

An Analysis about the Origin and Essence of Mass Based on Particle-Propagating Model and Wave Equations of Scalar Waves

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Abstract: If the singularity of the cosmic Big Bang is taken as the origin of the reference coordinate system, the surrounding vacuum in the initial moments of it would exhibit radially-outward right-handed spiral motion at light speed. Based on this spatial motion hypothesis, we derive a unified field equation and a set of Maxwell's equations for vacuum SWs (Scalar Waves) generating a huge spiral force field that drives the energy to spiral inwardly and distort, leading to the formation of mass. Furthermore, they also uncover that mass is fundamentally an ultimate expression of energy, manifesting as the result of spiral motion of space at light speed. And then, we indirectly validate the theory that coherent light waves' collision generate SWs and subsequently mass through the experiment verifying the Breit-Wheeler process. The establishment of our theory offers a new analytical tool for the exploration of mass origin, the cosmic Big Bang, unified field theories.

Key words: QED (Quantum Electrodynamics), SW, mass origin, unified field theories.

1. Preface

Mass is generally seen as an intrinsic and constant physical attribute of objects. However, its definition can be vague and abstract. In Newton's time, mass was defined as the product of density and volume [1], a simple but superficial concept that did not capture its true nature. Nikola Tesla [2] suggested that "Everything is light," implying that matter and mass might originate from light. Einstein's mass-energy equivalence equation [3] showed that mass and energy are interchangeable, though the exact mechanism of mass formation remains unclear. Modern quantum field theory indicates that about 99% of mass comes from strong nuclear force binding energy, while the remaining 1% is due to the Higgs field and particles [4, 5]. From relativity and quantum mechanics perspectives, mass is fundamentally a form of energy, but questions about the nature of the driving force behind mass generation remains

unanswered. SWs (Scalar Waves) can transmit energy and information, with properties like stable water absorption, non-destructive human body penetration, potential superluminal behavior, free energy absorption, and lossless energy transmission [6-9]. They have gained wide attention in medicine and energy fields [10-16]. Investigating the electromagnetic nature of SWs could help unify relativity and quantum mechanics [17, 18], revealing the essence of mass and fundamental issues like the origin of the universe.

2. Where Is the Singularity of the Cosmic Big Bang Located?

2.1 The Significance of Seeking the Singularity of the Cosmic Big Bang

The hypothesis of the cosmic Big Bang [19] posits that a singularity with high temperature, pressure, and energy would explode and expand to form our

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universe V. This singularity, lacking definite shape or volume, contained the potential energy needed for all matter in V. At a critical moment, the singularity's potential energy equilibrium was disrupted, converting energy into matter and shaping our universe—a symbiotic entity of matter and energy. Before our SW theory, it was unimaginable what caused this disruption of the singularity's energy equilibrium. Due to its unique nature, the singularity cannot be described using conventional space and time concepts [20]. However, identifying an absolute stationary point in V as the origin of the observer's coordinate system allows for a precise description of V's motion at the cosmic Big Bang, revealing the primordial driving force behind mass generation and the universe's creation.

2.2 The Particle Propagation Models for Light Waves and SWs

Based on the theory that SWs are produced by the coupling of particle spin and its orbital rotation [21, 22], combined with assumptions about photon structure [23], we propose the double helix models for photons illustrated in Fig. 1. The left-handed photon (γ_L) model consists of a PP (Positive Photino) and a NP (Negative Photino), both with equal electric charge. The PP, with a right-handed spin, undergoes a right-handed orbital

rotation around the forward axis, generating a left-handed SW B_{Lz+} . The NP, with a left-handed spin, undergoes a left-handed orbital rotation, generating a left-handed SW B_{Lz-} . The total left-handed SW is $B_{Lz} = B_{Lz-} + B_{Lz+}$. Since SWs propagate via neutrinos [22], which only participate in weak interactions much far weaker than electromagnetic forces, SWs generated by PP and NP can be disregarded under normal conditions. The right-handed photon (γ_R , see Fig. 1) model follows the same principles. Based on this analysis, photons can be classified into two types with a phase difference of π : γ_L and γ_R .

Referring to the particle structure of light waves, we derive the neutrino structure models of SWs in a vacuum. To conserve angular momentum, it is hypothesized that SWs consist of two left-handed neutrinos orbiting in opposite large helices. In the left-handed SW model (see Fig. 2), two left-handed neutrinos with a phase difference of π move along the forward axis in a left-handed helical orbit at the speed of light. This generates the high-energy state B_L . In the right-handed SW model (see Fig. 3), two left-handed neutrinos orbit in a right-handed helix, also with a phase difference of π , generating the low-energy state B_R . According to electromagnetic induction laws, the left-handed SW B_L generates a left-handed electric vortex potential,

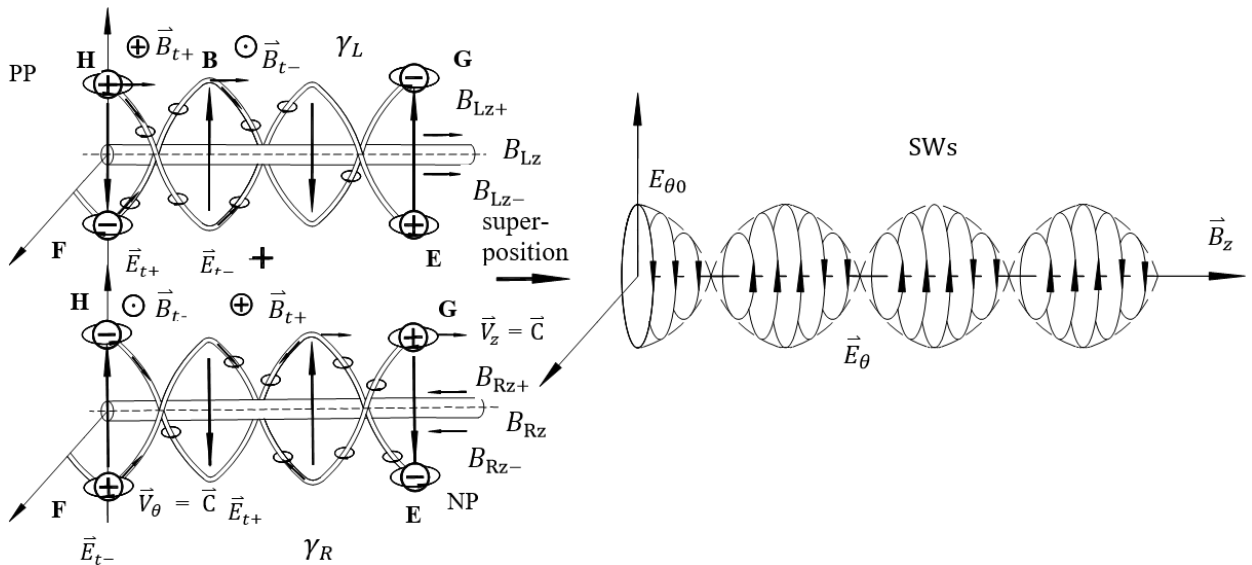


Fig. 1 SWs produced by the superposition of γ_L/γ_R .

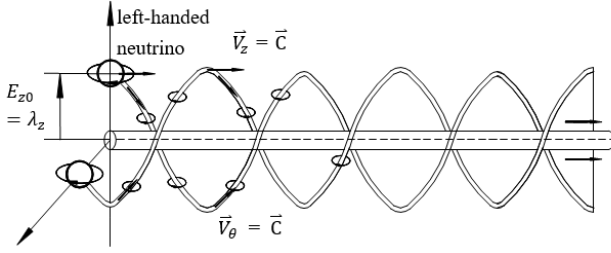


Fig. 2 Left-handed SWs' structure.

while the right-handed SW B_R generates a right-handed electric vortex potential. Following fluid mechanics vortex theory, vortices of the same direction attract each other, while those of opposite directions repel. Therefore, left-handed SWs attract each other and repel right-handed SWs, and vice versa.

2.3 The Singularity Existing Everywhere and Yet Nowhere

According to the Maxwell's equations of the left-handed SWs in a vacuum [9], their plane solutions, denoted as \vec{B}_z/\vec{E}_θ , can be represented as:

$$\vec{B}_z = B_{z0} \exp \left[j \left(\frac{\omega_p}{C} z - \omega_p t \right) \right] \vec{e}_z \quad (1)$$

$$= C B_{z0} \exp \left[j \left(\frac{\omega_p}{C} z - \omega_p t \right) \right] \vec{e}_\theta \quad (2)$$

where, ω_p , the wave frequency of \vec{B}_z/\vec{E}_θ , is presented as [8]:

$$\omega_p = j\tau_2^{-1} = jC/\lambda = j\omega^2 \epsilon_0 / \sigma_0 \sim 10^{31} \text{ Hz} \quad (3)$$

Here, $\tau_2 \sim 10^{-31} \text{ s}$ is the vortex attenuation period of \vec{E}_θ [8] produced by \vec{B}_z , $\omega \sim 10^{14} \text{ Hz}$ is the frequency of the source light waves generating SWs, $\lambda \sim 10^{-23} \text{ m}$ is the wave length of \vec{B}_z/\vec{E}_θ , $\sigma_0 \sim 10^{-14} \text{ S/m}$ is the vacuum conductivity [8] and ϵ_0 equaling $8.854 \times 10^{-12} \text{ F/m}$ is the vacuum dielectric constant. From the perspective of particle, for a left-handed neutrino propagating and spiraling around the central core of \vec{B}_z/\vec{E}_θ in Fig.4 (Fig. 5)

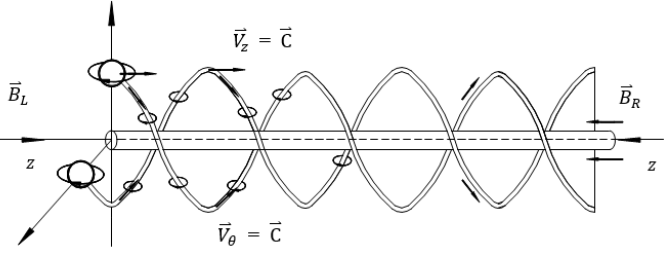


Fig. 3 Right-handed SWs' structure.

(equivalent to a clockwise helical motion at light speed from the perspective of wave: $\vec{V}_z = C\vec{e}_z$, $\vec{V}_\theta = -C\vec{e}_\theta$, see Fig.5 (Fig. 4), if its tangential velocity \vec{V}_θ is supposed to equal $1/137$ of the speed of light (Here, 137 is the fine-structure constant, and it is postulated that the mechanism of neutrino revolving around the SW core is identical to that of electron in the ground state revolving around the hydrogen nucleus [24]), we can obtain its helical radius R_z shown as Eq. (4) due to the equality of the centripetal force fields around the wave core produced by the particle and the wave of \vec{B}_z/\vec{E}_θ .

$$R_z = \left(\frac{V_\theta}{C} \right)^2 \lambda = \left(\frac{1}{137} \right)^2 \lambda = 10^{-27} \text{ m} \ll \lambda$$

$$= C\tau_2 \sim 10^{-23} \text{ m} \quad (4)$$

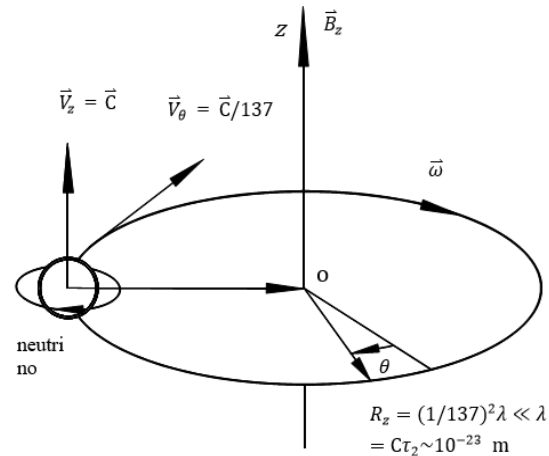


Fig. 4 The revolution of the neutrino around the central core of SW \vec{B}_z/\vec{E}_θ from the perspective of particle.

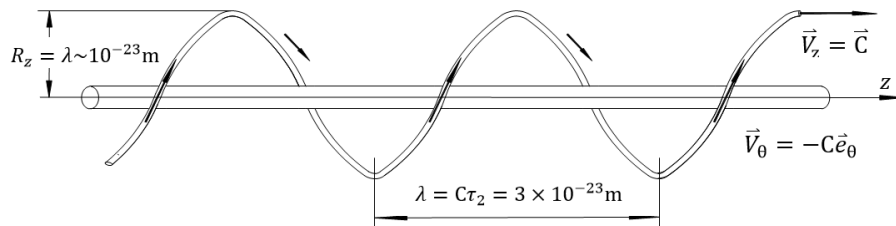


Fig.5 The clockwise helical line of light speed motion equivalent to SW \vec{B}_z/\vec{E}_θ from the perspective of wave.

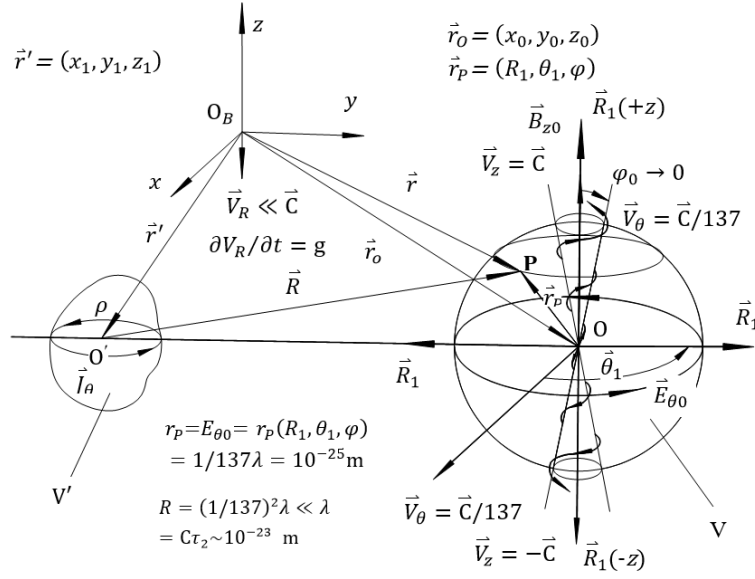


Fig. 6 Distribution map of source point region and field point region in a moving vacuum.

Therefore, based on the relative principle of motion, the left-handed SWs \vec{B}_z/\vec{E}_θ propagating at the speed of light along $+\vec{z}$ in a stationary vacuum can be equivalent to the LEM (Longitudinal Electromagnetic) waves formed by static field $\vec{B}_{z0}/\vec{E}_{\theta 0}$ fluctuating with the vacuum moving at the speed $\vec{V}_z = -C\vec{e}_z$, $\vec{V}_\theta = +C\vec{e}_\theta/137$ in a counterclockwise helical motion along $-\vec{z}$ (see Fig. 6), where the neutrino propagating \vec{B}_z/\vec{E}_θ serves as an absolutely stationary observer coordinate system. Special relativity's length contraction and time dilation effects imply that dimensions and time in the direction of light-speed motion both vanish [3]. Hence, analyzed from the wave perspective, observers constituted on the neutrinos propagating \vec{B}_z/\vec{E}_θ are always at the singularity and have never moved. Their position is the singularity's position, making the singularity omnipresent in V with light and SW propagation. But due to its unique nature, the singularity cannot be accurately described using conventional space and time concepts [19]. Therefore, it is nowhere in V, i.e., it is both infinitesimal and infinite.

Since the Big Bang singularity is ubiquitous in V, we can assume it coincides with the Earth's center. The spherical space $V(R_1, \theta_1, \varphi)$ centered at the Earth can be discretized into numerous micro-cones with a half-cone angle of φ_0 (non-zero but approaching zero) and

a base radius $R_z = \lambda/137^2 = 10^{-27} \text{ m} \ll \lambda$ [18], spirally diverging counterclockwise at the speed of light along the $+R_1$ direction. This spiral motion of V combines a linear motion $\vec{V}_z = -C\vec{e}_z$ in the $-z$ direction and a rotational motion $\vec{V}_\theta = +C\vec{e}_\theta/137$ in the $+\theta$ direction, following the right-hand screw rule (see Fig. 6). This conclusion aligns with special relativity and forms the spatial foundation of unified field theory [18].

3. The Wave Equations of SWs Generating Strong Nuclear Force Field

As shown in Fig. 6, the Big Bang expanded from singularity O to form our spherical vacuum space V, i.e., field region P (centered at the Earth's center O). In the adjacent fixed source region V' (centered at O'), continuous and time-varying charges $\rho(\vec{r}', t)$ and fluctuating vortex currents $\vec{J}_\theta(\vec{r}', t)$ induced by an external electromagnetic field generate quasi-steady electromagnetic fields $\vec{E}_{\theta 0}/\vec{B}_{z0}$ in V. An observer coordinate system (x, y, z) with origin O_B undergoes free-fall along the $-z$ direction with velocity $V_R = gt \ll C$, while a spherical coordinate system $(R_1, \theta_1, \varphi_0)$ centered at O describes the motion of space V, with φ_0 approaching zero. Assuming a gravity-only system is inertial, $\vec{B}'_z/\vec{E}'_\theta$ in the moving observer system and \vec{B}_z/\vec{E}_θ in the stationary observer

system satisfy Lorentz covariant relationships [25, 26] shown as:

$$\vec{E}'_\theta = \gamma(\vec{E}_\theta + V_R \vec{e}_R \times \vec{B}_z) \approx \vec{E}_\theta + V_R \vec{e}_R \times \vec{B}_z \approx \vec{E}_\theta \quad (5)$$

$$\begin{aligned} \vec{B}'_z / \mu_0 \epsilon_0 &= \gamma(\vec{B}_z / \mu_0 \epsilon_0 - V_R \vec{e}_R \times \vec{E}_\theta) \\ &\approx \vec{B}_z / \mu_0 \epsilon_0 - V_R \vec{e}_R \times \vec{E}_\theta \approx \vec{B}_z / \mu_0 \epsilon_0 \\ &\approx (C - V_R) \vec{e}_R \times \vec{E}_\theta \end{aligned} \quad (6)$$

Here, γ is the vacuum Lorentz factor. When V' approaches zero and O_B coincides with O' , it is given that $\vec{r} = \vec{r}_P + \vec{r}_O \rightarrow \vec{R}$ and:

$$\begin{aligned} \frac{\partial R}{\partial t} &= \frac{\partial r}{\partial t} = \frac{\partial r_P}{\partial t} = \frac{\partial r_P}{\partial R_1} \frac{\partial R_1}{\partial t} + \frac{\partial r_P}{\partial \theta_1} \frac{\partial \theta_1}{\partial t} + \frac{\partial r_P}{\partial \varphi} \frac{\partial \varphi}{\partial t} \\ &= \frac{\partial R_1}{\partial t} + V_\theta + V_\varphi = -V_R + C + V_\theta \end{aligned} \quad (7)$$

According to the relationship formula [9] between $\vec{B}_z / \vec{E}_\theta$ and the magnetic vector potential \vec{A}_θ the electromagnetic scalar potential φ_θ , when the vector radius from the source point to the field point R in V equals $(1/137)^2 \lambda \sim 10^{-27} \text{ m} \ll \lambda \sim 10^{-23} \text{ m}$ and $V_R \ll C$, we can obtain that:

$$\vec{B}_z = \nabla \times \vec{A}_\theta = \frac{\mu_0}{4\pi} \int_{V'} -R^{-2} (\vec{e}_R \times \vec{j}_\theta) dV' =$$

$$\vec{e}_R \times \frac{\mu_0}{4\pi} \int_{V'} -R^{-2} \vec{j}_\theta dV' \quad (8)$$

$$\begin{aligned} \vec{E}_\theta &= -\nabla \varphi_\theta - \frac{\partial \vec{A}_\theta}{\partial t} = -\frac{\partial \vec{A}_\theta}{\partial t} = \frac{\mu_0}{4\pi} \int_{V'} R^{-2} \frac{\partial R}{\partial t} \vec{j}_\theta dV' \\ &= -\frac{\partial r_P}{\partial t} \frac{\mu_0}{4\pi} \int_{V'} -R^{-2} \vec{j}_\theta dV' \end{aligned}$$

$$= -\left(\frac{\partial R_1}{\partial t} + V_\theta\right) \vec{e}_R \times \vec{B}_z$$

$$= (V_R - C - V_\theta) \vec{e}_R \times \vec{B}_z \approx -C \vec{e}_R \times \vec{B}_z \quad (9)$$

$$\begin{aligned} (-V_R + C + V_\theta)^2 \vec{B}_z &= (-V_R + C + V_\theta) \vec{e}_R \times \vec{B}_z \\ &\approx C \vec{e}_R \times \vec{E}_\theta \end{aligned} \quad (10)$$

The differentiations of Eqs. (9) and (10) lead to that:

$$\begin{aligned} \partial \vec{E}_\theta / \partial t &= -C \vec{e}_R \times \partial \vec{B}_z / \partial t - V_\theta \vec{e}_R \times \partial \vec{B}_z / \partial t - C \vec{B}_z \\ &\quad \times \partial \vec{e}_R / \partial t + g \vec{e}_R \times \vec{B}_z \\ &= -C \vec{e}_R \times \vec{B}_z / \tau_2 - V_\theta \vec{e}_R \times \vec{B}_z / \tau_2 \\ &\quad + C \sin \varphi_0 \vec{e}_\theta \times \vec{B}_z / \tau_2 + g \tau_2 \vec{e}_R \\ &\quad \times \vec{B}_z / \tau_2 \\ &\approx -C \vec{e}_R \times \vec{B}_z / \tau_2 = \vec{a}_H \times \vec{B}_z \end{aligned} \quad (11)$$

$$\begin{aligned} (-V_R + C + V_\theta)^2 \partial \vec{B}_z / \partial t &= C \vec{e}_R \times \vec{E}_\theta / \tau_2 + V_\theta \vec{e}_R \times \vec{E}_\theta / \tau_2 \\ &\quad - C \sin \varphi_0 \vec{e}_\theta \times \vec{E}_\theta / \tau_2 - g \tau_2 \vec{e}_R \\ &\quad \times \vec{E}_\theta / \tau_2 \\ &\approx C \vec{e}_R \times \vec{E}_\theta / \tau_2 = -\vec{a}_H \times \vec{E}_\theta \end{aligned} \quad (12)$$

Here, V_θ equaling $C/137 \sim 10^6 \text{ m/s}$ is the rotation velocity of neutrino revolving around the SW core.

In Eqs. (11) and (12), the first term, corresponds to the strong nuclear force field generated by the radially linear light-speed motion $C \vec{e}_z$ of V ; the second term undoubtedly represents the electromagnetic field produced by its light-speed rotational motion $V_\theta \vec{e}_\theta$; the third term constitutes the weak nuclear force field, and the final term g , represents the gravitational field of V . Eqs. (11) and (12) are renowned as the unified field equations. When vector radius $R = (1/137)^2 \lambda \sim 10^{-27} \text{ m} \ll \lambda \sim 10^{-23} \text{ m}$, analyzing Eqs. (11) and (12) and taking the ratio of strong nuclear force field:electromagnetic field:weak nuclear force field:gravitational field equaling $10^{38}:10^{36}:10^{25}:1$ [18] gives that $\varphi_0 = 10^{-12} \text{ rad}$. According to the vector directions of $\vec{B}_z / \vec{E}_\theta$ presented in Fig.7, when magnetic field generates electric field, the electromagnetic fields conform to the left-hand helix rule (see Fig. 8a), namely,

$$\begin{aligned} \vec{a}_H &= -a_H \vec{e}_R = -\frac{\vec{B}_z}{B_z^2 \tau_2} \times \vec{E}_\theta = -\frac{\vec{B}_{z0}}{B_{z0}^2 \tau_2} \times \vec{E}_{\theta 0} \\ &= -C / \tau_2 \vec{e}_R \sim -10^{39} \vec{e}_R \text{ m/s}^2 \end{aligned} \quad (13)$$

while when electric field generates magnetic field, the electromagnetic fields conform to the right-hand helix rule (see Fig. 8b), that is,

$$\begin{aligned} \vec{a}_H &= -a_H \vec{e}_R = \frac{\vec{B}_z}{B_z^2 \tau_2} \times \vec{E}_\theta = \frac{\vec{B}_{z0}}{B_{z0}^2 \tau_2} \times \vec{E}_{\theta 0} \\ &= -C / \tau_2 \vec{e}_R \\ &\sim -10^{39} \vec{e}_R \text{ m/s}^2 \end{aligned} \quad (14)$$

The direction of \vec{a}_H is depicted in Fig. 9. As can be observed from it, regardless of whether it is electric field generating magnetic field or magnetic field generating electric field, the strong nuclear force field \vec{a}_H generated by $\vec{E}_\theta / \vec{B}_z$ in V is a spirally centripetal acceleration field which is 10^2 times stronger than the

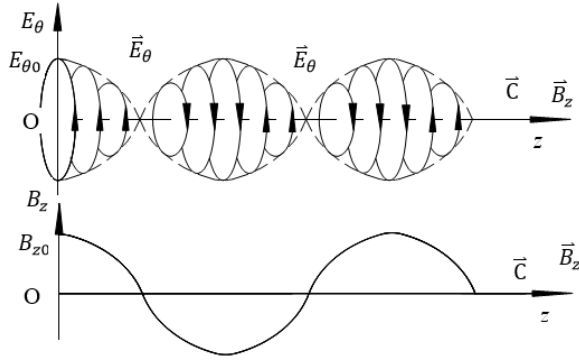


Fig. 7 The propagation mode of SWs in a vacuum.

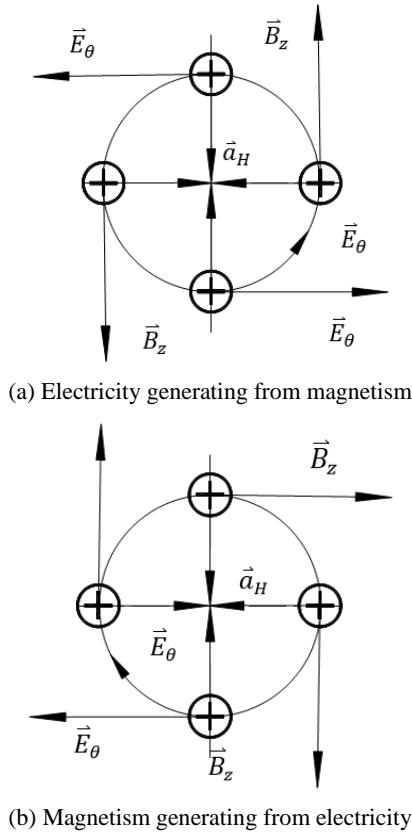


Fig. 8 The direction of the centripetal force field generated by SWs.

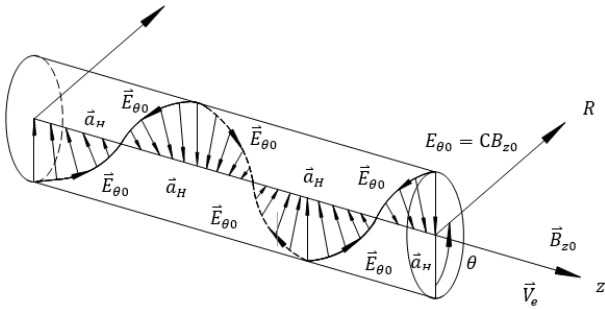


Fig. 9 The helically centripetal force field generated by SWs.

electromagnetic force and 10^{38} times stronger than gravity. The vast potential energy from \vec{a}_H causes the energy in V to spiral inward and convert to mass.

4. Dynamic Mode of Mass Generation

4.1 Phase of Substantial SWs Generating from Source Light Waves

The generation of SWs typically occurs when two coherent light waves with identical frequency, amplitude, opposite propagation direction, and a phase difference of π superpose in a vacuum [10] (referred to as “source waves”). After superposition, the resulting total electromagnetic field \vec{E}_t/\vec{B}_t can be shown as:

$$\vec{E}_t = \vec{E}_1 + \vec{E}_2 = \vec{E}_0 \exp[j(\vec{k} \cdot \vec{r} - \omega t)] + \vec{E}_0 \exp[j(\vec{k} \cdot \vec{r} - \omega t + \pi)] = 0 \quad (19)$$

$$\vec{B}_t = \vec{B}_1 + \vec{B}_2 = \vec{B}_0 \exp[j(\vec{k} \cdot \vec{r} - \omega t)] + \vec{B}_0 \exp[j(\vec{k} \cdot \vec{r} - \omega t + \pi)] = 0 \quad (20)$$

where the electric field components of the two source waves are denoted as \vec{E}_1/\vec{E}_2 respectively, while their corresponding magnetic field components are represented by \vec{B}_1/\vec{B}_2 . From Eqs. (19) and (20), after superposition \vec{E}_t/\vec{B}_t becomes zero, seemingly causing energy to vanish into vacuum. However, in accordance with the principle of energy conservation, all energy of source transverse electromagnetic waves (TEMs) is actually transferred to the SW \vec{E}_θ/\vec{B}_z [8]. This energy transfer can be explained by definitions of magnetic vector potential \vec{A} and electromagnetic scalar potential φ [27].

$$\vec{B}_t = \vec{B}_1 + \vec{B}_2 = \nabla \times (\vec{A}_1 + \vec{A}_2) = 0, \text{ i.e.,}$$

$$\vec{A} = \vec{A}_1 + \vec{A}_2 = \nabla \psi \neq 0 \quad (21)$$

$$\vec{E}_t = \vec{E}_1 + \vec{E}_2 = -\nabla \varphi - \partial \vec{A} / \partial t = 0,$$

and $\nabla \varphi = -\partial \vec{A} / \partial t = -\nabla \partial \psi / \partial t \neq 0$, that is,

$$\varphi = -\partial \psi / \partial t \neq 0 \quad (22)$$

Here, ψ represents a scalar field known as the “zero-point vacuum energy field” [28], “torsion field” [29], or “neutrino scalar field” [22]. Our photonic structure model can effectively elucidate the essence of this phenomenon. The superposition of two source light waves in a vacuum is equivalent to a γ_L superposing with a γ_R (or a γ_L colliding frontally with a γ_L).

As depicted in Figs. 1 and 10, a PP from the γ_L is intersecting with a NP from the γ_R , while a NP from the γ_L is meeting with a PP from the γ_R . Their annihilations lead to the generation of an extensive energy (zero-point vacuum energy) and SW \vec{E}_θ/\vec{B}_z [30]. These reactions can be mathematically expressed as follows:

$$\gamma_R + \gamma_L \text{ (superposition)} \rightarrow \vec{E}_\theta/\vec{B}_z \quad (23)$$

$$\gamma_L + \gamma_L \text{ (collision)} \rightarrow \vec{E}_\theta/\vec{B}_z \quad (24)$$

The left-handed SW \vec{E}_θ/\vec{B}_z absorbs hugely positive energies in ψ field and reaches a very high frequency, thereby explaining their medically therapeutic properties [9]. At this stage, although \vec{E}_t/\vec{B}_t vanish in space V, both \vec{A} and φ still persist where $\vec{A} = \nabla\psi \neq 0$ and $\varphi = -\partial\psi/\partial t \neq 0$.

4.2 Phase from Inflation to the Separation of Strong Nuclear Force

In the inflationary epoch [31] (ranging from 10^{-36} s to 10^{-31} s) of the universe, the singularity underwent exponential inflation at a superluminal speed ($V_e = 137C \sim 10^{10} \frac{m}{s}$), and its volume instantaneously increased by 10^{26} times, forming the initial high-temperature cosmic space (with a temperature of 100 billion degrees Celsius, which is approximately 1,000 times the temperature at the center of the sun [19]). Then a large number of high-energy photons moving at superluminal speed were generated in it and emitted an immense amount of heat. Coincidentally, the superimposition of two anti-phase coherent photons (or the collision of two in-phase coherent photons) gave rise to superluminal SWs that concurrently produced a spirally centripetal force field $V_e/\tau_2 \sim 10^{41} \text{ m/s}^2$. The potential energy of it caused the energy to converge and twist inward. Simultaneously, the four fundamental forces were unified by this “original single force” but began separating as the spatial expansion rate changed. About one second after inflation, the spatial expansion speed slowed to the speed of light ($3 \times 10^8 \text{ m/s}$), and the

strong nuclear force dropped to 10^{39} m/s^2 , completing its separation from the “original single force” [32], successively transforming energy into fundamental particles like, quarks, gluons and electron-positron pairs [33]. The reaction equations are shown as:

$$\gamma_R + \gamma_L \rightarrow \vec{E}_\theta/\vec{B}_z \rightarrow \text{quarks} + \text{gluons} \quad (25)$$

$$\gamma_R + \gamma_L \rightarrow \vec{E}_\theta/\vec{B}_z \rightarrow e^+ + e^- \quad (26)$$

At this juncture, the expansion radius R_2 of space V must attain the domain of the strong nuclear force, 10^{-15} m (see Fig. 11), and the amplitude R_p of the SW \vec{E}_θ/\vec{B}_z ought to lie between its wavelength $\lambda \sim 10^{-23} \text{ m}$ and the helical radius $R_z \sim 10^{-27} \text{ m}$ of the propagating particle—the neutrino. We adopt that:

$$R_2 = 10^{-15} \text{ m} \quad (26.1)$$

$$R_p = E_{\theta 0} = 137R_z = \lambda/137 \sim 10^{-25} \text{ m} \quad (26.2)$$

4.3 Phase for the Separation of Electromagnetic Force

Approximately one minute after the Big Bang, the rate of spatial expansion in V decreased to $1/137C$, and the electromagnetic force (10^{37} m/s^2) completed its separation from the “original single force”. Owing to

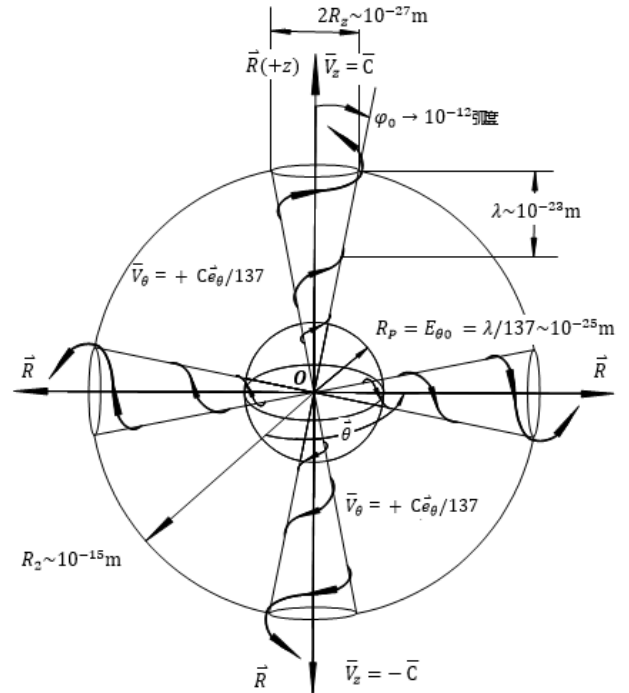
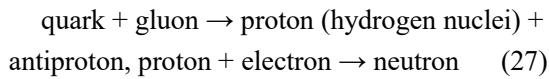


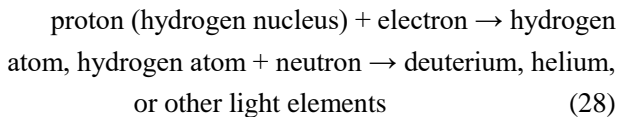
Fig. 11 The spiral motion of the vacuum at the moment when the strong nuclear force separated during the Big Bang.

the absorption of a considerable amount of energy, quarks and gluons continued to coalesce into protons and antiprotons under the action of the spirally centripetal force field generated by the luminal SWs. Subsequently, protons and electrons combined to form neutrons, while antiquarks, antigluons, antiprotons and positrons were repelled to the fringes of space V due to the repulsion property between opposite SWs and did not participate in the constitution of our universe [22]. The conclusion that the vacuum was filled with neutrons and protons for a certain period after the Big Bang, as believed by scientists, is derived from nuclear tests, nuclear fusion experiments, and long-term observations of stars and cosmic rays [34]. The chemical reaction equations for this process are:



4.4 Phase for the Separation of Weak Nuclear Force

Around 380,000 years after the Big Bang, at which point the expansion rate of V declined to 10^{-13} of C, namely 10^{-5} m/s, weak nuclear force (10^{26} m/s²) completed its separation from the “original single force”. Meanwhile, a proton captured an electron to form the first hydrogen atom, and gradually electrically neutral gas clouds began to form in V. Photons were liberated from their constraints and the universe began to emit light and become brighter. Owing to the continuous expansion of the entire system, the temperature of the universe dropped rapidly. When it decreased to 1 billion degrees Celsius, neutrons lost the conditions for free existence and, under the effect of the weak nuclear force, initiated hydrogen nuclear fusion, commencing to combine with hydrogen atoms to form deuterium, helium, or other light elements [19]. The chemical reaction equations for this process are shown as:



4.5 The Phase for the Separation of Gravity

Approximately one billion years after the Big Bang, the expansion rate of V declined to $g\tau_2 = 10^{-30}$ m/s and gravity (9.8 m/s²) separated from the “original single force”. At this juncture, the temperature of the universe decreased to several thousand degrees, electrons and atomic nuclei began to combine to form other atoms and the first galaxy emerged in the universe owing to the attractive effect of the gravitational field. As time elapsed, more galaxies, stars, planets, and other celestial bodies appeared in the universe, leading to the vast and boundless universe we observe today [19].

5. Indirect Experimental Validation of Mass Generation Utilizing Vacuum SWs

In 1934, physicists Breit and Wheeler predicted that two high-energy photons could collide in a polarized pulsed electromagnetic field to generate an electron-positron pair. This process, known as the Breit-Wheeler process [35], is the simplest way to convert pure light energy into matter. However, producing sufficient electron-positron pairs requires extremely high photon energy, typically only achievable with X-rays or gamma rays. Such lasers have not yet been developed, making experimental verification challenging. In 2021, a research team [35] at the Brookhaven National Laboratory in USA accelerated gold ions to 99.99% of the speed of light in opposite directions. When the ions passed through each other, the photons in their electromagnetic clouds collided, generating electron-positron pairs (see Fig. 12). The mass distribution,

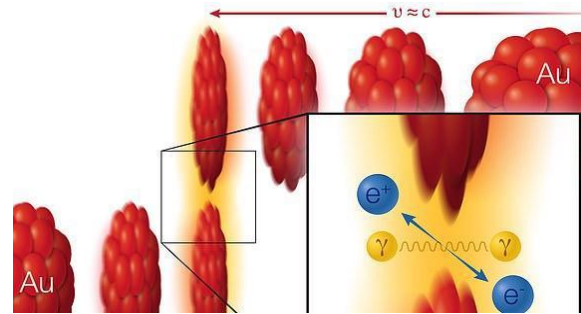


Fig. 12 Indirect experiment on vacuum SWs generating mass.

energy, and quantum state of these particles matched predictions from the Breit-Wheeler effect. The Breit-Wheeler process experiment indirectly verifies that the edge collision of two coherent light waves generates SWs, and their convolution with energy produces mass.

6. Discussion

6.1 The Essence of the Gravity

General relativity posits that the gravitational field is the spatial curvature effect generated by matter with mass in space. When objects move within this curved space, they display alterations in their motion states as in a rectangular space, thereby manifesting the gravitational effect. At the initial stage of the Big Bang, when the gravitational field completed its separation from the “primitive single force”, at this moment, the acceleration field of the spatial expansion motion of vacuum V can be expressed as:

$$a_g = \partial V_S / \partial t = V_S / \tau_2 = g \tau_2 / \tau_2 = g \quad (29)$$

which means that the acceleration field of the expansion motion V_S of the current space V is precisely the gravitational field of V. From the aforementioned theoretical analysis, it is clear that mass results from the spiral motion of space, while gravitational field is generated by mass. Therefore, gravity, in essence, is not a “force”, but an effect of space-time curvature and distortion. In the reference frame with the Big Bang singularity as the origin, gravity has no impact on the conservation of momentum and energy. Thus, the system on Earth that is solely subjected to gravitational forces pertains to an inertial coordinate system.

6.2 The Wave Equation of Mass

For an object (for the purpose of simplifying the model, it is hypothesized that its volume is zero) only subjected to the action of gravity with a rest mass m in V that spirals at the speed of light, the total momentum in V [36] of it can be expressed as:

$$\vec{P} = m(C - V_R)\vec{e}_R + mV_\theta\vec{e}_\theta \quad (30)$$

$$\vec{F}/m = -g\vec{e}_R + C\vec{e}_R/\tau_2 + V_\theta\vec{e}_\theta/\tau_2 + V_\theta\partial\vec{e}_\theta/\partial t \quad (31)$$

Here, $C\vec{e}_R$ represents the linear velocity of V in the radial direction; $V_\theta\vec{e}_\theta$ represents the tangential rotational linear velocity of V. In the spherical coordinate $V(R, \theta, \varphi_0)$ (see Fig. 13), $\frac{\partial\vec{e}_\theta/\partial t}{\partial\theta/\partial t} = \frac{\partial\vec{e}_\theta}{\partial\theta} = -\sin\varphi_0\vec{e}_R$, $\partial\theta/\partial t = 2\pi\omega_p = 2\pi C/\lambda = C/\lambda = V_\theta/R_p$, and thus we have:

$$\partial\vec{e}_\theta/\partial t = -\vec{e}_R \sin\varphi_0 V_\theta/R_p \quad (32)$$

Substituting Eqs. (32) into (31), we obtain:

$$\begin{aligned} \vec{F}/m &= \vec{e}_R C/\tau_2 + \vec{e}_\theta V_\theta/\tau_2 - \vec{e}_R \sin\varphi_0 V_\theta^2/R_p - g\vec{e}_R \\ &= \vec{a}_H + \vec{a}_{T\varphi} + \vec{a}_{TR} + \vec{g} \end{aligned} \quad (33)$$

In Eq. (33), the first term C/τ_2 corresponds to the strong nuclear force field generated by the radial linear motion $C\vec{e}_z$ of V. The second term C/τ_2 undoubtedly represents the electromagnetic field generated by its tangential rotation $V_\theta\vec{e}_\theta$. The third term $\sin\varphi_0 V_\theta^2/R_p$ is the weak nuclear force field related to the cone angle φ_0 of V's spatial micro-conically helical motion. The last term g represents the gravitational field of V. Eq. (33) is the renowned unified field equation. Analyzing Eq. (30), when $\tau_2 \sim 10^{-31}$ s, $R_p = 137R_z \sim 10^{-25}$ m, $\varphi_0 = R_z/R_2 = 10^{-27}/10^{-15} = 10^{-12}$ rad, we can obtain the ratio of the strong nuclear force field: electromagnetic field: weak nuclear force field: gravitational field = $10^{38}:10^{36}:10^{25}:1$.

The tangential projection of Eq. (33) in V (see Fig. 13) yields:

$$\begin{aligned} F_\theta/m &= a_T \cos\varphi_0 = a_{T\varphi} = V_\theta^2/R_p = \frac{1}{137} V_\theta^2/R_z = \\ &= \frac{1}{137} C^2/\lambda = V_\theta/\tau_2 \sim 10^{37} \text{ m/s}^2 \end{aligned} \quad (34)$$

Eq. (34) is undoubtedly the electromagnetic force, whose direction is perpendicular to the radial direction of space V and can be either the tangential direction \vec{e}_θ or the normal direction \vec{e}_φ . This indicates that the electromagnetic force has two directions, namely the \vec{e}_θ direction of electric field force and the \vec{e}_φ direction of magnetic field force.

The unified field equation Eq. (33) must satisfy Eq. (35) which reveals that the mass m is also fluctuating.

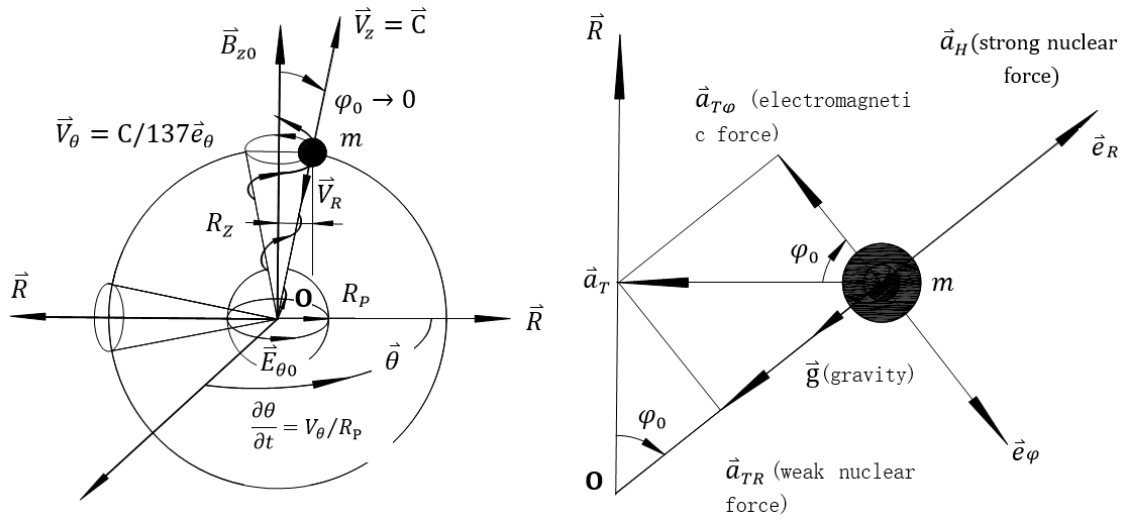


Fig. 13 Unified force fields caused by the spiral motion of our vacuum.

As the fluctuation of mass is induced by the spatial fluctuating, the fluctuation frequency and wave velocity of mass are also equal to ω_p and the speed of light. Additionally, since mass is a scalar, the fluctuation equation of mass can be expressed as a SW propagating along the radial direction of space V with an amplitude of m_0 , the speed of light C , and a frequency of ω_p . Eq. (35.1) constitutes the material basis of the unified field theory, while the vacuum of the helical motion of light speed serves as the spatio-temporal basis of the unified field theory.

$$C \frac{\partial m}{\partial t} = m C / \tau_2 = m \frac{C^2}{\lambda} \quad (35)$$

$$m = m_0 \exp \left[j \left(\frac{\omega_p}{C} R - \omega_p t \right) \right] \quad (35.1)$$

7. Conclusion

Taking the Big Bang singularity as the origin of the reference frame, the nascent space exhibited a particular motion pattern: spirally diverging counterclockwise at the speed of light along the radial direction. Based on this spatial space motion and the wave equations of SWs in a vacuum, it is proved that vacuum SWs can generate a strong nuclear force field which drives the conversion of mass from energy. Similar to how the gravitational field represents space curvature, mass reflects the light-speed spiral motion of space.

Therefore, the total momentum of the system only under gravity remains conserved, placing it within the category of inertial coordinate systems.

Competing Interests

Authors declare that they have no competing interests.

Data and Materials Availability

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

Ethical Approval Statement

The study did not require ethical approval.

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