

The Assumption of Electronic Inherent Waves and Its Potential Significance

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Abstract

Suppose there exists an ideal particle that radiates electromagnetic wave at a constant frequency in any inertial frame. When this inherent wave disturbs another particle and is reflected, an incident-reflected wave pair is formed between the two particles. When the two particles move relative to each other, the superposition of the incident and reflected waves will produce a beat frequency. Does the disturbance (or secondary wave) associated with this “beat frequency” have any physical significance? Furthermore, if the electron also possesses such an inherent wave, what characteristics would the electron exhibit? This paper discusses the possibility that the electron has an inherent wave, as well as the potential significance of the beat frequency in quantum mechanics.

Keywords: Electron; inherent wave; motion-related wave; standing wave; beat frequency; quantum mechanics

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1. Introduction

We first imagine an unknown medium that surrounds the electron and mediates the electromagnetic force ¹. The electron sustains this inherent medium through periodic actions: brief bursts of emission followed by a reset via reabsorption of the medium. These periodic perturbations give rise to spherical waves centered on the electron. In this model, the electron can be conceptualized as a point-like source of spontaneous wave emission and absorption, exhibiting several distinctive properties.

This proposed action is reminiscent of spontaneous excitations observed in biological systems, such as ion channels and cardiac pacemaker cells, where internal structures govern cyclic actions characterized by refractory periods ². Hence, throughout this paper, we use the term “excite” to describe this action, as opposed to “vibrate” or “periodically expand and contract.” Based on these considerations, we formulate the following fundamental assumption regarding electrons:

Every electron excites at an inherent frequency and sustains a spherical harmonic wave that propagates at the speed of light c within its inherent medium (or inherent electromagnetic field).

2. Electronic Waves

2.1 Inherent Waves of Electrons

For a stationary electron, the proposed electronic inherent wave (EIW) is characterized by its inherent frequency f_c and wavelength λ_c . These are related by the fundamental relation:

$$f_c \lambda_c = c \quad (1)$$

Extending the principles from special relativity ³, moving objects are measured to be contracted along the direction of motion. The inherent wavelength and frequency of a moving electron, when measured directly along the direction of motion and denoted as λ_i and f_i , is given by:

$$\begin{aligned} \lambda_i &= \lambda_c / \gamma \\ f_i &= c \gamma / \lambda_c \end{aligned} \quad (2)$$

where $\gamma = 1/\sqrt{1-v^2/c^2}$ is the Lorentz factor.

Relations (1) and (2) imply that the period and wavelength of the EIW, as defined by a stationary electron in any inertial reference frame, can serve as fundamental units of time

30 and length that conform to the Lorentz Transformation ³. Essentially, our assumption extends the fundamental concepts underlying the Lorentz Transformation and special relativity to the intrinsic behavior of the electrons.

Next, we derive the wave function of a stationary electron in vacuum, denoted by $\Psi_0(r, t)$.

Each inherent excitation comprises two sequential processes: 1) the release of a discrete
35 energy packet E_{out} , which generates an outward-propagating spherical harmonic wave

$\Psi_{out}(r, t)$; and 2) the reabsorption of the same energy packet E_{in} after a half-period delay, which generates an inward-propagating spherical harmonic wave $\Psi_{in}(r, t)$. The resultant wave function of the stationary electron can then be expressed as the superposition of these outward and inward waves:

$$\begin{aligned}\Psi_0(r, t) &= \Psi_{out}(r, t) + \Psi_{in}(r, t) \\ 40 \quad \Psi_{out}(r, t) &= A(r) \cos(2\pi f_c t - 2\pi r / \lambda_c) \\ \Psi_{in}(r, t) &= \Gamma A(r) \cos(2\pi f_c t + 2\pi r / \lambda_c - \pi)\end{aligned} \quad (3)$$

Where r is the radius vector with the electron as origin, $r = |r|$, and Γ denotes the amplitude reflection coefficient.

Since the emitted and reabsorbed energy packets are balanced in a “stationary” electron (i.e., no net energy dissipation, $\Gamma = 1$), we have:

$$45 \quad \Psi_0(r, t) = 2A(r) \sin(2\pi r / \lambda_c) \sin(2\pi f_c t) \quad (4)$$

Consequently, equation (4) corresponds to a spherical standing wave with nodes and antinodes separated by half a wavelength ($\lambda_c/2$) (see Figure 1a).

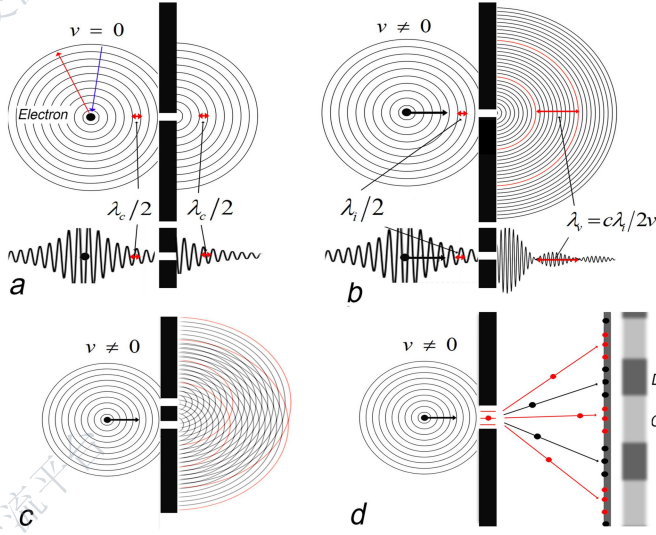


Figure 1. Electronic wave phenomena. (a) The EIW of a stationary electron (standing wave) interacts with a small aperture, generating a secondary hemispherical wave on the right side of a fixed screen. The lower panel illustrates the corresponding variations in wave amplitude. (b) The EIW of a moving electron, along with its wave medium, passes through an aperture, generating an additional motion-related wave (MRW), indicated by red semicircles. (c) Double-slit interference pattern. (d) Electron diffraction pattern. In regions of constructive interference (CI) on the screen, a higher number of electrons are activated (denoted by red dots with a higher radiation), whereas in regions of destructive interference (DI), more electrons remain inactive (denoted by black dots).

2.2 Motion-Related Waves of Electrons

The standing wave formed by EIW exhibits an amplitude distribution with alternating local maxima and minima, separated by a characteristic distance $\lambda_i/2$ as given by relations (2) and (4). When an electron moves toward a stationary target particle with speed v , the frequency f_v at which these maxima reach the target is directly proportional to v and inversely proportional to $\lambda_i/2$ (see Figure 1b). These periodic disturbances introduce an additional frequency component f_v to the target, If the target reflects the disturbances, it generates a reflected wave of the same frequency; alternatively, if the target particle acts as

a secondary wave source by absorbing and re-emitting energy, it emits a secondary wave.

Both the reflected and secondary waves, having frequency f_v , and originating from the relative motion between the electron and the perturbed target, are collectively defined as the electron's motion-related wave (MRW). The MRW propagates at the speed of light, and its

70 frequency f_v and wavelength λ_v are given by:

$$\begin{aligned} f_v &= 2v/\lambda_i = 2\gamma v/\lambda_c \\ \lambda_v &= c/f_v \end{aligned} \quad (5)$$

The general expression for the MRW generated by an electron is

$$\begin{aligned} \Psi_v(r, t) &= \Psi_{out}(r, t) + \Psi_{in}(r, t) \\ \Psi_{out}(r, t) &= B(r) \cos(2\pi f_v t - 2\pi r/\lambda_v) \\ \Psi_{in}(r, t) &= \Gamma B(r) \cos(2\pi f_v t + 2\pi r/\lambda_v - \alpha) \end{aligned} \quad (6)$$

Where r is the radius vector from the electron or the target particle and α is the phase

75 difference between the inward wave and outward waves. Usually, reflected waves from particles have a half-wave delay.

Essentially, the MRW generated by electrons is a modulated wave carried on EIW. The modulated wave can be written as:

$$\begin{aligned} \Psi_v(r, t) &= \Psi_{out}(r, t) + \Psi_{in}(r, t) \\ \Psi_{out}(r, t) &= A(r)[1 + m \cos(\pi f_v t - \pi r/\lambda_v)] \cos(2\pi f_i t - 2\pi r/\lambda_i) \\ \Psi_{in}(r, t) &= \Gamma A(r)[1 + m \cos(\pi f_v t + \pi r/\lambda_v - \beta)] \cos(2\pi f_i t + 2\pi r/\lambda_i) \end{aligned} \quad (7)$$

80 Where m is the modulation coefficient.

Typically, the MRW between an electron and its disturbing target forms a partial standing wave along their connect line. In diffraction and interference setups, the MRW generated by small apertures is a radical wave, with the apertures treated as secondary wave sources (Figure 1. a, b and c). This framework provides a comprehensive explanation for the
85 observed double-slit interference and single-slit diffraction patterns, applicable both to ensembles of many electrons and to individual electron events. When electrons move perpendicularly to a stationary screen with two adjustable slits (see Figure 1c), each electron passes through one of the two slits. However, the MRW associated with each electron,

together with its EIW, splits into two coherent components that simultaneously pass through both slits.

Furthermore, the wavelength λ_v of the MRW can be experimentally determined through stationary interference or diffraction experiments performed along the electron's direction of motion (see Figure 1c and 1d). The magnitude of the relativistic electron's momentum can be determined via the following important relation:

$$p = mv = m_0 c \lambda_c / 2 \lambda_v \quad (8)$$

Where m_0 is the rest mass of the electron³.

Relation (8) suggests that the MRW is analogous to the matter wave of the electron as originally proposed by de Broglie. Therefore, we may write the inherent wavelength

$\lambda_c = 2h/m_0 c$, where h is Planck constant. Rearranging relation (8), we obtain:

$$p = h / \lambda_v \quad (9)$$

Which relates the electron's momentum to its wavelength.

2.3 Motion State of Photons Emitted by Electrons

In this section, we characterize photons by first describing the process by which electrons emit photons under specific conditions. Consider an electron that emits a photon along its direction of motion. During this emission, the electron's relativistic mass, speed, and the wavelength and frequency of its MRW change from initial values m_1, v_1, λ_{v_1} , and f_{v_1} to

final values m_2, v_2, λ_{v_2} , and f_{v_2} , respectively. The magnitude of the emitted photon's momentum can be indirectly obtained from the following expressions:

$$\begin{aligned} p_p &= h / \lambda_{v_1} - h / \lambda_{v_2} \\ p_p &= \Delta m c \end{aligned} \quad (10)$$

Here Δm is defined as the relativistic mass of the photon.

Furthermore, we interpret this emission process from the perspective of the EIW. In this picture, the standing wave of the EIW can store energy by increasing its wave amplitude. When the stored energy exceeds a certain threshold, the excess energy, together with a portion of the associated wave medium (namely, the standing wave with antinodes

115 separated by $\lambda_c/2\gamma_1$, where $\gamma_1 = 1/\sqrt{1-v_1^2/c^2}$, is emitted outward, forming the main body
of a photon (see Figure 2). Simultaneously, the electron undergoes recoil and promptly adds
a new standing wave of the EIW with antinodes separated by $\lambda_c/2\gamma_2$, where

$\gamma_2 = 1/\sqrt{1-v_2^2/c^2}$ to “the escaping photon”. The superposition of two standing waves,
observed along the photon’s propagation direction, exhibits a beat frequency

120 $\nu = 2\gamma_1 f_c - 2\gamma_2 f_c$. This superimposed wave structure serves as the signature of the emitted
photon (see Figure 2). An alternative explanation is that a “photon” is simply the
superimposition of two “escaped standing waves” from the electron, which can be treated as
pulse trains separated by c/ν and moving at the speed of light. In either case, the photon’s
energy can be indirectly estimated by:

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$$E = (m_1 - m_2)c^2 = (m_0\gamma_1 - m_0\gamma_2)c\lambda_c f_c = h\nu \quad (11)$$

Where ν represents the photon frequency.

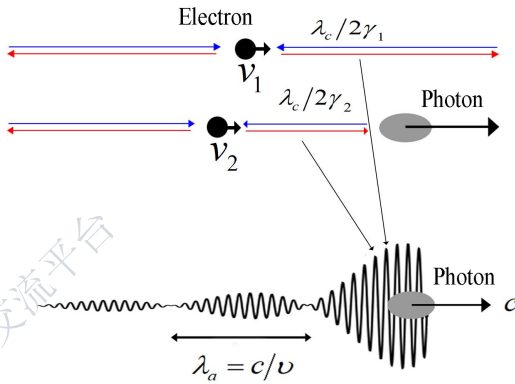


Figure 2. A conceptual illustration of a photon carrying two standing waves with a beat frequency ν .

130 Relation (10) and (11) yield $\nu = f_{v_1} - f_{v_2}$ and $\Delta m = m_2 - m_1$. We propose that equation (11)
is an analog to the Planck-Einstein relation. The energy and momentum of photons thus take
the same formal expressions as those of electrons. Based on this framework,
electromagnetic waves can be classified into two categories: 1) Regular electromagnetic

disturbances and propagation in the wave medium (e.g., EIW and MRW), which conform to the principles governing mechanical waves; and 2) Traveling pulse trains of the electromagnetic medium at light speed (i.e., electromagnetic radiation), which can travel over long distances with negligible energy loss and can induce secondary waves via their perturbations.

3. Motion State of Electrons

In the context of photon emission, the energy of a relativistic electron with motion-related frequency f_v can be described by the following important relation:

$$E = hf_v \quad (12)$$

We consider an electron as an entity whose mass is concentrated in its central region, and we model this central part as a point-like energy source. When a relativistic electron undergoes deceleration, it emits electromagnetic waves, conversely, it absorbs electromagnetic waves to maintain its dynamical equilibrium to meet $E = hf_v$. The power P of the electron is governed by the following relation:

$$P = h(\partial f_v / \partial t) = \dot{p} \cdot a \quad (13)$$

Where $\dot{p}$ is the electron's momentum and a is the acceleration. The positive P indicates

that an electron absorbs electromagnetic waves, while the negative indicates that an electron emits electromagnetic waves.

When an electron interacts with another particle, it exchanges energy via their mutual force (typically an action-reaction pair) and through emitting (or absorbing) electromagnetic waves. Suppose we apply a force to a relativistic electron, causing it to decelerate from a frequency f_v to zero (i.e., at rest). The energy E released by the electron satisfies the relation:

$$\begin{aligned} E &= W_f + E_w \\ E &= hf_v \end{aligned} \quad (14)$$

Where W_f is the work done by the mutual force and E_w is the energy transmitted via the accompany electromagnetic waves.

160 In Newtonian mechanics, the action-reaction force pair between two bodies is regarded as
 an undamped one-dimensional force, which is equal, opposite and along the shortest line
 connecting the two bodies (force line). Owing to the presence of EMW and MRW, this
 action-reaction force pair between two particles possesses wave-like features. Namely, there
 are “incident-reflected wave pairs” between the two particles. When energy exchange
 165 occurs exclusively between the two particles (i.e., no energy dissipation in the two-particle
 system), we put forward the following assumption:

***Assumption 2: the accompanying incident-reflected wave pair in an action-reaction force
 pair, can be treated as undamped waves propagating along the force line.***

We introduce the real part of a complex number to describe the above MRW denoted as
 170 relation (6) and have the following expressions:

$$\begin{aligned}\Psi_v(r, t) &= \Psi_{out}(r, t) + \Psi_{in}(r, t) & \Psi_v(r, t) &= \Psi_{out}(r, t) + \Psi_{in}(r, t) \\ \Psi_{out}(r, t) &= B(r)e^{-i(2\pi Et - 2\pi rp)/h} & \text{or} & \Psi_{out}(r, t) = B(r)e^{i(2\pi Et - 2\pi rp)/h} \\ \Psi_{in}(r, t) &= \Gamma B(r)e^{-i[(2\pi Et + 2\pi rp)/h - \alpha]} & & \Psi_{in}(r, t) = \Gamma B(r)e^{i[(2\pi Et + 2\pi rp)/h - \alpha]}\end{aligned}\quad (15)$$

Where $E = hf_v$ and $p = h/\lambda_v$.

In this paper, we adopt the first expression. Further, in accordance with Assumption 2, the
 MRWs associated with an action-reaction force pair can be expressed as

$$\begin{aligned}\Psi_v(r, t) &= \Psi_i(r, t) + \Psi_r(r, t) \\ \Psi_i(r, t) &= B(L)e^{-i(2\pi Et - 2\pi rp)/h} \\ \Psi_r(r, t) &= \Gamma B(L)e^{-i[(2\pi Et + 2\pi rp)/h - \alpha]}\end{aligned}\quad (16)$$

Where r is the radius vector with the electron or the target particle as original point, L is
 the length of the “incident-reflected wave pairs”, $B(L)$ and $\Gamma B(L)$ are wave amplitudes, and
 $0 \leq r \leq L$.

Taking the derivative of $\Psi_v(r, t)$ with respect to time in relation (15) yields the following
 180 expression with energy E in an explicit form:

$$i\hbar \frac{\partial \Psi_v(r, t)}{\partial t} = E \Psi_v(r, t) \quad (17)$$

Where $\hbar = h/2\pi$.

Taking the second derivative of $\Psi_v(r, t)$ with respect to r in relation (16) yields the following expression with momentum p in explicit form:

$$-\hbar^2 \frac{\partial^2 \Psi_v(r, t)}{\partial r^2} = p^2 \Psi_v(r, t) \quad (18)$$

For a low-speed electron, the W_f in relation (14) can be approximately estimated from the classical kinetic energy of the electron, thus, we have $\hbar f_v = mv^2/2 + E_w$. Relation (17) can

be written as $i\hbar \frac{\partial \Psi_v(r, t)}{\partial t} = (mv^2/2 + E_w) \Psi_v(r, t)$. Applying relation (18) to it yields the following expression:

$$i\hbar \frac{\partial \Psi_v(r, t)}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \Psi_v(r, t)}{\partial r^2} + E_w \Psi_v(r, t) \quad (19)$$

Where $\Psi_v(r, t)$ represents an incident-reflected wave pair of MRWs observed along the electron's direction of motion. The energy of electromagnetic waves emitted or absorbed by an electron can be estimated by the change of E_w .

4. Wave-Driving Effects

When an electron emits a wave to disturb a neighboring particle, the particle reflects the incident wave and/or acts as a secondary wave source, typically at the same frequency. The incident wave and the reflected wave superimpose to form a composite wave (an "incident-reflected wave pairs"), which in turn disturbs the electron itself in a resonant manner. Taking the standard standing wave, a representative incident-reflected wave pair, as an example, we further illustrate this disturbance. When both endpoints of the standing wave are antinodes, the disturbance exerted on both the electron and the particle reaches a local maximum. Sustaining such a standing wave requires continuous energy expenditure from the wave source, which consequently induces changes in the motion states of the

involved particles, including the wavelength of the MRW, the direction of motion, the spatial position, and the separate distance (i.e., the length of the standing wave). This influence persists until the two endpoints of the standing wave are adjusted to nodes. An electron can minimize the disturbance caused by its own standing wave by adjusting its motion states. To formalize this behavior, we propose the following assumption regarding the standing wave:

Assumption 3: The standing wave drives its disturbing particles to distribute at nodes as much as possible.

We refer to this phenomenon as the driving effect of standing waves. A key question then arises: how can this effect be quantified?

In our basic assumption, we introduced the concept of electronic excitation. Here, we characterize the excitability of an electron in terms of its power. Suppose the electron appears randomly and is observed within a region R at discrete times $t_1, t_2, \dots, t_i, \dots, t_n$, with corresponding instantaneous power values $P_1, P_2, \dots, P_i, \dots, P_n$. We calculate its average

power as $\mu = \frac{1}{n} \sum_{i=1}^n P_i$ and define the disturbing function of the electron in region R as

$D(t_i) = P_i - \mu$. To characterize the disturbing variation of the electron, we introduce a

measure based on the statistical variance $\sigma^2 = \frac{1}{n} \sum_{i=1}^n [P_i - \mu]^2$. When the region R shrinks to

a position r , we denote the disturbing function by $D(r, t) = P(r, t) - \mu(r)$, where $\mu(r)$ is the

average power of the electron at position r . If the power $P(r, t)$ varies with a fundamental

time period T_0 , the disturbing function and the disturbing variation can be expressed as:

$$\begin{aligned} D(r, t) &= P(r, t) - \mu(r) \\ \sigma^2(r) &= \frac{1}{T_0} \int_0^{T_0} D^2(r, t) dt = \frac{1}{T_0} \int_0^{T_0} P^2(r, t) dt - \mu^2(r) \end{aligned} \quad (20)$$

225 Where $\mu(r) = \frac{1}{T_0} \int_0^{T_0} P(r, t) dt$.

Next, we discuss the excitability of a wave source at position r . When the power originating from position r is the cumulative contribution of different particles appearing at that position, we treat the position r as a point-like energy source (or sink). Given the energy current density at the source is $s(r, t) = d(r, t) + s(r)$, where $s(r)$ is the time-averaged value, the disturbing function and the disturbing variation can be described as:

$$\begin{aligned} D(r, t) &= \nabla \cdot s(r, t) - \nabla \cdot s(r) \\ \sigma_s^2(r) &= \frac{1}{T_0} \int_0^{T_0} [\nabla \cdot s(r, t)]^2 dt - [\nabla \cdot s(r)]^2 \end{aligned} \quad (21)$$

Where $\nabla \cdot s(r)$ is the average volumetric power density of the source and T_0 is the fundamental time period of $s(r, t)$.

Similarly, for a wave $\Psi(r, t)$ with time-averaged value $\Psi(r)$, we define its disturbing function and disturbing variation as:

$$\begin{aligned} D(r, t) &= \Psi(r, t) - \Psi(r) \\ \sigma_A^2(r) &= \frac{1}{T_0} \int_0^{T_0} \Psi^2(r, t) dt - \Psi^2(r) \end{aligned} \quad (22)$$

We use the disturbing variation in relation (22) to indicate the wave-driving effect. In relation (22), $\sigma_A^2(r) = 0$ indicates that the wave-driving effect is minimal (zero). For simple harmonic waves, it immediately follows that the disturbing variation $\sigma_A^2(r)$ is proportional to the square of the wave amplitude.

5. Evolution of Particle Systems

In an atomic system, electrons mutually disturb one another by generating electromagnetic waves, which results in energy dissipation. Energy dissipation drives the system to proceed toward a stable configuration with minimal disturbances (or interactions) both internally and with the external environment. When a particle system evolves to an equilibrium state in which the time averages of all characteristic parameters remain stable and unchanged, we define this system as an ideal particle equilibrium system. We accordingly propose the fourth basic assumption regarding this evolutionary tendency:

Assumption 4: In an ideal particle equilibrium system, particles select motion states that minimize their excitability.

We regard a stable atomic (or molecular) system in thermodynamic equilibrium as our ideal particle equilibrium system. Based on these considerations, we derive the following important conclusions for determining the motion states of its electrons.

Conclusion 1: The average power μ and disturbing variation σ^2 of an electron have the following relations

$$\begin{aligned}\mu &= 0 \\ \sigma^2 &\leq \sigma_c^2\end{aligned}\quad (23)$$

Where σ_c^2 is the critical value of the disturbing variation that maintains the equilibrium of the system. Relation (23) characterizes the evolutionary trend of a particle in a stable atomic (or molecular) system.

Conclusion 2. An electron attains its minimal excitability at the spatial positions satisfying:

$$\begin{aligned}\nabla \cdot s(r) &= 0 \\ \sigma_s^2(r) &= 0\end{aligned}\quad (24)$$

Where $\nabla \cdot s(r)$ is the average volumetric power density at position r . In the paper, the spatial positions determined by relation (24) are designated as equilibrium positions. Electrons are preferentially distributed at and near their equilibrium positions.

6. Theoretical applications

6.1 Electromagnetic Fields Generated by Electrons

We believe that a disturbance analogous to that described by the EIW also exists in the inherent electromagnetic field of an electron. Hence, the charge of an electron “oscillates”.

We extend this parading-shifting concept to Coulomb's law. The charge and the inherent electric field of a stationary electron are expressed as:

$$\begin{aligned} q_e &= -[1 + \eta_0 \sin(2\pi r/\lambda_c) \sin(2\pi f_c t)]e \\ E_0(r, t) &= [1 + \eta_0 \sin(2\pi r/\lambda_c) \sin(2\pi f_c t)]E_0(r) \end{aligned} \quad (25)$$

Where r is the radius vector with the electron as origin, η_0 represents a proportionality factor, e denotes the average charge of the electron, which is constant ⁴, and $E_0(r) = -(ke/r^3)r$ denotes the time-averaged value of the electric field at position r . The

q_e is the charge of an electron measured at position r .

In general, when an electron passes through position R^{**} at a low speed v , the electromagnetic field at position r established by the electron can be approximately evaluated by

$$\begin{aligned} E(r, t) &= [1 + \eta_0 \sin(2\pi |r - R^{**}|/\lambda_c) \sin(2\pi f_c t)]E(r) \\ B(r, t) &= \frac{1}{c^2} v \times E(r, t) \end{aligned} \quad (26)$$

This oscillatory nature of the electron charge and the electromagnetic field can also provide a novel explanation for the tunneling effect of electrons.

6.2 Quantization of Energy Levels Based on Wave-Driving Effects

We describe waves in terms of variations in energy flux density. With reference to relation (21), the perturbation function of a spatial wave can be expressed as

$D(r, t) = \nabla \cdot s(r, t) - \nabla \cdot s(r)$. When stable incident-reflected wave pairs exist within a particle system, they give rise to local extrema in the spatial distribution of energy flux density. When the particle system evolves into an ideal particle equilibrium system, according to relations (23) and (24), the following relation can help us determine the most probable spatial distribution positions of the particles:

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$$\begin{cases} \nabla \cdot s(r) = 0 \\ \frac{\partial \sigma_s^2(r)}{\partial r} = 0 \\ \sigma_s^2(r) \leq \sigma_c^2 \end{cases} \quad (27)$$

Particles are preferentially distributed at local minima determined by relation (27). In these spatial positions, their quantities such as energy and momentum exhibit discretization (discontinuous distribution).

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In an atomic system in thermodynamic equilibrium, all incident-reflected wave pairs among particles evolve toward standard standing waves and drive their disturbing particles to distribute at nodes as much as possible ($\sigma_A^2(r) = 0$). Electronic waves include at least EIW and MRW. Here, we focus on the MRW of electrons in conservative potential fields. The energy conversion of a low-speed electron is described by $E_t = mv^2/2 + U(R^{**})$, where E_t denotes the total energy of the electron and $U(R^{**})$ represents its potential energy at position

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R^{**} . Applying relation (18) to it to obtain the expression of MRW:

$$[E_t - U(R^{**})]\Psi_v(r, t) = -\frac{\hbar^2}{2m} \frac{\partial^2 \Psi_v(r, t)}{\partial r^2} \quad (28)$$

Where $\Psi_v(r, t)$ denotes the incident-reflected wave pair of the MRW created by the electron at position R^{**} .

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Several representative incident-reflected wave pairs are presented in Figure 3. When these pairs evolve into standard standing waves whose lengths satisfy $n\lambda_v/2$, $n=1, 2, 3, \dots$, the wave-driving effect of MRW becomes minimal.

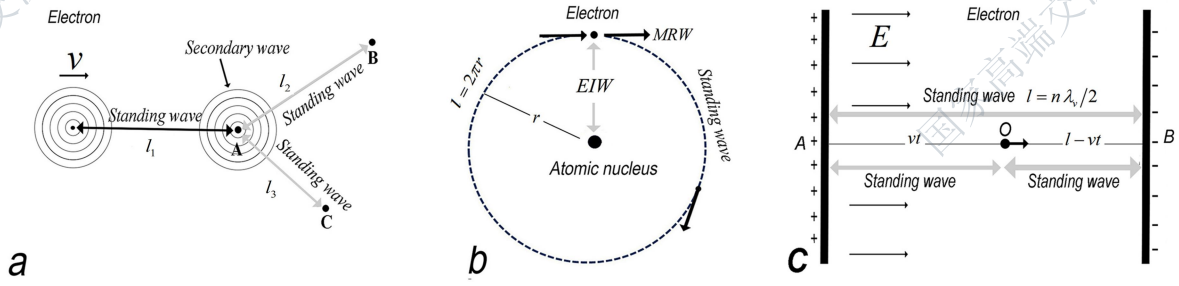


Figure 3. Typical MRWs and their standing waves. (a) A moving electron disturbs charged particle A to produce a secondary wave, which further forms standing waves with particles B and C. (b) Circular standing waves of the MRW formed by an orbiting electron. (c) Standing waves of the MRW generated by a moving electron between two parallel charged plates.

6.3 Electronic Distribution and Its Detection Probability

The electron diffraction experiment⁵ provides key evidence for wave-particle duality and matter wave, suggesting that the diffraction pattern of electrons represents their actual distribution in space. However, our explanation for this experiment differs slightly. When a particle randomly appears at a certain position r at probability $\text{Pr}(r)$ and power $P(r)$, we regard this site as an energy source, and we have:

$$\nabla \cdot s(r) \propto \text{Pr}(r)P(r) \quad (29)$$

Where $\nabla \cdot s(r)$ is the average volumetric power density contributed by the particle. The negative values of $\nabla \cdot s(r)$ and $P(r)$ mean that the particle releases energy.

An alternative explanation is suggested for the electron diffraction experiment. We detect electrons through the electromagnetic waves they radiate. When electrons are in regions of constructive interference of the diffraction wave, they are disturbed to radiate at a higher level and more of them become active electrons (i.e., detectable electrons with higher $P(r)$), thereby highlighting these regions. Consequently, the distribution pattern of active electrons exactly matches the diffraction pattern of the wave (see Figure 1d). Furthermore, the uncertainty principle for particles⁶⁻⁸ can be explained by the disturbance arising from their inherent waves and various motion-related waves. For example, when an electron passes

through a slit of appropriate size (see Figure 1d), its EIW and/or MRW are reflected from the inner wall of the slit, causing self-disturbance. As the electron exits the slit, both its speed and position distributions become dispersed. Typically, if the inner wall of the slit is regular and smooth, the electrons will follow a regular deviation from their original path and reach the receiving screen, forming a specific regular pattern. In our framework, the actual probability distribution of electrons ($\Pr(r)$) and the detection probability distribution, which is related to the detection method and the particle's own effects, are treated as two separate concepts.

Summary

Our basic assumption posits that electrons possess an inherent wave. We propose that the concept of electronic inherent excitation should be extended to all fundamental particles. In other words, any fundamental particle can generate an inherent wave via its surrounding wave medium. Their momentum magnitudes can be calculated using $p = M_0 c \lambda_i / 2\lambda_v$, where

M_0 , λ_i and λ_v are the rest mass, the inherent wavelength, and the motion-related

wavelength of the particle, respectively. However, certain experiments⁹ appear to support extending the de Broglie relation from electrons to all particles. This extension implies that the inherent frequency of any particle should be proportional to its rest mass regardless of its size and mass, a conjecture that warrants further investigation. Our work also demonstrates that the quantization characteristics observed in quantum mechanics are mainly the result of the wave-driving effects of standing waves and the natural evolution of a system toward minimal excitability.

Competing interests: the author declares no competing interests.

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