes the area of the closed loop where the current-carrying conductor is located. Clarification of the nature of the electromagnetic force will deepen the understanding of the current envelope pattern during current conduction, as shown in Figure 8, in which a U-current is generated. In some cases, the U-current can significantly reduce the efficiency of power transmission.

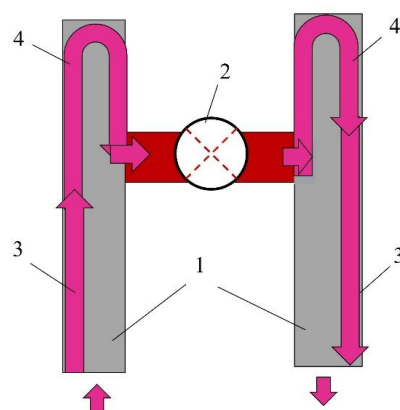


Figure 8. A schematic illustration of a U-turn current. 1. conductor, 2. Electrical load, 3. Current, 4. U-turn current.

11.5 On the new definition of the relationship between force and current

In 1948, in the International System of Units (SI), as shown in the left part of Figure 8, the International Bureau of Weights and Measures (BIPM) defined the relationship between force (Newton) and current (Ampere) according to the fundamental laws of traditional electromagnetism. That is, when two conductor sticks in one meter long, set one meter apart and carry one Ampere of current, the force between the two current-carrying conductor sticks is 2×10^{-7} Newton. However, in 2019, the International Bureau of Weights and Measures (BIPM) changed the definition of Ampere unit back to the value based on a fixed elementary charge. However, based on the results of this study, the relationship between force (Newton) and current (Ampere) can be redefined in the following two ways.

First, as shown in Figure 9 in the right part of Figure 9, two circular closed loops with a diameter of one meter and with a current of 1000A are set one meter apart, and the force between the two closed loops is accurately measured in Newtons, and then the constant K value in Figure 9 can be determined to define the relationship between force (Newtons) and current (Amperes). Since the value of force Newton and the value of current Ampere have long been determined, they can only be related in the equation by adjusting the constant K with experiments.

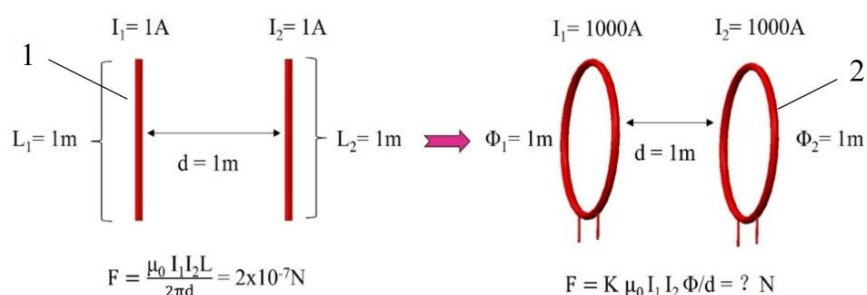


Figure 9. The definition of the relationship between force (Newton) and current (Ampere) with two closed loops. 1. The conductor, 2. The circular closed loop.

Second, as illustrated in Figure 10, make a circular closed loop with a diameter of one meter and make it carry a current of 1000A, then accurately measure how many Newtons of the inflating force per length of closed loop, and determine the value of the constant K. Then, determine the relationship between the force (Newton) and the current (Amperes). And it is also because the value of force Newton and the value of current

Ampere have long been determined, they can only be related in the equation by adjusting the constant K with experiments.

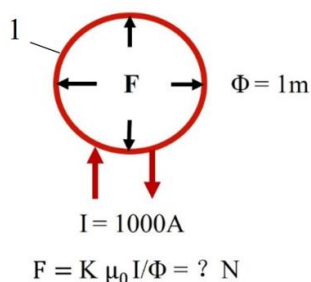


Figure 10: The definition of the relationship between force (Newton) and current (Ampere) with one closed loop. 1. The circular closed loop.

11.6 On the working mechanism of electric motor

The fundamental law proposed for electromagnetic force indicates that it is not the electromagnetic force that is commonly thought to be driving the electric motor, but the electromagnetic magnetic force, but the force between the magnetic field and the magnetic field. And this indicates that the design theory of electric motor will be changed for better.

6. Conclusions

In conclusion, this study proposes nine new fundamental laws of electromagnetism, providing a more accurate and comprehensive understanding of electromagnetic phenomena. They are:

The First Fundamental Law of Electromagnetism: The fundamental law on what is the minimum physical unit indispensably required to generate electromagnetic phenomena, which is: The whole of a closed loop (that is, the entire closed loop) of one turn is the minimum physical unit indispensably required to generate an electromagnetic phenomenon, any part of this minimum physical unit cannot generate any electromagnetic phenomenon, electromagnetic phenomena are all generated by the whole of a closed loop with a change in magnetic flux and/or in magnetic induction intensity within the closed loop.

The Second Fundamental Law of Electromagnetism: The fundamental law on what are the necessary and sufficient conditions for generating electromagnetic phenomena, which is: The whole of a closed loop (that is, the entire closed loop) of one turn with a change in magnetic flux and/or in magnetic induction intensity within the closed loop is the necessary and sufficient conditions for generating an electromagnetic phenomenon.

The Third Fundamental Law of Electromagnetism: The fundamental law on how electromagnetic phenomena are interacted with each other, which is: The nature of electromagnetic processes is the induction among changing magnetic fields, changing electric fields and changing electromagnetic forces through the whole of a closed loop (that is, the entire closed loop) of integer turns with a change in magnetic flux and/or in magnetic induction intensity within the closed loop, any and all electromagnetic processes are the result of the coexistence of these five. That is, only the whole of integer turns closed loops can generate electromagnetic phenomena.

The Fourth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of electromagnetic force, which is as: The nature of electromagnetic force is the force generated by the current envelope (electric field envelope) of a current-carrying closed loop to change its own area to lower the magnetic induction intensity within the current envelope of the current-carrying closed loop that generated the electromagnetic force; electromagnetic force is self-balanced within the current envelope of the current-carrying closed loop, that is, it is self-balanced within the current-carrying closed loop; electromagnetic force is the internal force inside the current envelope of the current-carrying closed loop, that is, it is the internal force inside the current-carrying closed loop; at each point of the current envelope of the closed loop, the electromagnetic force per unit length of the current envelope is the same, and the direction of the electromagnetic force on the current envelope is perpendicular to the tangent at each point of the current envelope; although the magnitude and direction of electromagnetic force are affected by external magnetic field, the electromagnetic force has no force on the external magnetic field.

The Fifth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of the electromagnetic magnetic force, which is: Electromagnetic magnetic force is not the force between the current-carrying edge of a current-carrying closed loop and the other magnetic field, but it is the force between the magnetic field generated by the current envelope (electric field envelope) of a closed loop and the other magnetic field, it is the magnetic force between magnetic fields, such as the magnetic force between two permanent magnets; electromagnetic magnetic force obeys the rule that the same poles repel and the opposite poles attract; the direction of the action of electromagnetic magnetic force tends to increase the magnetic flux and to increase the magnetic induction intensity within the current envelope of the closed loop; the electromagnetic magnetic force is not self-balanced within the current envelope of a closed loop, but it acts on the external magnetic field.

The Sixth Fundamental Law of Electromagnetism: The fundamental law on what is the nature of electric field flux, which is: The net electric field flux through any closed surface is always equal to zero, that is:

$$\Phi_e = \oint_S \mathbf{E} \cdot d\mathbf{S} = 0$$

The Seventh Fundamental Law of Electromagnetism: The fundamental law on what is the logic of the mutually-inducing process between a changing magnetic field and a changing electric field, which is: The formation and the propagation of electromagnetic waves can only take place where there is a closed loop consisting of a medium of some kind, which must contain movable charge or oscillatory charge; the propagation of a changing magnetic field in a vacuum environment will carry on in the form of a magnetic field itself, and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop, similarly, the propagation of a changing electric field in a vacuum environment will carry on in the form of an electric field itself and will only switch to the alternating propagation mode of a changing magnetic field and a changing electric field when it encounters a closed loop. Otherwise, there must be something in the vacuum environment, which can provide movable charge or oscillatory charge, or the vacuum environment is just a part of a closed loop.

The Eighth Fundamental Law of Electromagnetism: The fundamental law on what is the

prerequisite for the application of superposition principle in electromagnetism, which is: The prerequisite for the application of superposition principle is that the minimum unit the superposition starts from must indeed have the necessary characteristics to be superimposed, otherwise, the application of the superposition principle lacks logical and physical foundations.

The Ninth Fundamental Law of Electromagnetism: The fundamental law on are there interactions in perpendicular direction of physical field lines, which is: It is impossible for a physical field to act in its perpendicular direction, i.e., there are no interactions in perpendicular direction of physical field lines.

The essence of the closed loop here is a closed loop of electric field, and as long as there is a charge, a closed loop will be established under the action of electric fields, magnetic fields, and forces (such as triboelectric generation).

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Author Declarations

Ethics approval and consent to participate The author declares that this study was conducted in accordance with ethical standards and guidelines.

Consent for publication The author declares that this manuscript does not contain any personal data or sensitive information that requires consent for publication.

Competing interests The author declares that he has no competing interest.

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