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Analysis of the Electromagnetic Characteristics and the Mechanism Underlying Bio-Medical Function of Longitudinal Electromagnetic (LEM) Waves

Jianzhong Jiang[1]*, Yufeng Wang[2]

[1]Department of Mechanical Engineering, Jiangnan University, Wuxi, China
[2]Wuxi Hongyu Automobile Parts Manufacturing Co., Ltd., Wuxi, China
Email: *8043000163@jiangnan.edu.cn

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Abstract

Based on theoretical system of current Maxwell's equations, the Maxwell's equations for LEM waves concealed in full current law and Faraday's law of electromagnetic induction (Faraday's law) are proposed. Then, taking them as the fundamental equations, the wave equation and energy equation of LEM waves are established, and a new electromagnetic wave propagation mode based on the mutual induction of scalar electromagnetic fields/vortex magneto-electric fields, which was overlooked in current Maxwell's equations, are put forward. Moreover, through theoretical derivation based on vacuum LEM waves, the Maxwell's equations of the gravitational field generated by vacuum LEM waves, the wave equations of the electromagnetic scalar potential/magnetic vector potential and the constraint equation governing the wave phase-velocities between LEM/TEM waves are discovered. Finally, on the basis of these theoretical research results, the electromagnetic properties of vacuum LEM waves are analyzed in detail, encompassing the speed of light, harmless penetrability to the human body, absorption and stable storage by water, the possibility of generating artificial gravitational fields, and the capability of extracting free energy. This reveals the medical functional mechanism of LEM waves and establishes a solid theoretical basis for the application of LEM waves in the fields of medicine and energy.

Keywords

QED (Quantum Electrodynamics), Longitudinal Electromagnetic Wave, Maxwell's Equations, Electromagnetic Induction, Artificial Gravitational Field, Unified Field Theory

1. Introduction

The exceptional properties of LEM waves have attracted widespread attention [1]-[8] for their huge potential and practical values in medicine and energy areas due to their harmlessly free penetration of the human body, potentially superluminal speed, absorption of free energy, and lossless energy transsssssmission. They can penetrate organisms without causing damage and directly convey the energy and information to cells. Ebbers [9] utilized LEM wave as a carrier to transmit biochemical information about clotrimazole (a fungicide) to yeast in order to inhibit its growth. He discovered that it was approximately half as effective as direct drug application. This represents an exciting research outcome demonstrating drug-free mediation via LEM wave while completely circumventing chemical side effects arising from direct organism-drug contact. Meyl [10] [11] found that LEM wave exhibits distinctive energetic properties and could increase ATP (adenosine triphosphate) content 40% in Epomoea chrysanthemum mitochondria, thereby extending the flowering period by nearly 10%. LEM wave can also stimulate the body's natural analgesic mechanism, reducing chronic pain discomfort [12]; enhancing the immune system [13], being applicable for treating AIDS, cancer, bacterial/viral diseases; and improving blood circulation [14]. Moreover, LEM wave exhibits immense potential for application in psychological disorders and stress relief [15]; Priore applied for a patent for a LEM wave treatment device capable of curing cancer, leukemia, various infectious diseases [16]. However, there are some skepticisms [17] regarding their existence and effectiveness due to the lack of rigorous theoretical models for LEM waves. Therefore, establishing robust energy mode and wave equation for LEM waves are essential for advancing their practical applications. However, current Maxwell's equations neglect the LEM wave item, rendering them incompatible with such waves. It is imperative to reintroduce the longitudinal wave item into Maxwell's equations and develop a rigorous mathematical model for LEM waves, integrating it into the theoretical framework of Maxwell's equations [18]-[20]. Meanwhile, exploring the electromagnetic essence of LEM wave is helpful to unveil the underlying mechanisms of their applications in medicine and energy areas.

2. D'Alembert's Equation of the Electromagnetic Scalar Potential and the Magnetic Vector Potential in a Conductor

2.1. The d'Alembert's Equation of the Scalar Potential

When an electromagnetic wave propagate in a conductive medium, the scalar potential φ of the electromagnetic field is related to the distribution density ρ of free charges in the medium, and the magnetic vector potential $\boldsymbol{A}$ has relation to the induced electric field. The definition formulas of φ and $\boldsymbol{A}$ are as follow $-\nabla\varphi - \partial\boldsymbol{A}/\partial t = \boldsymbol{E}$ and $\nabla\times\boldsymbol{A} = \boldsymbol{B}$. From Gauss's law and Lorentz gauge [21], it can be obtained that

$$\nabla^2\varphi - \mu\varepsilon\frac{\partial^2\varphi}{\partial t^2} = -\rho/\varepsilon \tag{1}$$

which is called as d'Alembert's equation of the scalar potential in the electromagnetic field [21].

2.2. Solution of d'Alembert's Equation of the Scalar Potential

As shown in the Figure 1, there is a single and static charge $q(\boldsymbol{r}',t)$ or some continuous, static and time-varying charges $\rho(\boldsymbol{r}',t)$ in the source region V' having a coordinate system $P'(R',\theta',z')$ in the conductive medium. The field point region is V having a coordinate system $P(R,\theta,z)$. O is the origin point of the coordinate system. The source point P' is in a stationary state.

In Figure 1, $\boldsymbol{r}$ and $\boldsymbol{r}'$ are the vectors from the origin point O to P and P'; $\boldsymbol{R}$ is the vector from P' to P, which is equal to $\boldsymbol{r}-\boldsymbol{r}'$; R is the magnitude of the vector $\boldsymbol{R}$; $\boldsymbol{e}_R$ is the unit vector of $\boldsymbol{R}$, which is equal to $\boldsymbol{R}/R$.

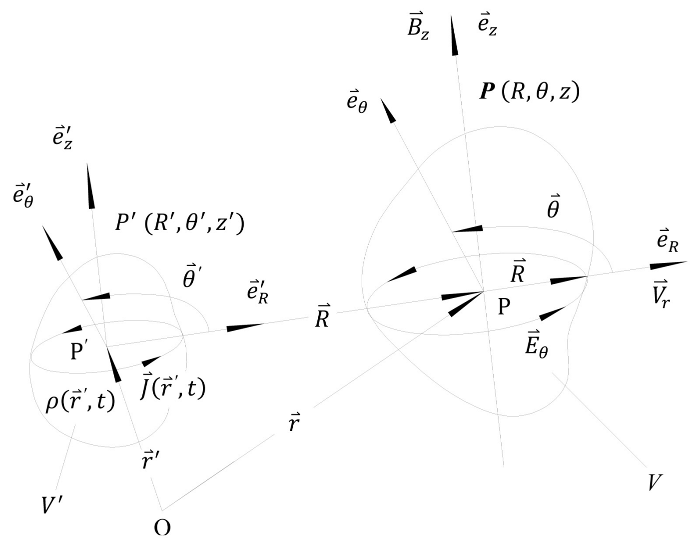

Figure 1. Distribution diagram of source points and field points in the medium.

The solution of d'Alembert's equation for φ generated by a single time-varying charge $q(\boldsymbol{r}',t)$ is $\frac{q\left(\boldsymbol{r}',t-\frac{R}{C}\right)}{4\pi\varepsilon R}$. By using the superposition principle [21], the scalar potential φ caused by $\rho(\boldsymbol{r}',t)$ can be expressed as

$$\varphi(\boldsymbol{R},t)=\frac{1}{4\pi\varepsilon}\int_{V'}\frac{\rho\left(\boldsymbol{r}',t-\frac{R}{C}\right)}{R}\mathrm{d}V', \tag{2}$$

in which $t-R/C$ is the delay potential item [21]. Equation (2) is the general solution of Equation (1).

2.3. The Expression of the Magnetic Vector Potential Generated by the Time-Varying and Waving Current Source

In Figure 1 the continuous and time-varying charges $\rho(\boldsymbol{r}',t)$ in V' are stationary and a time-varying and waving current source $\boldsymbol{J}(\boldsymbol{r}',t)$ is excited by external electromagnetic field. At the same time assuming that the LEM wave travels along the positive *z*-axis in the field point region V with a wave velocity V_{ez} and a frequency ω_P gives that $\partial \boldsymbol{r}'/\partial t = 0$, $\partial \rho(\boldsymbol{r}',t)/\partial t \neq 0$ and $\partial R/\partial t = (\partial R/\partial z)\cdot(\partial z/\partial t) = V_{ez}$. From Lorentz gauge and the law of charge conservation [21], it is obtained that

$$\begin{aligned}
\nabla\cdot\boldsymbol{A} &= -\mu\varepsilon\frac{\partial\varphi}{\partial t} = -\mu\varepsilon\frac{1}{4\pi\varepsilon}\int_{V'}\left[\frac{1}{R}\frac{\partial\rho\left(\boldsymbol{r}',t-\frac{R}{C}\right)}{\partial t}-\frac{1}{R^2}\frac{\partial R}{\partial t}\rho\right]\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}\left[\frac{1}{R}\nabla'\cdot\boldsymbol{J}\left(\boldsymbol{r}',t-\frac{R}{C}\right)-\frac{1}{R^2}V_{ez}\rho\right]\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}\left[\nabla'\cdot\left(\frac{1}{R}\boldsymbol{J}\right)-\nabla'\left(\frac{1}{R}\right)\cdot\boldsymbol{J}-\frac{1}{R^2}J_z\right]\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}\left[\nabla\left(\frac{1}{R}\right)-\frac{1}{R^2}J_z\right]\mathrm{d}V' = \frac{\mu}{4\pi}\int_{V'}\left(-\frac{1}{R^2}\boldsymbol{e}_R\cdot\boldsymbol{J}-\frac{1}{R^2}J_z\right)\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}\left(-\frac{1}{R^2}J_t-\frac{1}{R^2}J_z\right)\mathrm{d}V' \approx \frac{\mu}{4\pi}\int_{V'}-\frac{1}{R^2}J_t\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}-\frac{1}{R^2}\boldsymbol{e}_R\cdot\boldsymbol{J}\mathrm{d}V'
\end{aligned}$$

When $\left|\frac{1}{R^2}\boldsymbol{e}_R\cdot\boldsymbol{J}\right|\Big/\left|\frac{1}{R}\nabla\cdot\boldsymbol{J}\right| = \frac{|V_{ez}J_t|}{|R\omega_P J_z|} \gg \frac{|V_{ez}|}{|R\omega_P|} \gg 1$ and $R \ll 3\times10^8\ \mathrm{m}$ *i.e.*, if it is ensured that $R \ll \frac{V_{ez}}{\omega_P} \approx \frac{C}{\omega_P} \ll C$, it can be considered that $\frac{R}{C} \ll 1\,\mathrm{s} \approx 0\,\mathrm{s}$, $t-\frac{R}{C}\approx t$ and

$$\begin{aligned}
&\frac{\mu}{4\pi}\int_{V'}\nabla\cdot\left[\frac{1}{R}\boldsymbol{J}\left(\boldsymbol{r}',t-\frac{R}{C}\right)\right]\mathrm{d}V' \approx \frac{\mu}{4\pi}\int_{V'}\nabla\cdot\left[\frac{1}{R}\boldsymbol{J}(\boldsymbol{r}',t)\right]\mathrm{d}V' \\
&= \frac{\mu}{4\pi}\int_{V'}-\frac{1}{R^2}\boldsymbol{e}_R\cdot\boldsymbol{J}\mathrm{d}V' + \frac{\mu}{4\pi}\int_{V'}\frac{1}{R}\nabla\cdot\boldsymbol{J}(\boldsymbol{r}',t)\mathrm{d}V' \approx \frac{\mu}{4\pi}\int_{V'}-\frac{1}{R^2}\boldsymbol{e}_R\cdot\boldsymbol{J}\mathrm{d}V'
\end{aligned}$$

, which gives that

$$\boldsymbol{A}(\boldsymbol{R},t) = \frac{\mu}{4\pi}\int_{V'}\frac{1}{R}\boldsymbol{J}(\boldsymbol{r}',t)\mathrm{d}V', \tag{3}$$

$$\varphi(\boldsymbol{R},t) = \frac{1}{4\pi\varepsilon}\int_{V'}\frac{\rho(\boldsymbol{r}',t)}{R}\mathrm{d}V'. \tag{4}$$

It is obvious that Equation (3) is not derived from Biot-Savart's law [22], and can be applied to the time-varying and waving current source $\boldsymbol{J}(\boldsymbol{r}',t)$. Applying the second mean value theorem of integration [23] to Equation (3) and Equation (4) gives

$$\boldsymbol{A}(\boldsymbol{R},t) = \frac{\mu}{4\pi}\bar{\boldsymbol{J}}(\boldsymbol{r}',t)F(R), \tag{5}$$

$$\varphi(\boldsymbol{R},t) = \frac{1}{4\pi\varepsilon}\bar{\rho}(\boldsymbol{r}',t)F(R), \tag{6}$$

where $\bar{J}$ and $\bar{\rho}$ are the space average values of $\boldsymbol{J}$ and ρ in V' while $F(R)$ is defined as $F(R)=\int_{V'}\frac{1}{R}\mathrm{d}V'$.

Taking the limits of both sides of Equation (5) and Equation (6) gives

$$\lim_{V'\to 0}\varphi(\boldsymbol{R},t)=\varphi(\boldsymbol{R},t)=\lim_{V'\to 0}\frac{1}{4\pi\varepsilon}\bar{\rho}(\boldsymbol{r}',t)F(R)=\frac{1}{4\pi\varepsilon}\rho(\boldsymbol{r}',t)\lim_{V'\to 0}F(R), \tag{7}$$

$$\lim_{V'\to 0}\boldsymbol{A}(\boldsymbol{R},t)=\boldsymbol{A}(\boldsymbol{R},t)=\lim_{V'\to 0}\frac{\mu}{4\pi}\bar{\boldsymbol{J}}(\boldsymbol{r}',t)F(R)=\frac{\mu}{4\pi}\boldsymbol{J}(\boldsymbol{r}',t)\lim_{V'\to 0}F(R). \tag{8}$$

Since $\lim_{V'\to 0}F(R)$ is independent of the ∇ operator and time t, and the source charges $\rho(\boldsymbol{r}',t)$ are continuously distributed and stationary, it follows that $\nabla^2\varphi=\frac{1}{4\pi\varepsilon}\nabla^2\rho\lim_{V'\to 0}F(R)$, $\frac{\partial^2\varphi}{\partial t^2}=\frac{1}{4\pi\varepsilon}\frac{\partial^2\rho}{\partial t^2}\lim_{V'\to 0}F(R)$. Substituting the above two equations into Equation (1), it is obtained that $\nabla^2\rho-\mu\varepsilon\frac{\partial^2\rho}{\partial t^2}=-\frac{\rho}{\varepsilon}4\pi\varepsilon\frac{1}{\lim_{V'\to 0}F(R)}$. While the ρ in it is canceled, a new operator $\square$ is defined as

$$\square=\nabla^2-\mu\varepsilon\frac{\partial^2}{\partial t^2}=-4\pi\frac{1}{\lim_{V'\to 0}F(R)}. \tag{9}$$

And then applying the new operator $\square$ to both sides of Equation (8) yields

$$\nabla^2\boldsymbol{A}-\mu\varepsilon\frac{\partial^2\boldsymbol{A}}{\partial t^2}=-\mu\boldsymbol{J}(\boldsymbol{r}',t). \tag{10}$$

Equation (2) and Equation (12) are well known as d' Alembert's equations of the electromagnetic field [21] in the conductive medium.

3. The Wave Equations of the Electromagnetic Scalar Potential and the Magnetic Vector Potential in a Vacuum

In a metal conductor, the electric field intensity $\boldsymbol{E}$ can be represented by $\boldsymbol{A}$ and φ as

$$\begin{aligned}\boldsymbol{E}&=-\nabla\varphi-\partial\boldsymbol{A}/\partial t=-\boldsymbol{V}_B\times(\nabla\times\boldsymbol{A})=-\mathrm{j}\boldsymbol{k}\varphi+\mathrm{j}\boldsymbol{A}\omega\\&=-\mathrm{j}\boldsymbol{k}(\boldsymbol{V}_B\cdot\boldsymbol{A})+\mathrm{j}\boldsymbol{A}(\boldsymbol{k}\cdot\boldsymbol{V}_B)=-\mathrm{j}\boldsymbol{k}(\boldsymbol{V}_B\cdot\boldsymbol{A})+\mathrm{j}\boldsymbol{A}\omega,\end{aligned}$$

which leads to

$$\varphi=\boldsymbol{V}_B\cdot\boldsymbol{A}=V_BA_z. \tag{11}$$

According to the Lorentz gauge, we have $\nabla\cdot\boldsymbol{A}=-\mu\varepsilon\,\partial\varphi/\partial t=\mu\varepsilon\,\mathrm{j}\omega_PV_BA_z=\frac{\mathrm{j}\omega_PA_z}{V_{ez}}$, which leads to

$$1/\mu\varepsilon=V_{ez}V_B. \tag{12}$$

Equation (12) represents the constraint equation governing the phase speeds of LEM and TEM waves. Here, V_{ez} denotes the phase velocity of the LEM wave while V_B signifies the phase velocity of TEM wave. According to Equation (3) and Equation (4), we can obtain in a conductive medium that

$$\begin{aligned}\boldsymbol{V}_B\cdot\boldsymbol{A}&=\boldsymbol{V}_B\cdot\boldsymbol{A}_z=\left(V_B/\mathrm{j}k\right)\mathrm{j}\boldsymbol{k}\cdot\boldsymbol{A}_z=\left(V_B/\mathrm{j}k\right)\nabla\cdot\boldsymbol{A}_z\\&=\left(V_B/\mathrm{j}k\right)\frac{\mu}{4\pi}\int_{V'}\nabla\cdot\left(\frac{1}{R}\boldsymbol{J}_z\right)\mathrm{d}V'=\left(V_B/\mathrm{j}k\right)\frac{\mu}{4\pi}\int_{V'}\frac{1}{R}\mathrm{j}kJ_z\mathrm{d}V'\\&=V_B\frac{\mu}{4\pi}\int_{V'}\frac{1}{R}J_z\mathrm{d}V'=V_{ez}V_B\frac{\mu}{4\pi}\int_{V'}\frac{1}{R}\rho\mathrm{d}V'=\frac{1}{4\pi\varepsilon}\int_{V'}\frac{1}{R}\rho\mathrm{d}V'=\varphi.\end{aligned}$$

Hence, in a vacuum, we are able to obtain

$\nabla\varphi=\nabla\left(CA_z\right)=C\frac{\mu}{4\pi}\int_{V'}\nabla\left(J_z/R\right)\mathrm{d}V'=\nabla\varphi_t+\nabla\varphi_\theta+\nabla\varphi_z$, where

$$\nabla\varphi_R=\nabla\varphi_t=\frac{\mu}{4\pi}\int_{V'}-R^{-2}CJ_z\boldsymbol{e}_R\mathrm{d}V', \tag{13}$$

$$\nabla\varphi_\theta=0, \tag{14}$$

and

$$\nabla\varphi_z=\mathrm{j}\omega_P\boldsymbol{A}_z. \tag{15}$$

When $R\ll3\times10^8\,\mathrm{m}$, *i.e.*, $R/C\ll1\,\mathrm{s}\approx0\,\mathrm{s}$, from Equation (1) and Equation (10), it is given that the wave equations of φ and $\boldsymbol{A}$ in a vacuum are shown as

$$\nabla^2\varphi-\mu_0\varepsilon_0\frac{\partial^2\varphi}{\partial t^2}=0, \tag{16}$$

$$\nabla^2\boldsymbol{A}-\mu_0\varepsilon_0\frac{\partial^2\boldsymbol{A}}{\partial t^2}=0, \tag{17}$$

which have the general solutions shown as $\varphi=CA_z=CA_{z0}\exp\left[\mathrm{j}\left(\frac{\omega}{C}z-\omega t\right)\right]$ and $\boldsymbol{A}=\boldsymbol{A}_0\exp\left[\mathrm{j}\left(\frac{\omega}{C}z-\omega t\right)\right]$.

4. The Wave Equations of LEM Waves in a Vacuum

In a vacuum, we have that $\boldsymbol{E}_z=-\nabla\varphi_z-\partial\boldsymbol{A}_z/\partial t=-\mathrm{j}\omega_P\boldsymbol{A}_z+\mathrm{j}\omega_P\boldsymbol{A}_z=0=\frac{1}{\sigma_0}\boldsymbol{J}_z$, which gives that $\boldsymbol{J}_z=0$, $\boldsymbol{A}_z=0$ and $\boldsymbol{B}_\theta=\nabla\times\boldsymbol{A}_z=0$. Hence, if LEM waves exist here, they can merely be $\boldsymbol{E}_\theta$ and $\boldsymbol{B}_z$ shown as

$\boldsymbol{E}_\theta=-\nabla\varphi_\theta-\partial\boldsymbol{A}_\theta/\partial t=-\partial\boldsymbol{A}_\theta/\partial t\neq0$ and

$\boldsymbol{B}_z=\nabla\times\boldsymbol{A}_\theta=\frac{\mu_0}{4\pi}\int_{V'}\nabla\times\left(\boldsymbol{J}_\theta/R\right)\mathrm{d}V'\neq0$, where as $R\to0$, there are $\boldsymbol{J}_\theta\to0$ and $\boldsymbol{A}_\theta=\frac{\mu_0}{4\pi}\int_{V'}\lim_{R\to0}\left(\boldsymbol{J}_\theta/R\right)\mathrm{d}V'\neq0$. When $R\ll C/\omega_P\ll3\times10^8\,\mathrm{m}$ and the source point region V' approaches one point, and the origin O of the coordinate system coincides with the source point P', that is, $\boldsymbol{R}=\boldsymbol{r}$. Additionally, in the field point space V, a stationary field point system $P\left(r,\theta,z\right)$ is established as depicted in Figure 1. Supposing that the vacuum LEM waves travel along the positive *z*-axis of the coordinate system *P* at the speed of light *C*, it follows that

$$\boldsymbol{B}_z=\nabla\times\boldsymbol{A}_\theta=\frac{\mu_0}{4\pi}\int_{V'}-r^{-2}\left(\boldsymbol{e}_r\times\boldsymbol{J}_\theta\right)\mathrm{d}V' \tag{18}$$

and

$$\begin{aligned}\boldsymbol{E}_\theta &= -\nabla\varphi_\theta - \frac{\partial \boldsymbol{A}_\theta}{\partial t} = -\frac{\partial \boldsymbol{A}_\theta}{\partial t} = \frac{\mu_0}{4\pi}\int_{V'} -r^{-2}\frac{\partial r}{\partial t}\boldsymbol{J}_\theta \mathrm{d}V' \\ &= \frac{\mu_0}{4\pi}\int_{V'} -r^{-2}\left(\frac{\partial r}{\partial z}\frac{\partial z}{\partial t}\right)\boldsymbol{J}_\theta \mathrm{d}V' = C\frac{\mu_0}{4\pi}\int_{V'} -r^{-2}\boldsymbol{J}_\theta \mathrm{d}V',\end{aligned} \tag{19}$$

which gives that $\frac{1}{\mu_0\varepsilon_0}\boldsymbol{B}_z = C\boldsymbol{e}_r \times \boldsymbol{E}_\theta$ and $\boldsymbol{E}_\theta = -C\boldsymbol{e}_r \times \boldsymbol{B}_z$.

Similarly, by using Equation (18) and Equation (19), it can be proved that

$$\nabla \times \boldsymbol{E}_\theta = -\frac{\partial \boldsymbol{B}_z}{\partial t}, \tag{20}$$

$$\frac{1}{\mu_0\varepsilon_0}\nabla \times \vec{B}_z = \frac{\partial \boldsymbol{E}_\theta}{\partial t} = C^2\frac{\mu_0}{4\pi}\int_{V'} r^{-3}\boldsymbol{J}_\theta \mathrm{d}V'. \tag{21}$$

From Equation (20) and Equation (21), we can gain that

$$\boldsymbol{E}_\theta = E_{\theta 0}\exp\left[\mathrm{j}\left(\frac{\omega_P}{C}z - \omega_P t\right)\right]\boldsymbol{e}_\theta. \tag{22}$$

According to literature [18], the frequency of the vacuum LEM waves can be expressed as

$$\omega_P = \mathrm{j}\frac{1}{\tau_2} = \mathrm{j}\frac{\omega^2\varepsilon_0}{\sigma_0}, \tag{23}$$

where τ_2 is the vortex attenuation period of the vacuum vortex electric field $\boldsymbol{E}_\theta$, ω is the frequency of the source light waves generating the LEM waves, σ_0 and ε_0 are the vacuum conductivity and vacuum dielectric constant. Substituting Equation (23) into Equation (20), Equation (21), Gauss's theorem and Gauss's magnetic theorem [21], we can obtain

$$\nabla \times \boldsymbol{E}_\theta = -\frac{\partial \boldsymbol{B}_z}{\partial t} = \mathrm{j}\omega_P \boldsymbol{B}_z = -\boldsymbol{B}_z/\tau_2, \tag{24}$$

$$\frac{1}{\mu_0\varepsilon_0}\nabla \times \boldsymbol{B}_z = \frac{\partial \boldsymbol{E}_\theta}{\partial t} = -\mathrm{j}\omega_P \boldsymbol{E}_\theta = \boldsymbol{E}_\theta/\tau_2, \tag{25}$$

$$\nabla \cdot \boldsymbol{E}_\theta = \mathrm{j}\omega_P E_\theta \boldsymbol{e}_z \cdot \boldsymbol{e}_\theta / C = \rho/\varepsilon_0 = 0, \tag{26}$$

$$\nabla \cdot \boldsymbol{B}_z = \mathrm{j}\boldsymbol{k} \cdot \boldsymbol{B}_z = \mathrm{j}\omega_P B_z / C = \varepsilon_0\omega^2 B_z / C\sigma_0 \neq 0. \tag{27}$$

Equations (24)-(27) represent the Maxwell's equations of vacuum LEM waves, which have the solutions shown as

$$\begin{aligned}\boldsymbol{B}_z &= B_{z0}\exp\left[\mathrm{j}\left(\frac{\omega_P}{C}z - \omega_P t\right)\right]\boldsymbol{e}_z = \frac{E_{\theta 0}}{C}\exp\left[\mathrm{j}\left(\frac{\omega_P}{C}z - \omega_P t\right)\right]\boldsymbol{e}_z, \\ \boldsymbol{E}_\theta &= E_{\theta 0}\exp\left[\mathrm{j}\left(\frac{\omega_P}{C}z - \omega_P t\right)\right]\boldsymbol{e}_\theta.\end{aligned} \tag{28}$$

The propagation model for $\boldsymbol{E}_\theta$ and $\boldsymbol{B}_z$ is depicted in **Figure 2**, illustrating that $\boldsymbol{E}_\theta$ and $\boldsymbol{B}_z$ have the same phase angle and propagate along the positive z-axis at a phase velocity C. Equation (28) and Equation (22) disclose the electromagnetic induction law that scalar magnetic field $\boldsymbol{B}_z$ and vortex electric field $\boldsymbol{E}_\theta$ can mutually transform in a vacuum, which unveils more essential law of electromagnetic induction. What's more, the vortex-motion of E_θ has the capability to extract zero-point vacuum energy through the entangled interaction between the torsion field produced by it in the center of $\boldsymbol{E}_\theta$ and zero-point vacuum energy field [24].

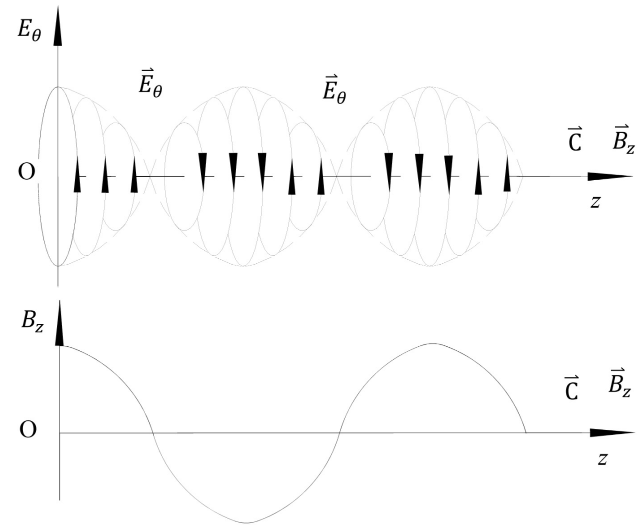

Figure 2. The propagation mode of ELM waves in a vacuum.

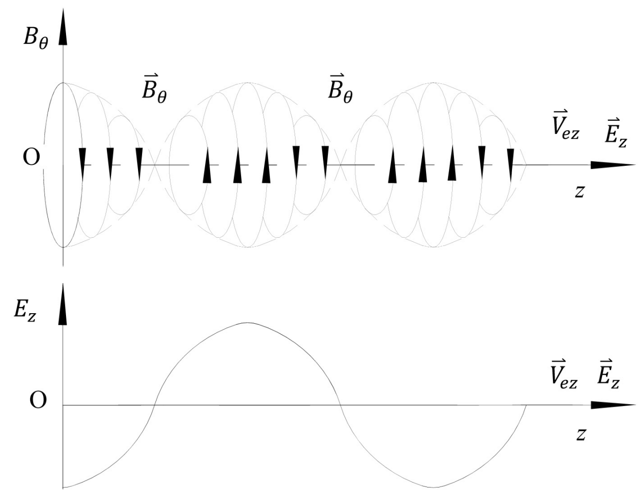

Figure 3. The propagation model of ELM waves in a conductor.

By employing the same approach, the Maxwell's equations for LEM waves in a conductor can be derived as $\nabla \times \boldsymbol{E}_z = -\boldsymbol{B}_\theta / \tau_1$ and $\nabla \times \boldsymbol{B}_\theta / \mu\varepsilon = \boldsymbol{E}_z / \tau_1$ which implies that in the conductor medium, scalar electric field and vortex magnetic field can convert into each other (see **Figure 3**). Herein, $\omega_P = \mathrm{j}\dfrac{1}{\tau_1} = \mathrm{j}\dfrac{\sigma}{\varepsilon}$ being the frequency of the LEM waves, τ_1 is the vortex attenuation period of the vortex magnetic field $\boldsymbol{B}_\theta$ in the conductor, σ and ε are the conductivity and dielectric constant of the conductor. Thus, the Maxwell's equations for LEM waves compensate for the incompleteness of the electromagnetic transformation laws depicted by current Maxwell's equations and broaden their application scope.

5. The Energy Density Equation of Vacuum LEM Waves

In general, LEM waves is usually allowed to be neglected due to their significantly smaller amplitudes compared with that of TEM waves. But in certain scenarios such as the near fields [25], current Maxwell's equations fail to elucidate the mechanism of them. Hence, consideration must be given to LEM waves. The generation of substantial LEM waves typically occurs when two coherent light waves with identical frequency, amplitude, and propagation direction, but a phase difference of π (referred to as source waves), are superimposed within a vacuum medium, they will generate a magnetic P-wave B_z [2]. The electric field components of the source waves are represented by $\boldsymbol{E}_1$ and $\boldsymbol{E}_2$, while their corresponding magnetic field components are denoted as $\boldsymbol{B}_1$ and $\boldsymbol{B}_2$. Upon superposition of them, the resultant electric fields are represented by $\boldsymbol{E}_t$ and $\boldsymbol{B}_t$, where

$$\begin{aligned}\boldsymbol{E}_t &= \boldsymbol{E}_1 + \boldsymbol{E}_2 = \boldsymbol{E}_0 \exp\left[\mathrm{j}\left(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t\right)\right] + \boldsymbol{E}_0 \exp\left[\mathrm{j}\left(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t + \pi\right)\right] \\ &= \boldsymbol{E}_0 \exp\left[\mathrm{j}\left(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t\right)\right]\left[1 + \exp\left(\mathrm{j}\pi\right)\right] = 0,\end{aligned} \tag{28.1}$$

$$\boldsymbol{B}_t = \boldsymbol{B}_1 + \boldsymbol{B}_2 = \boldsymbol{B}_0 \exp\left[\mathrm{j}\left(\boldsymbol{k}\cdot\boldsymbol{r} - \omega t\right)\right]\left[1 + \exp\left(\mathrm{j}\pi\right)\right] = 0. \tag{28.2}$$

When two source waves are superimposed, the total electromagnetic fields seemly both vanish. However, in accordance with the principle of energy conservation, all energy of source waves is actually transferred to B_z and E_θ. This energy transfer can be explained by definitions of magnetic vector potential $\boldsymbol{A}$ and scalar potential φ shown as

$\boldsymbol{B}_t = \boldsymbol{B}_1 + \boldsymbol{B}_2 = \nabla\times\left(\boldsymbol{A}_{R1} + \boldsymbol{A}_{R2}\right) = 0$, *i.e.*, $\boldsymbol{A}_R = \boldsymbol{A}_{R1} + \boldsymbol{A}_{R2} = 0$,
$\boldsymbol{E}_t = \boldsymbol{E}_1 + \boldsymbol{E}_2 = -\nabla\varphi_R - \frac{\partial \boldsymbol{A}_R}{\partial t} = 0$ and $\nabla\varphi_R = -\frac{\partial \boldsymbol{A}_R}{\partial t} = 0$, that is, in a vacuum, $\nabla\varphi = 0$, $\boldsymbol{A}_\theta \neq 0$, $\boldsymbol{E}_\theta = -\frac{\partial \boldsymbol{A}_\theta}{\partial t} \neq 0$ and $\boldsymbol{B}_z = \nabla\times\boldsymbol{A}_\theta \neq 0$.

A certain region $\mathrm{d}\Omega$ in a conductive medium where source light waves $\boldsymbol{E}$ and $\boldsymbol{B}$ propagate has a free charge density ρ with a charge number q. At any given moment, the Lorentz force acting on charge q in region $\mathrm{d}\Omega$ can be expressed as $\boldsymbol{F} = q\left(\boldsymbol{E} + \boldsymbol{V}\times\boldsymbol{E}\right)$, where $\boldsymbol{V}$ represents the motion speed of free charge. Consequently, after $\mathrm{d}t$ time, the work done by $\boldsymbol{F}$ on q in $\mathrm{d}\Omega$ is $\mathrm{d}w = q\left(\boldsymbol{E} + \boldsymbol{V}\times\boldsymbol{E}\right)\cdot\boldsymbol{V}\mathrm{d}t = \rho\mathrm{d}\Omega\left(\boldsymbol{E} + \boldsymbol{V}\times\boldsymbol{E}\right)\cdot\boldsymbol{V}\mathrm{d}t = \mathrm{d}\Omega\boldsymbol{E}\cdot\left(\rho\boldsymbol{V}\right)\mathrm{d}t = \mathrm{d}\Omega\boldsymbol{E}\cdot\boldsymbol{J}\mathrm{d}t$. By applying superposition principle, work done by Lorentz force $\boldsymbol{F}$ on all free charges in entire region Ω per unit time can be expressed as

$$\mathrm{d}W/\mathrm{d}t = \int_\Omega \boldsymbol{E}\cdot\boldsymbol{J}\mathrm{d}\Omega, \tag{29}$$

where $\boldsymbol{J}$ denotes electric current density within $\mathrm{d}\Omega$. According to total current law, we can obtain

$$\boldsymbol{E}\cdot\boldsymbol{J} = \boldsymbol{E}\cdot\frac{1}{\mu}\left(\nabla\times\boldsymbol{B}\right) - \frac{\varepsilon}{2}\frac{\partial\left(\boldsymbol{E}^2\right)}{\partial t} = \frac{1}{\mu}\boldsymbol{B}\cdot\left(\nabla\times\boldsymbol{E}\right) - \frac{1}{\mu}\nabla\cdot\left(\boldsymbol{E}\times\boldsymbol{B}\right) - \frac{\varepsilon}{2}\frac{\partial\left(E^2\right)}{\partial t}. \tag{30}$$

If Faraday's law is substituted into Equation (30), it is obtained that

$$\begin{aligned}\boldsymbol{E}\cdot\boldsymbol{J} &= -\frac{1}{\mu}\boldsymbol{B}\cdot\left[\partial\boldsymbol{B}_t/\partial t+\partial\boldsymbol{B}_\theta/\partial t\right]-\frac{1}{\mu}\nabla\cdot\left(\boldsymbol{E}\times\boldsymbol{B}\right)-\varepsilon\boldsymbol{E}\cdot\partial\boldsymbol{E}/\partial t \\ &= -\frac{1}{\mu}\boldsymbol{B}_t\cdot\partial\boldsymbol{B}_t/\partial t-\frac{1}{\mu}\boldsymbol{B}_\theta\cdot\partial\boldsymbol{B}_\theta/\partial t-\frac{1}{\mu}\nabla\cdot\left(\boldsymbol{E}\times\boldsymbol{B}\right)-\frac{\varepsilon}{2}\frac{\partial E_t^2}{\partial t}-\frac{\varepsilon}{2}\frac{\partial E_z^2}{\partial t}\end{aligned} \tag{31}$$

Substituting Equation (31) back to Equation (29) gives

$$\begin{aligned}E_T &= \int_\Omega -\frac{1}{2\mu}\frac{\partial\left(B_t^2\right)}{\partial t}-\frac{\varepsilon}{2}\frac{\partial\left(E_t^2\right)}{\partial t}\mathrm{d}\Omega \\ &= \mathrm{d}W/\mathrm{d}t+\int_\Omega -\frac{1}{2\mu}\frac{\partial\left(B_\theta^2\right)}{\partial t}-\frac{\varepsilon}{2}\frac{\partial\left(E_z^2\right)}{\partial t}\mathrm{d}\Omega+\int_\Omega\frac{1}{\mu}\nabla\cdot\left(\boldsymbol{E}\times\boldsymbol{B}\right)\mathrm{d}\Omega \\ &= \mathrm{d}W/\mathrm{d}t+E_P+\int_\Omega\frac{1}{\mu}\nabla\cdot\left(\boldsymbol{E}\times\boldsymbol{B}\right)\mathrm{d}\Omega \\ &= \mathrm{d}W/\mathrm{d}t+E_P+\oiint_S\frac{1}{\mu}\left(\boldsymbol{E}\times\boldsymbol{B}\right)\cdot\mathrm{d}\boldsymbol{s}\end{aligned} \tag{32}$$

In Equation (32), the first term on the right-hand side represents the power done by the electromagnetic force on free charges, *i.e.*, energy density converted into joule heat; the second term signifies the energy density E_P transformed into LEM waves; and final term accounts for pure incoming and outgoing energy density at Ω's boundary surface. Equation (32) presents a modified Poynting theorem incorporating consideration of LEM wave terms. After superimposing two source light waves in a vacuum, as per Equation (28.1), Equation (28.2) and Equation (28), B_z gains non-zero value while $\boldsymbol{E}_t$ and $\boldsymbol{B}_t$ equal 0, *i.e.*,

$$\oiint_S\frac{1}{\mu}\left(\boldsymbol{E}\times\boldsymbol{B}\right)\cdot\mathrm{d}\boldsymbol{s}=\oiint_S\frac{1}{\mu}\left(\boldsymbol{E}_\theta\times\boldsymbol{B}_z\right)\cdot\mathrm{d}\boldsymbol{s}=0\,.$$

Moreover, for a vacuum medium without electric charge, $\mathrm{d}W/\mathrm{d}t=0$. And then E_T is equal to E_P, that is, the energy density of vacuum LEM waves can be represented as

$$\begin{aligned}E_P &= \int_\Omega -\frac{1}{2\mu_0}\frac{\partial B_z^2}{\partial t}-\frac{\varepsilon_0}{2}\frac{\partial E_\theta^2}{\partial t}\mathrm{d}\Omega=\int_\Omega -\frac{1}{\mu_0}\frac{\partial\left(B_z^2\right)}{\partial t}\mathrm{d}\Omega=\int_\Omega \mathrm{j}2\omega B_z^2\frac{1}{\mu}\mathrm{d}\Omega \\ &= E_T=\int_\Omega -\frac{1}{\mu}\frac{\partial\left(B_1^2\right)}{\partial t}-\frac{1}{\mu}\frac{\partial\left(B_2^2\right)}{\partial t}\mathrm{d}\Omega=\int_\Omega 2\mathrm{j}\omega\frac{1}{\mu}\left(B_1^2+B_2^2\right)\mathrm{d}\Omega,\end{aligned}$$

which gives that

$$\left|B_z\right|=B_{z0}=\sqrt{B_1^2+B_2^2}=\sqrt{1+1\exp^2\left(\mathrm{j}\pi\right)}B_0=\sqrt{2}B_0. \tag{33}$$

Under this circumstance, magnetic P-wave $\left|B_z\right|\neq 0$, which cannot be disregarded; that is, $E_P\neq 0$ in Equation (32). Otherwise, it would lead to a violation of energy conservation in Equation (32). It is deduced from Equations (28.1) and (32) that the total energy density associated with two source light waves can be represented as

$$\begin{aligned}E_T &= \int_\Omega -\varepsilon_0\frac{\partial\left(E_1^2\right)}{\partial t}-\varepsilon_0\frac{\partial\left(E_2^2\right)}{\partial t}\mathrm{d}\Omega=\int_\Omega 2\mathrm{j}\omega\varepsilon_0\left(E_1^2+E_2^2\right)\mathrm{d}\Omega \\ &= \int_\Omega 2\mathrm{j}\omega\varepsilon_0E_0^2\left\{\exp^2\left[j\left(\boldsymbol{k}\cdot\boldsymbol{r}-\omega t\right)\right]+\exp^2\left[j\left(\boldsymbol{k}\cdot\boldsymbol{r}-\omega t+\pi\right)\right]\right\}\mathrm{d}\Omega \\ &= \int_\Omega 4\omega\varepsilon_0E_0^2\sin 2\left(\frac{\omega}{C}z-\omega t\right)\mathrm{d}\Omega=4\Omega\omega\varepsilon_0E_0^2=4\Omega\omega\frac{1}{\mu_0}B_0^2.\end{aligned} \tag{34}$$

From Equation (22) and Equation (32), after the superposition the total energy density of E_P can be expressed as

$$\begin{aligned} E_P &= \int_\Omega -\frac{1}{2\mu_0}\frac{\partial B_z^2}{\partial t} - \frac{\varepsilon_0}{2}\frac{\partial E_\theta^2}{\partial t}\mathrm{d}\Omega = \int_\Omega -\frac{1}{\mu_0}\frac{\partial B_z^2}{\partial t}\mathrm{d}\Omega = \int_\Omega -\varepsilon_0\frac{\partial E_\theta^2}{\partial t}\mathrm{d}\Omega \\ &= \int_\Omega \mathrm{j}2\omega_P\varepsilon_0 E_\theta^2 \mathrm{d}\Omega = \mathrm{j}2\omega_P\varepsilon_0 E_{\theta 0}^2 \int_\Omega \exp^2\left[\mathrm{j}\left(\frac{\omega_P}{C}z - \omega_P t\right)\right]\mathrm{d}\Omega \\ &= 2\Omega\omega_P\varepsilon_0 E_{\theta 0}^2 = 2\Omega\omega_P\frac{1}{\mu_0}B_{z0}^2 = 4\Omega\omega_P\frac{1}{\mu_0}B_0^2. \end{aligned} \tag{35}$$

which is the energy density equation of vacuum LEM waves.

6. Discussion

6.1. Wave Speed, Frequency, Amplitude and Wavelength of Vacuum LEM Waves

According to Equation (28), the wave speed of B_z in a vacuum is equal to the speed of light C. According to Equation (23), the frequency ω_P of B_z can be expressed as $|\omega_P| = \left|-\mathrm{j}\frac{1}{\tau_2}\right| = \frac{\omega^2\varepsilon_0}{\sigma_0} = 10^{29}\ \mathrm{Hz}$, where $\varepsilon_0 \sim 10^{-11}\ \mathrm{F/m}$, is the vacuum dielectric constant [21], $\sigma_0 \sim 10^{-14}\ \mathrm{S/m}$ is the atmospheric electrical conductivity [26], which is approximately the vacuum electrical conductivity, ω taken as 10^{13} Hz (the frequency of light waves) is the source light waves frequency. The typical wavelength of B_z is calculated as $\lambda_z = \frac{C}{\omega_P} \sim 10^{-21}\ \mathrm{m}$. B_{z0} equaling $B_{t0}\lim_{V'\to 0}\left|\frac{\nabla\times\bar{A}_\theta}{\nabla\times\bar{A}_t}\right| = B_{t0}\lim_{V'\to 0}\left|\frac{\int_{V'} -r^{-2}\left(\boldsymbol{e}_r\times\boldsymbol{J}_\theta\right)\mathrm{d}V'}{\int_{V'} -r^{-2}\left(\boldsymbol{e}_r\times\boldsymbol{J}_t\right)\mathrm{d}V'}\right| = B_{t0}\lim_{V'\to 0}\left|\frac{\bar{\boldsymbol{J}}_\theta}{\bar{\boldsymbol{J}}_t}\right| = B_{t0}\frac{J_\theta}{J_t}$ is far smaller than B_{t0}, which imply that it is possible that conventional equipment for detecting TEM waves may fail to detect LEM waves.

6.2. Ability to Absorb Free Energy

The ratio of the energy density of LEM wave to TEM waves can be expressed as

$$E_P/E_T = \hbar\omega_P/\hbar\omega = 10^{29}\ \mathrm{Hz}/10^{13}\ \mathrm{Hz} = 10^{16}, \tag{36}$$

which means that apart from $E_T = \hbar\omega$, B_z must acquire huge additionally free energy from zero-point vacuum field [5] [27]. The mechanism for the free energy gained by B_z is likely associated with its induced vortex-magnetic field E_θ, which has the capability to extract zero-point vacuum energy through the entangled interaction between its produced torsion field and zero-point vacuum energy field. As per Equation (32), the total energy density of B_z can be represented as $E_P = -\mathrm{d}W/\mathrm{d}t + E_T$, where $-\mathrm{d}W/\mathrm{d}t$ denotes work performed by the zero-point vacuum energy field on B_z. Because $E_P \gg E_T$, it follows that $E_P \approx -\mathrm{d}W/\mathrm{d}t$; thus, indicating that most of B_z's energy originates from its interaction with "zero-point vacuum energy field".

When two source light waves are superimposed in a vacuum, the resultant electromagnetic fields seemly both vanish. But the resultant magnetic vector potential

A_θ still persist and produce $E_\theta = -\partial A_\theta / \partial t = \sqrt{2} C B_0 \exp\left[j\left(\frac{\omega_P}{C} z ? \omega_P t \right) \right]$ and $B_z = \nabla \times A_\theta = \sqrt{2} B_0 \exp\left[j\left(\frac{\omega_P}{C} z - \omega_P t \right) \right]$ called as "vacuum artificial free energy field" with huge energy ($\hbar\omega_P \gg \hbar\omega$).

This mechanism for LEM waves absorbing free energy is validated by the experiments of Meyl [10] [11] who found that LEM wave exhibits distinctive energetic properties and could increase ATP (adenosine triphosphate) content 40% in Epomoea chrysanthemum mitochondria, thereby extending the flowering period by nearly 10%. We can utilize this way to generate substantially free energy that might replace petrochemical and electrical energy and be the main energy in the future. Moreover, this free energy can be transmitted to thousands of households through a wireless network via the wireless energy transmission mode of LEM waves. This is an enticing new energy application scenario.

6.3. Exceptionally Harmless Penetration for Conductive Material and Organism Cells

Owing to the skin effect, TEM waves are unable to penetrate conductive medium and can only propagate within a thin layer δ on its surface [28]. B_z with a frequency 10^{29} Hz possessess "high-frequency transparency" [29] [30] and can freely traverse through metallic media and human body (weak electrolyte). Particularly, it can non-destructively penetrate the blood barrier of the human brain, convey the drug information it carries to the brain tissue, and treat related diseases. What's more, neutrinos are assumed as the propagating particles of B_z. The extremely small cross-section of 10^{-43} cm^2 for neutrino to interact with atomic nuclei results in a minuscule probability of its capture by an atomic nucleus within a square centimeter area, thus demonstrating a harmlessly penetrative capability of B_z to organism cells [31].

6.4. The Energy of LEM Waves Is Capable of Being Absorbed and Stably Stored by Water

The hydrogen bond energy between water molecule-groups is relatively weak and susceptible to be disrupted. Moreover, the vortex movement of LEM wave is also coherent with torsion field to extract the zero point energy, producing high-energy rays, neutrons and high-energy particles in its vortex center, accompanied by highly directional cold nuclear fusion [32]-[34]. On the one hand, the huge energy released by this process first breaks the fragile hydrogen bonds between water molecules (bond energy 23 kJ/mol, 0.24 eV) and produces smaller molecule groups of water. At the same time, it enhances the HO-H covalent bond energy of water molecules (bond energy 492 kJ/mol, 5.10 eV) [35]. On the other hand, it makes the bound electrons of water molecules be extremely active and become free electrons [35]. The increase of free electron concentration will weaken the ionization of water molecules, and finally form an ionization equilibrium state, which can increase the conductivity of water, and finally form high conductivity, weak alkaline-small molecule group-high energy state water. In this way, the energy of LEM waves is capable of being absorbed and stably stored by water for a very long time [36].

Lee Sichen has demonstrated through nuclear magnetic resonance experiments that the size of water molecular groups can be reduced after absorbing LEM waves [37]. The results of the experiments show that after the LEM waves generated by LEM wave generator was directly irradiated to water for 100 minutes, there exhibited a significant increase in the half height and width change amplitude of the nuclear magnetic resonance signal of oxygen isotope O17 in water, reaching up to +10%. This LEM wave's energy can remain stable in water for approximately one years [36]. Smaller water molecular groups are more adept at transporting oxygen and nutrient molecules into human cells, thereby enhancing blood oxygen concentration and nutritional absorption capacity. This is why Guopu from the Jin Dynasty of China called that "Qi" (LEM waves) "stops when it meets water and disperses when it encounters wind" [37]-[39].

6.5. LEM Waves May Be Capable of Generating Artificial Gravitational Field

The particle model of magnetic P-wave B_z in **Figure 4** representing a high energy state consists of two neutrinos with same rotation and spin directions [18] [36] [40]. Assuming the neutrinos' revolution velocity $\boldsymbol{V}_R$ and radius $\boldsymbol{R}$ are equal to light speed C and the wavelength λ_z of B_z in **Figure 5**, the centripetal acceleration $\boldsymbol{a}_R$ of the neutrinos' revolution around the center core of B_z is shown as

$$\boldsymbol{a}_R = -\frac{C^2}{\lambda_z}\boldsymbol{e}_R = -\frac{C}{\tau_2}\boldsymbol{e}_R . \tag{37}$$

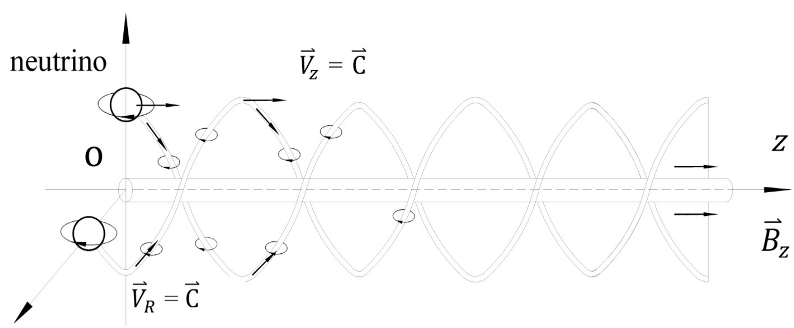

Figure 4. Particle model of $\boldsymbol{B}_z$.

When $R \ll C/\omega_P = 3\times10^{-21}$ m, and the source point region V' approaches zero that results in that $\boldsymbol{R} = \boldsymbol{r}$. In the field point coordinate system $P(r,\theta,z)$

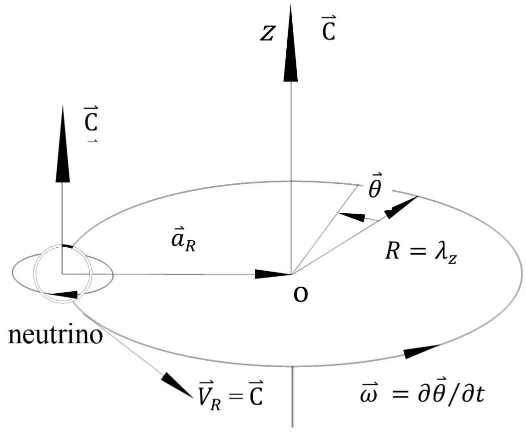

Figure 5. Centripetal acceleration of the neutrinos' revolution around the center core.

shown in **Figure 1**, supposing the field point space V expands along the positive r-axis at a velocity V_r, we can gain

$$\begin{aligned}\boldsymbol{B}_z &= \nabla\times\boldsymbol{A}_\theta = \frac{\mu_0}{4\pi}\int_{V'}\nabla\times\left(\frac{1}{r}\boldsymbol{J}_\theta\right)\mathrm{d}V' \\ &= \frac{\mu_0}{4\pi}\int_{V'}\left(-r^{-2}J_\theta\boldsymbol{e}_z\right)\mathrm{d}V' + jk\frac{\mu_0}{4\pi}\int_{V'}\left(-r^{-1}J_\theta\boldsymbol{e}_r\right)\mathrm{d}V' \\ &\approx \frac{\mu_0}{4\pi}\int_{V'}\left(-r^{-2}J_\theta\boldsymbol{e}_z\right)\mathrm{d}V',\end{aligned} \tag{38}$$

$$\boldsymbol{E}_\theta = -\nabla\varphi_\theta - \frac{\partial\boldsymbol{A}_\theta}{\partial t} = \frac{\mu_0}{4\pi}\int_{V'}\left(-r^{-2}V_r\boldsymbol{J}_\theta - r^{-1}V_r j\omega_P\boldsymbol{J}_\theta\right)\mathrm{d}V'. \tag{39}$$

From Equation (21), we are able to obtain

$$\nabla\times\boldsymbol{B}_z = \frac{1}{C^2}\frac{\partial\boldsymbol{E}_\theta}{\partial t} = \frac{1}{C^2}\boldsymbol{E}_\theta/\tau_2 = \frac{\mu_0}{4\pi}\int_{V'}r^{-3}\boldsymbol{J}_\theta\mathrm{d}V'. \tag{40}$$

From Equation (39), it is given that

$$\begin{aligned}\frac{\partial\boldsymbol{E}_\theta}{\partial t} &= \frac{\partial}{\partial t}\left(-\frac{\partial\boldsymbol{A}_\theta}{\partial t}\right) \\ &= a_r\frac{\mu_0}{4\pi}\int_{V'}-r^{-2}\boldsymbol{J}_\theta\mathrm{d}V' + V_r^2\frac{\mu_0}{4\pi}\int_{V'}2r^{-3}\boldsymbol{J}_\theta\mathrm{d}V' \\ &\quad + V_r j\omega_P\frac{\mu_0}{4\pi}\int_{V'}2r^{-2}\boldsymbol{J}_\theta\mathrm{d}V' - \omega_P^2\boldsymbol{A}_\theta \\ &= \boldsymbol{B}_z\times\boldsymbol{a}_r + V_r^2\nabla\times\boldsymbol{B}_z + \left(2\frac{V_r}{C}-1\right)\boldsymbol{A}_\theta/\tau_2^2 \\ &= \boldsymbol{B}_z\times\boldsymbol{a}_r + \frac{V_r^2}{C^2}\boldsymbol{E}_\theta/\tau_2 + \left(2\frac{V_r}{C}-1\right)\boldsymbol{A}_\theta/\tau_2^2 = \boldsymbol{E}_\theta/\tau_2.\end{aligned} \tag{41}$$

In Equation (41), the first term presumably represents the portion where the vacuum LEM wave $\boldsymbol{E}_\theta$ generates the acceleration $\boldsymbol{a}_r$ (gravitational field), the second term might be the part that gives rise to the weak nuclear force field, and the third term undoubtedly is the component that generates the electromagnetic field. Supposing that the portions of the vacuum LEM waves $\boldsymbol{B}_z$ and $\boldsymbol{E}_\theta$ that generates the acceleration $\boldsymbol{a}_r$ still compliy with the wave equations of the LEM waves shown as Equation (24) and Equation (25), *i.e.*,

$$\frac{1}{\mu_0\varepsilon_0}\boldsymbol{B}_z = C\boldsymbol{e}_r \times \boldsymbol{E}_\theta \quad \text{and} \quad \boldsymbol{E}_\theta = -C\boldsymbol{e}_r \times \boldsymbol{B}_z\,, \tag{42}$$

thus, we can obtain

$$\boldsymbol{a}_r = \boldsymbol{E}_\theta \times \frac{\boldsymbol{B}_z}{B_z^2\tau_2} = -\frac{C}{\tau_2}\boldsymbol{e}_r = -\frac{C^2}{\lambda_z}\boldsymbol{e}_r = \boldsymbol{a}_R, \tag{43}$$

which means that the acceleration produced by $\boldsymbol{E}_\theta$ and $\boldsymbol{B}_z$ is precisely the acceleration generated by the centripetal force field of the neutrino constituting the LEM wave and revolving around its center core in **Figure 5**. To sum up, it should be inferred that vacuum LEM waves are capable of generating gravitational fields. This conclusion still requires a substantial amount of experimentation for validation. If the aforementioned theory holds true, humanity can utilize LEM waves to achieve anti-gravity fields. When the mass of an object becomes zero, in accordance with special relativity [41], the object can reach the speed of light. Furthermore, based on the relativistic length contraction effect and time dilation effect [42] [43], the space at the speed of light can be reduced to zero, and time comes to a halt, meaning that humanity can achieve interstellar teleportation and explore any location in the universe within a finite life cycle. Based on Equation (41) and Equation (43), it is obtained that

$$\frac{1}{\mu_0\varepsilon_0}\frac{\partial \boldsymbol{B}_z}{\partial t} = \boldsymbol{a}_r \times \boldsymbol{E}_\theta, \tag{44}$$

$$\frac{\partial \boldsymbol{E}_\theta}{\partial t} = -\boldsymbol{a}_r \times \boldsymbol{B}_z, \tag{45}$$

which are the fundamental formulas called as the Maxwell's equations of the gravitational field generated by vacuum LEM waves. Analyzing (41) on the Earth's surface, we can gain $\boldsymbol{a}_r = \frac{V_0^2}{r_D} = \frac{7.9\times7.9\times10^6}{6.371\times10^6} = 9.8\ \text{m/s}^2$ while V_r presenting space expanding speed of our vacuum is equal to $r_D H = 6.371\times10^6\times67.8\times 10^3/\left(3.08\times10^{22}\right) = 1.4\times10^{-11}\ \text{m/s} \ll C$. Here, V_0 is the first cosmic velocity, r_D is the radius of the Earth and H is Hubble constant [44], which gives that $\frac{V_r}{C}\sim10^{-19}\ll1$, $\left|\boldsymbol{B}_z\times\boldsymbol{a}_r\right| = (9.8/3)\times10^{-8}\,\omega_P A_\theta$, $\left|\frac{V_r^2}{C^2}\boldsymbol{E}_\theta/\tau_2\right| = 10^{10}\,\omega_P A_\theta$ and $\left|\left(2\frac{V_r}{C}-1\right)\omega_P^2\boldsymbol{A}_\theta\right| = 10^{29}\,\omega_P A_\theta$. Evidently, at this circumstance, the electromagnetic force: the weak nuclear force: the gravitational force =10^{37}:10^{18}:1. When $V_r = C$, $\left|\boldsymbol{B}_z\times\boldsymbol{a}_r\right| = \left|\boldsymbol{E}_\theta/\tau_2\right| = \left|\left(2\frac{V_r}{C}-1\right)\omega_P^2\boldsymbol{A}_\theta\right| = 10^{29}\,\omega_P A_\theta$, that is, when an object moves at the speed of light, its electromagnetic field = weak nuclear force field = the gravitational field. However, since the object's mass is zero at this circumstance, the gravitational force acting on the object is zero while its electromagnetic force remains unchanged, but the weak nuclear force is increased to equal the electromagnetic force. From the viewpoint of LEM waves, the weak nuclear field, gravitational field and electromagnetic field seem to be unified.

7. Conclusion

Based on the theoretical demonstration of full current law and Faraday's law, we established the wave equation and energy equation of LEM waves. Through theoretical deduction, we discovered the wave equation of the vacuum electromagnetic scalar potential/magnetic vector potential and the constraint equation between the longitudinal wave speed of the and the transverse wave speed concealed in full current law and Faraday's law in a conductive media. These research results demonstrate the significance of LEM waves, which possess characteristics such as the speed of light, harmless penetration of the human body, absorption and stable storage by water, the possibility of generating artificial gravitational fields and extracting free energy, reflecting a more fundamental electromagnetic nature and being an important part of electromagnetics that cannot be disregarded. Establishing a rigorous wave equation, energy equation, and propagation mode of LEM waves can provide theoretical support and optimization means for the applications of them in the medical and energy fields. Additionally, the breakthrough in the theoretical research of LEM waves can solve difficult problems in fields such as new energy, wireless power transmission, and electromagnetic near-field analysis. Furthermore, this propagation mode of electromagnetic waves with the alternating mutual induction and transformation of magnetic-electric vortices and scalar electromagnetic fields reveals a more fundamental law of electromagnetic induction and is a powerful tool for exploring vacuum zero-point energy, neutrinos, and torsion fields. Most importantly, it can be foreseen that many intractable diseases of humanity will be cured due to the advent of this new energy produced by LEM wave, thereby triggering a disruptive revolution in medical and health care technologies.

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Author Contributions

Conceptualization: JJZ (JIANG Jian-zhong).
Methodology: JJZ.
Investigation: JJZ, WYF (WANG Yu-feng).
Visualization: JJZ.
Funding acquisition: WYF.
Project administration: WYF.
Supervision: WYF.
Writing-original draft: JJZ.

Writing-review & editing: JJZ.

Data and Materials Availability

All data are available in the main text or the supplementary materials.

Competing Interests

Authors declare that they have no competing interests.

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