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General Maxwell Theory of Fields

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Abstract

This paper explores Maxwell's analogy idea between electromagnetic field lines and incompressible fluid, and explains Faraday's law and Maxwell's formula for displacement currents by means of fluid dynamics theory: They show the transport properties of electromagnetic field lines as incompressible fluids, not just effects. Combined of the steady electromagnetic fields, Maxwell's idea of the analogy between the electromagnetic fields and the incompressible fluids has reached a perfect conclusion. Viewing the electromagnetic field as a vacuum state excited by charges, and extending Maxwell analogy, we consider the gravitowagnetic field as a vacuum state excited by mass. This led to the establishment of the generalized Maxwell equations and the application of this new theory to explain various natural phenomena.

Keywords

Electromagnetic, Gravitowagnetic, Incompressible, Reynolds

1. Introduction

In 1857, James Clerk Maxwell published his paper "On Faraday's Lines of Force". The analogy he presented for lines of force was the flow of an incompressible fluid. The streamlines of flow represented lines of force either electric or magnetic while the speed and direction of fluid flow at any point represented the density and direction of the lines of force there. It was Maxwell who noticed that lines of force in a field could not cross or coincide, showing their incompressibility. He had given the mathematical interpretation of Faraday's conceptions regarding the nature of electric and magnetic forces. Maxwell's imaginary electric or magnetic fluid was weightless, friction-free, and incompressible [1]. The author of the reference [1] pointed out that the last property (incompressible) was the key to the analogy. Maxwell's theory of electromagnetic fields encompasses steady and unstable electromagnetic fields. The steady electromagnetic fields include the electrostatic field and steady-state magnetic field, and their properties conform to the laws of fluid mechanics: The electrostatic field conforms to the Gaussian theorem of the fluid, and in turn, the Helmholtz analogy and Maxwell analogy can be used to derive the formula of velocity field by vortex filament (assumed of infinite length) with the help of the Biot-Savart law of the magnetic field [2]. There are the following correspondences: $\boldsymbol{B}/\mu_0 \leftrightarrow \boldsymbol{v}$, $I_0 \leftrightarrow \Gamma$, where $\boldsymbol{B}$ is the magnetic induced intensity, μ_0 is the space permeability, $\boldsymbol{v}$ is the velocity, I_0 is the electric current, and Γ is the circulation. The velocity field has the same form of formula as the magnetic field

$$\mathrm{d}\boldsymbol{v} = \frac{1}{4\pi}\Gamma\frac{\mathrm{d}\boldsymbol{l}\times\boldsymbol{r}}{r^3} \tag{1}$$

Equation (1) is a mature formula of hydrodynamics and has been around for a long time [2]. Obviously, the two parties involved in the analogy can have different dimensions. Unstable electromagnetic fields include Faraday's law (hereafter referred to as F law) and Maxwell's formula of displacement current (simply referred to as M law), the two extremely important theories that describe the laws of electromagnetism, without which there would be no electromagnetic wave. Xiao-gang Wen pointed out that the true essence of Maxwell theory is the discovery of a new form of matter: wave-like (or field-like) matter, the electromagnetic wave [3]. Unfortunately, these two laws have not yet been explained by fluid dynamics, making Maxwell's analogy between electromagnetic and fluid fields imperfect. F law of induction states: The induced electromotive force in a closed loop equals the negative of the time rate of change of magnetic flux through the loop. The law reveals that electricity and magnetism can be exchanged with each other. Lenz's law is a convenient alternative method for determining the direction of an induced current or electromotive force. The law is not an independent principle; it can be derived from F law. It always gives the same results as the sign rules we introduced, in connection with F law, but it is often easier to use. The law states: The direction of any magnetic induction effect is such as to oppose the cause of the effect. The law helps us gain intuitive understanding of various induction effects and of the rule of energy conservation [4]. Lenz's viewpoint is consistent with modern field theory that considers a field as a form of material existence. M law points out that a change of electric field can produce a displacement current in a vacuum or in a perfect insulator, which can produce a magnetic field. We believe that since electromagnetic waves are inseparable from these two laws, if we compare the propagation of electromagnetic waves to the transport of fluids, then these two laws describe the transport characteristics under the condition of conservation of energy: In a local space, two fluid fields (electric field $\boldsymbol{E}$ and magnetic field $\boldsymbol{B}$) must obey the law of change during transport at a certain time interval.

Further, we consider the electromagnetic field as a vacuum excitation state caused by electric charges, and on this basis, we introduce a new concept: a vacuum excitation state caused by mass. Based on gravitational wave experiments and the Helmholtz theorem, a field excited by moving mass is introduced: the wagnetic field ($\boldsymbol{W}$ field), which together with the gravitational field ($\boldsymbol{G}$ field) constitutes a vector field related to mass, and called gravitomagnetic field. The reason is that incompressible fluids are composed of matter with mass, which means that moving mass can also generate a force field in the same way that moving electric charges can generate a magnetic field. We introduced the concept of force lines for these two new fields, and drew an analogy with incompressible fluids, thereby deriving several formulas.

This article adopts a right-handed coordinate system, and for operators and coordinate variables of the left-handed system, a negative sign is added uniformly. The content of this paper is arranged as follows: Section 2 is theory, which compares the F law and M law to the transport process of fluids, and makes an analogy with the Reynolds transport theorem in fluid mechanics, pointing out that F law and M law correspond to two independent transport processes. Subsequently, we derived several important formulas for the gravitowagnetic field. Section 3 is discussion, firstly, from the perspective of macroscopic parity on conservation, explain the rationality of the coexistence of the electromagnetic field and the gravitowagnetic field. Then derive the Lorenz gauge in the gravitowagnetic field under the condition of mass conservation, and pointing out that there exists a force similar to the Lorentz force is caused by the wagnetic field, thereby explaining some natural phenomena including the light bending and photon precession in university, superfluid climbing walls, etc. Section 4 is conclusion.

2. Theory

2.1. The Transport Nature of Electromagnetic Fields

The dynamics of incompressible fluids are established within the frame work of Newtonian mechanics and must satisfy the conservation laws of Newtonian mechanics: Conservation of mass, conservation of charge, and conservation of energy. These conservation laws can be derived from Reynolds' transport theorem, which states that the rate of a physical function in the local volume V of space with time is equal to the rate of change of the physical function in the volume with time plus the flux of the function through the surface S of the V at a certain time interval Δt [5]. The physical function mentioned here can be any physical properties of the system, for the electromagnetic field, a composite system composed of $\boldsymbol{E}$ and $\boldsymbol{B}$ fields, the physical functions include electric field strength and magnetic induction intensity. The Reynolds theorem can be formulated as

$$\frac{\mathrm{d}}{\mathrm{d}t}\oint_V f\mathrm{d}v = \oint_V \left[\frac{\partial f}{\partial t} + \nabla \cdot \left(f\boldsymbol{v} \right)\right]\mathrm{d}v \tag{2}$$

where f is the physical function. The theorem implies that only the physical properties corresponding to the two items in the same equation can participate in the transport process at the same time and in the same place, otherwise it is impossible to participate in them.

Suppose there be only one type of energy transport in a local volume V of space, ϕ be the energy density (nothing except it), $\varphi\boldsymbol{v}$ be the energy flow density, $\boldsymbol{v}$ be the transporting velocity. The total rate of change of ϕ in the V can be expressed by using Equation (2)

$$\frac{\mathrm{d}}{\mathrm{d}t}\oint_V \phi \mathrm{d}v = \oint_V \left[\frac{\partial \phi}{\partial t} + \nabla \cdot (\phi \boldsymbol{v})\right] \mathrm{d}v \tag{3}$$

If there is no energy loss, the integrand on the right-hand of Equation (3) is equal to zero, and the energy is conserved:

$$\frac{\partial \phi}{\partial t} + \nabla \cdot (\phi \boldsymbol{v}) = 0 \tag{4}$$

This equation is in a fully Eulerian form. The energy of electromagnetic fields is composed of the E-field energy and the B-field energy. There is no electromagnetic wave without F law and M law, and these two laws run through the entire wave propagation process. From this point of view, they describe the energy transport characteristics of electromagnetic fields. The forms of F law and M law are [4]

$$\nabla \times \boldsymbol{E} + \frac{1}{c}\frac{\partial \boldsymbol{B}}{\partial t} = 0 \tag{5}$$

$$\nabla \times \boldsymbol{B} - \frac{1}{c}\frac{\partial \boldsymbol{E}}{\partial t} = 0 \tag{6}$$

Equations (5) and (6) are basic laws for unstable electromagnetic fields, which indicate that $\boldsymbol{E}$ and $\boldsymbol{B}$ are not independent, they are influence and restrict each other. Consider the electric field and magnetic field as fluid fields by Maxwell's analogy, and notice that the materiality of the field indicates that the two formulas are certainly energy transport equations.

By definition, the direction of the curl field $\nabla \times \boldsymbol{E}$ is the direction in which the circulation density is maximized, which can ensure the conservation of energy in the energy transition process [6]:

$$\nabla \times \boldsymbol{E} = \lim_{\Delta S \to 0} \frac{1}{\Delta S} \boldsymbol{n} \cdot \left\{\oint_L \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{l}\right\}_{\max} \tag{7}$$

where L is the closed path surrounding S, the S is the surface of the volume V, $\boldsymbol{n}$ is the unit normal vector of the ΔS. The choice of $\boldsymbol{n}$ ensures that the circulating current has a maximum value. Because of the conservation of electromagnetic energy, the change of energy in the volume V should equal to the change of energy passing through the surface S of the V, namely that

$$\int_S \left[(\nabla \times \boldsymbol{E}) + \frac{1}{c}\frac{\partial \boldsymbol{B}}{\partial t}\right] \cdot \boldsymbol{n} \cdot \mathrm{d}s = 0 \tag{8}$$

There is an analogy between equations (8) and (3), the correspondences are

$$\frac{\partial \phi}{\partial t} \leftrightarrow \frac{1}{c}\frac{\partial \boldsymbol{B}}{\partial t} \cdot \boldsymbol{n}, \quad \nabla \cdot (\phi \boldsymbol{v}) \leftrightarrow (\nabla \times \boldsymbol{E}) \cdot \boldsymbol{n} \tag{9}$$

Similarly, another correspondences are

$$\frac{\partial \phi}{\partial t} \leftrightarrow -\frac{1}{c}\frac{\partial \boldsymbol{E}}{\partial t}\cdot \boldsymbol{n}, \quad \nabla\cdot(\phi \boldsymbol{v}) \leftrightarrow (\nabla\times \boldsymbol{B})\cdot \boldsymbol{n} \tag{10}$$

These show that F law and M law are respectively the representations of Reynolds' theorem for free electromagnetic fields under the condition of energy conservation.

2.2. Generalization of Maxwell's Analogy Idea

Biot-Savart law is an experimental law, the current intensity I_0 is actually contributed by the negative charge of electrons, which current intensity is I_e, and $-I_0 = I_e$, the formula is rewritten as

$$\mathrm{d}\boldsymbol{B} = -\frac{\mu_0}{4\pi}\frac{I_e \mathrm{d}\boldsymbol{l}\times \boldsymbol{r}_0}{r^2} \tag{11}$$

where $\boldsymbol{r}_0 = \boldsymbol{r}/r$, $\boldsymbol{r}$ is radius vector, μ_0 is the permeability of vacuum, $I_e \mathrm{d}\boldsymbol{l}$ is the current-carrying element for the electrons. The mass flow intensity of electrons formed by the masses of electrons are I_m, which is in the same direction as I_e, and the resulting $\boldsymbol{W}$ can be expressed as

$$\mathrm{d}\boldsymbol{W} = -\frac{\xi_0}{4\pi}\frac{I_m \mathrm{d}\boldsymbol{l}\times \boldsymbol{r}_0}{r^2} \tag{12}$$

where $\xi_0/4\pi$ is proportional constant. The negative sign in the right side of this formula indicates that the wagnetic field obeys the left-handed rule. On one hand, Newton's equation of gravitational field and Coulomb's equation of electrostatic field have similar algebraic forms (parity); on the other hand, $\mathrm{d}\boldsymbol{W}$ and $\mathrm{d}\boldsymbol{B}$ share a similar algebraic form (parity). This suggests that we can describe the properties of the gravitowagnetic field using force lines, which can be likened to an incompressible fluid. Helmholtz theorem provides a theoretical reason for the existence of wagnetic field. By vector properties, the gravitational field is a longitudinal field like electrostatic field, and wagnetic field is a transverse field like magnetic field.

Helmholtz's theorem is only applicable vector fields in an infinite space [4]. It also indicates that: 1) a vector field in an infinite space is uniquely determined by its divergence and rotation. If both the divergence and rotation of a vector are zero, the vector field also vanish; 2) any vector field can be expressed by the sum of an irrotational field and a non-divergence field. The existence of electromagnetic waves indicates that the electromagnetic field conforms to this theorem. In recent years, gravitational waves have been detected, reminding us that the vector field excited by mass may also conform to this theorem. Introduce the scalar potential and vector potential, and represent the field excited by mas as

$$\boldsymbol{G} = \nabla\varphi_m, \quad \boldsymbol{W} = -\nabla\times \boldsymbol{A}_m \tag{13}$$

where $\boldsymbol{G}$ is static gravitational field, $\boldsymbol{W}$ is steady-state wagnetic field, φ_m is scalar potential, and $\boldsymbol{A}_m$ is vector potential. For fields excited by electric charge, there are interactions between charges of the same sign as well between charges of opposite signs. For fields excited by mass, there is no interaction between negative mass and mass; there is only interaction between the masses of two objects. Therefore, the interaction between the masses of two objects is similar to the interaction two electric charges of the same sign. The difference lies in the fact that the force related to mass is gravitational, while the force related to electric charge is repulse. This means that the gravitowagnetic field follows left-handed rules.

The experimental law of magnetic induction intensity states

$$\nabla \times \boldsymbol{B} = \frac{4\pi}{c}\boldsymbol{j}_0 = -\frac{4\pi}{c}\boldsymbol{j}_e \tag{14}$$

where $\boldsymbol{j}_e = -\boldsymbol{j}_0$, $\boldsymbol{j}_0$ is current density, $\boldsymbol{j}_e$ is current density contributed by electronic charges, the corresponding electronic mass flux density is $\boldsymbol{j}_m$, which has the same direction as $\boldsymbol{j}_e$, So

$$\nabla \times \boldsymbol{W} = -\frac{4\pi}{c}\boldsymbol{j}_m \tag{15}$$

2.3. The F Law and M Law in Gravitowagnetic Field

During the transition from a high energy orbit to a low energy orbit, an electron emits electromagnetic wave. Since the speed of the wave is limited, the electromagnetic wave continues to propagate after the transition is complete, and the received radiation wave can be considered as a source-free wave. After the process of gravitowagnetic waves generated in the distant depths of the universe has ended, the Earth receives this radiation waves, and therefore it is also considered a source-free waves. Since the properties of $\boldsymbol{G}$ and $\boldsymbol{W}$ are similar to those of $\boldsymbol{E}$ and $\boldsymbol{B}$, we can write similar wave equations,

$$\nabla^2 \boldsymbol{G} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{G}}{\partial t^2} = 0 \tag{16}$$

$$\nabla^2 \boldsymbol{W} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{W}}{\partial t^2} = 0 \tag{17}$$

The corresponding Poynting vector (obeys the left-handed rule) is

$$\boldsymbol{S}_m = -\frac{c}{4\pi}\boldsymbol{G} \times \boldsymbol{W} = \frac{c}{4\pi}\boldsymbol{W} \times \boldsymbol{G} \tag{18}$$

$\boldsymbol{S}_m$ is parallel to z-axis. The plane wave solutions fro equations (16) and (17) are

$$\boldsymbol{G} = \left(G_{\max} \cdot \boldsymbol{j}\right)\sin\left(k_z \cdot z - \omega t\right) = G_y \cdot \boldsymbol{j} \tag{19}$$

$$\boldsymbol{W} = \left(W_{\max} \cdot \boldsymbol{i}\right)\sin\left(k_z \cdot z - \omega t\right) = W_x \cdot \boldsymbol{i} \tag{20}$$

where $G_{\max} = W_{\max}$, $\boldsymbol{i}$ and $\boldsymbol{j}$ are basis vectors of the x-axis and y-axis, k_z is wave vector in the z-axis, ω is frequency, $k_z = \omega c$,

$$\nabla \times \boldsymbol{G} = \left(-\boldsymbol{i}\right)G_{\max}\cos\left(k_z \cdot z - \omega t\right)\cdot k_z \tag{21}$$

$$\frac{\partial \boldsymbol{W}}{\partial t} = \left(W_{\max} \cdot \boldsymbol{i}\right)\cos\left(k_z \cdot z - \omega t\right)\cdot\left(-\omega\right) \tag{22}$$

From Equations (21) and (22), we get the F law for the gravitowagnetic field

$$\nabla \times \boldsymbol{G} = \frac{1}{c}\frac{\partial \boldsymbol{W}}{\partial t} \tag{23}$$

With the same reason, the relevant M law is

$$\nabla \times \boldsymbol{W} = -\frac{1}{c}\frac{\partial \boldsymbol{G}}{\partial t} \tag{24}$$

In contrast to the F law and M law of electromagnetic field, the F law and M law embody compliance and resistance, respectively.

3. Discussion

3.1. General Maxwell's Equations

General Maxwell's equations include electromagnetic field equations and gravitowagnetic field equations,

$$\nabla \cdot \boldsymbol{E} = 4\pi\rho_0\,, \quad -\nabla \cdot \boldsymbol{G} = 4\pi\rho_m \tag{25}$$

$$\nabla \times \boldsymbol{E} = -\frac{1}{c}\frac{\partial \boldsymbol{B}}{\partial t}\,, \quad -\nabla \times \boldsymbol{G} = -\frac{1}{c}\frac{\partial \boldsymbol{W}}{\partial t} \tag{26}$$

$$\nabla \cdot \boldsymbol{B} = 0\,, \quad \nabla \cdot \boldsymbol{W} = 0 \tag{27}$$

$$\nabla \times \boldsymbol{B} = \frac{1}{c}\frac{\partial \boldsymbol{E}}{\partial t} + \frac{4\pi}{c}\boldsymbol{j}_0\,, \quad -\nabla \times \boldsymbol{W} = \frac{1}{c}\frac{\partial \boldsymbol{G}}{\partial t} + \frac{4\pi}{c}\boldsymbol{j}_m \tag{28}$$

The equations indicate that electromagnetic field and gravitowagnetic field maintain the parity of the excited vacuum, with no overall time reversal, meaning time maintains a forward direction. Locally, there is time reversal and parity violation, where a weak force field exists. Such states exist only momentarily and do not interfere with the overall parity and unidirectionality of time. As T. D. Lee pointed out: symmetry breaking is observable and there should exist field and force that disrupt symmetry [7]. To date, no force or field has been observed that violates the vacuum excitation-state's parity on a large scale. Here it needs to be emphasized that parity is a property of topological space, and it's not related to numerical value because measure is not a topological quantity, a topological space can exist without a metric.

3.2. Lorenz Gauge in Gravitowagnetic Field

The F law and M law should exhibit transport characteristics, from which the wave equations can be derived.

Take the time derivative of the second equation in (28), then substitute the second equation of (26) into the differential expression to eliminate $\boldsymbol{W}$,

$$\frac{1}{c^2}\frac{\partial^2 \boldsymbol{G}}{\partial t^2} = -\nabla \times \left(\nabla \times \boldsymbol{G}\right) - \frac{4\pi}{c^2}\frac{\partial \boldsymbol{j}_m}{\partial t} \tag{29}$$

Using the formula of vectors $\nabla \times \left(\nabla \times \boldsymbol{G}\right) = \nabla\left(\nabla \cdot \boldsymbol{G}\right) - \nabla^2 \boldsymbol{G}$, get active wave equation,

$$\nabla^2 \boldsymbol{G} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{G}}{\partial t^2} = 4\pi\left(-\nabla \rho_m + \frac{1}{c^2}\frac{\partial \boldsymbol{j}_m}{\partial t}\right) \tag{30}$$

The radiation wave equation is

$$\nabla^2 \boldsymbol{G} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{G}}{\partial t^2} = 0 \tag{31}$$

Similarly, for the $\boldsymbol{W}$

$$\nabla^2 \boldsymbol{W} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{W}}{\partial t^2} = \frac{4\pi}{c}\nabla \cdot \boldsymbol{j}_m \tag{32}$$

$$\nabla^2 \boldsymbol{W} - \frac{1}{c^2}\frac{\partial^2 \boldsymbol{W}}{\partial t^2} = 0 \tag{33}$$

Apart from the plane wave solutions, Equations (31) and (33) also have other forms of solutions. This indicates that the F law and M law are universally applicable, even though they were derived from the solutions for plane waves. Using the second formula of (13) and Equation (23), we get $\nabla \times \left(\boldsymbol{G} + \frac{1}{c}\frac{\partial \boldsymbol{A}_m}{\partial t}\right) = 0$, the brackets enclose a longitudinal field, referring to the first formula of Equation (13) and noticing the parity of $\boldsymbol{G}$ and $\boldsymbol{E}$:

$\boldsymbol{E} = -\nabla \varphi_e - \frac{1}{c}\frac{\partial \boldsymbol{A}_e}{\partial t}$, it can be represented as $\nabla \varphi_m$, and

$$\boldsymbol{G} = \nabla \varphi_m - \frac{1}{c}\frac{\partial \boldsymbol{A}_m}{\partial t} \tag{34}$$

Substituting Equation (34) into the second formula of Equation (25), we obtain the wave equation of the scalar vector,

$$\nabla^2 \varphi_m - \frac{1}{c^2}\frac{\partial^2 \varphi_m}{\partial t^2} = -4\pi \rho_m \tag{35}$$

The radiation wave equation is

$$\nabla^2 \varphi_m - \frac{1}{c^2}\frac{\partial^2 \varphi_m}{\partial t^2} = 0 \tag{36}$$

On the other hand, Equation (35) can be rewritten as

$$\frac{1}{c}\frac{\partial}{\partial t}\left[-\nabla \cdot \boldsymbol{A}_m + \frac{1}{c}\frac{\partial \varphi_m}{\partial t}\right] = 0 \tag{37}$$

The sum of the two terms in brackets of the formula is constant, let it be zero,

$$-\nabla \cdot \boldsymbol{A}_m + \frac{1}{c}\frac{\partial A_{mm}}{\partial t} = 0 \tag{38}$$

This is the Lorenz gauge for the gravitowagnetic field. Below, we prove the rationality of the Lorenz gauge. Let the left side of Equation (38) be

$$H\big|_{t=0} = \left(-\nabla \cdot \boldsymbol{A}_m + \frac{1}{c}\frac{\partial A_{mm}}{\partial t}\right)_{t=0} = 0 \tag{39}$$

If H meets this initial condition, then at any given moment $H = 0$. From the derivation of the Lorenz gauge, it is known that the initial values must satisfy the following equation

$$\left[-\frac{1}{c}\frac{\partial}{\partial t}(\nabla\cdot\boldsymbol{A}_m)+\nabla^2\varphi_m+4\pi\rho_m\right]_{t=0}=0 \tag{40}$$

Combine (39), get

$$\left(\nabla\cdot\boldsymbol{G}+4\pi\rho_m\right)_{t=0}=0 \tag{41}$$

Substitute Equation (35) into (40), get

$$\left.\frac{\partial H}{\partial t}\right|_{t=0}=0 \tag{42}$$

Take the derivation of the wave equation of φ_m with respect to t, and then take the divergence of the wave equation of $\boldsymbol{A}_m$, get

$$\nabla^2 H-\frac{1}{c^2}\frac{\partial^2 H}{\partial t^2}=\frac{4\pi}{c}\left(\nabla\cdot\boldsymbol{j}_m+\frac{\partial\rho_m}{\partial t}\right) \tag{43}$$

The two terms within the parentheses on the right side of Equation (43) precisely form the mass continuity equation, which equals zero when mass is conservation. H satisfies the homogeneous wave equation

$$\nabla^2 H-\frac{1}{c^2}\frac{\partial^2 H}{\partial t^2}=0 \tag{44}$$

Combining Equations (38) and (39), it can be derived that $H=0$ at any time. Therefore, under the condition of mass conservation, the Lorenz gauge holds true.

3.3. Lorentz Force in the Wagnetic Field

The generalized Maxwell's equations indicate that the wagnetic field and the magnetic field have similar properties. Therefore, we believe that there is an action of the wagnetic field on moving mass, analogous to the action of the magnetic field on moving charges. We collectively refer to this force as the Lorentz force $\boldsymbol{f}_g$,

$$\boldsymbol{f}_g=-m\boldsymbol{v}\times\boldsymbol{W}=-\boldsymbol{p}\times\boldsymbol{W} \tag{45}$$

where $\boldsymbol{v}$ is velocity, $\boldsymbol{p}$ is momentum, and the negative sign indicates that the force conforms the let-handed rule.

The diameter of the Sun is about 1.39 million kilometers, which is 109 times that of the Earth's diameter. The volume of the Sun is 1.3 million times that of the Earth, and its mass is 330,000 times that of the Earth. The Sun is a star located at the center of the solar system and is almost an ideal sphere. Due to the presence of flowing hot plasma, the wagnetic field generated by its rotation fluctuates unpredictably in space, resembling an alternating field. The photons emitted from the Sun may exhibit a precession similar to that electrons in an alternating magnetic field, under the action of the Lorentz force of the alternating wagnetic field. In addition, the influence of the Sun's wagnetic field on Mercury's motion cannot be ignored when calculating the position of Mercury's perihelion.

When photons approach a massive star in the universe, they are subjected to the Lorentz force of the wagnetic field of the rotating star, causing the path of light to bend. The more higher the frequency, the more the momentum, and the more curved the path.

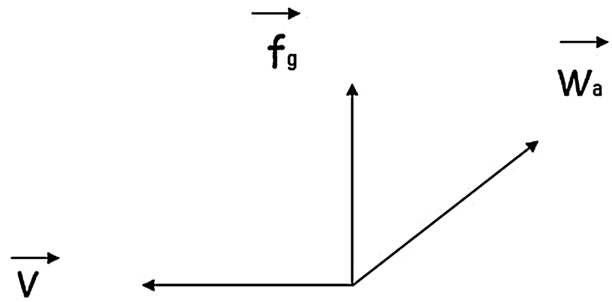

Figure 1. The Lorentz force experienced by the molecules in the upper layer of the superfluid.

Consider the phenomena observed in superfluid experiments. From equation (23), F law, it is known that the wagnetic field induced by the superfluid is aligned with the Earth's wagnetic field, and the Lorentz force $\boldsymbol{f}_g$ acting on the upper layer of the superfluid molecules is as illustrated in Figure 1, where $\boldsymbol{W}_a$ is the wagnetic field of the Earth, $\boldsymbol{v}$ is the velocity of the molecules in the upper fluid layer. In the experiment, on the cross-section perpendicular to $\boldsymbol{W}_a$, the liquid circulate in a counterclockwise direction: It is this force that drives the superfluid molecules in the upper layer to climb up the walls of the container. As shown in Figure 1, the climbing phenomenon exhibits a distinct directional nature, with no such effect observed on the opposite side of the container. If the force were due to molecular interactions with the container material, the wall climbing phenomenon would be no directionality. Similarly, at the bottom of the container, the superfluid molecules experience a downward Lorentz force from the Earth's wagnetic field because their velocity direction is opposite to that of the upper layer molecules, causing them to penetrate through the bottom and exit the container. The osmosis also occurs at the side walls parallel to $\boldsymbol{W}_a$, with no osmosis at the side walls perpendicular to $\boldsymbol{W}_a$. In summary, the phenomena of wall climbing and penetration demonstrate directionality [8].

4. Conclusion

All objects are in motion; what we perceive as stillness is merely relative. Therefore, the fact that moving charges and masses can excite fields is absolute. General Maxwell theory of fields reveals that the vacuum in an excited state maintains global parity. The properties of the gravitowagnetic field will help us gain a profound understanding of the essence of natural phenomena.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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