An Understanding of the Particle-like Property of Light and Charge

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Note: This theoretical work was successful at predicting experimental results described in subsequent essays. Those experiments justify many of the claims and models used here.

ABSTRACT

In an analysis of experiments famous for particle models of light and charge, a non-classical wave model is developed to explain these particle-like properties in terms of waves. The experiments and issues examined include: charge diffraction, charge quantization, photoelectric effect, Compton effect, black body radiation, spin, and antimatter. The model has three postulates: (a) a threshold concept whereby charge, mass, and action are maximums at e, m_e, and h respectively, (b) a ratio concept whereby free space measures of e, m_e, and h will always reveal themselves in ratios e/m, e/h, or h/m, allowing components of these ratios to individually diminish as the wave spreads while the ratio value remains intact, and (c) an envelope property of the Ψ wave (Schrödinger's amplitude) whereby the envelope is full and stable with a graphic area of h. The envelope concept is developed by replacing the phase wavelength in de Broglie's equation with the group length. Some conclusions: Our constants h, e, and m_e, can only be independently measured in atoms or collisions where the envelopes are full, but not in free-space diffraction, or in deflection experiments. The particle-like properties of charge are explained with envelopes displacing each other in space as they reach threshold h. Particles of light then become an illusion of these threshold and ratio properties of the charge-wave.

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1. DEVELOPING THE MODEL

1.1. Why we need a new model

We assert that the long standing wave- particle paradox is not some inherently unsolvable attribute of nature; it is a riddle to be resolved. Toward resolving this riddle we must consider that the most respected names in the history of physics have made problematic assumptions. This paper challenges wave-particle dualism by: (a) revealing specific problematic assumptions in accepted interpretation of experiment, and (b) introducing a visualizable replacement, a Threshold-Ratio Model (TRM), or simply the Loading Theory. Where wave phenomena are observable in either light or charge, what seems like particles may be understood with non-classical wave properties. In the de Broglie-Einstein model[1] or in the Born model,[67] the wave properties are usually assigned to a guidance mechanism of particles. These particles, properly called quantum mechanical particles, typically maintain a classical particle nature while being guided by a strange non-physical probability wave. It is apparent in

writings of the founders of quantum mechanics, that after acknowledging wave properties, they revert to describing particles with a greater reality than waves. Authors will often assume a particle exists prior to a detection event. Written discussion of this profound assumption are rarely satisfactory, and the issue is usually ignored with immediate reference to *the particle*. You do not usually read about the particle nature of waves, you read of the wave nature of particles. We are dealing with a *particle biased mindset*. This particle-bias has profoundly altered our interpretation of experiment. To avoid confusion a few definitions are required. In the context of conventional theory, the words "photon" and "electron" imply particles in a dualistic (quantum mechanical) sense where the particle is somehow guided by a wave. In the context of TRM, instead of "photon," it is best to just use $h\nu$, pronounced *acheNew* in honor of Max Planck who used his action constant h and the Greek letter nu (ν) for electromagnetic and charge-oscillator frequency. Please don't confuse ν with v = *velocity*. Here, an $h\nu$ of electromagnetic energy is emitted quantized, but thereafter can spread classically in space. Similarly, instead of "electron," we should talk of a special quantity of charge e, with other properties of the charge-wave to be described.

Quantum mechanical models of light and charge have great problems. If a wave guides a particle, what generates this wave? If the particle generates the wave, the field must have a center. There has never been devised a causal model whereby such a field can guide particles to create an interference pattern. If the wave were to somehow convert itself to a particle, the wave must superluminally and magically collapse[1, 2, 3, 4] (Ref. 2 pg. 39) and shrink down to the location of the particle-like event in order to maintain *particle-conservation* of matter and energy. A guiding wave-like potential could not exist independent of particles because such a potential would need to originate from these particles. In developing the concept of a wave associated with particles, Louis de Broglie[1] derived his famous relation

$$h = m_p v_p \lambda_\Psi, \tag{1}$$

where m_p is total relativistic particle mass, v_p is particle velocity, and λ_Ψ is a phase wavelength of a matter wave function Ψ. After Eq. (1) was endorsed by Einstein,[5, 6] used by Schrödinger,[7] and shown to be consistent with electron diffraction experiments,[2, 8] the equation was routinely used.[5] The mixture of wave and particle terms in Eq. (1) had inescapably preserved the conceptual difficulties of wave-particle duality in quantum mechanics. Intimately linked to the derivation of Eq. (1), de Broglie calculated a matter frequency ν_Ψ using the relations:

$$\epsilon_p = m_p c^2 = h\nu_\Psi, \tag{2}$$

where ϵ_p is total mass-equivalent energy plus kinetic energy of a particle.

Notice that this association of h with a matter-frequency ν_Ψ is very different from its use connected to any experiment; we never measure this matter frequency. When h enters analysis of black body, photoelectric, Compton effect, and other experiments, h relates to *kinetic* energy, and relates to an oscillator at a *light* frequency. The link between Planck's constant and mass-equivalent energy only entered our conceptual framework through this great leap of faith made at Eq. (2) by de Broglie. With this overview, our experiments are telling us that h is really about kinetic energy, not mass-equivalent energy. The only cases where equation (2) are correct are for light, and for pair creation/annihilation. De Broglie guessed Eq. (2) (Ref. 5 p. 517).

Using Eqs. (1) and (2), put ν_Ψ and λ_Ψ into $v_\Psi = \nu_\Psi\lambda_\Psi$. This leads to $v_p v_\Psi = c^2$, where v_Ψ is phase velocity of a Ψ matter wave. Alternatively, one can use dimensional analysis on the Lorentz transformation of time, and then extract $v_p v_\Psi = c^2$, the way de Broglie did to derived Eq. (1). However, this only works if you fail to distribute the relativistic $1/(1-v_p^2/c^2)^{1/2}$ Lorentz factor. For arbitrarily slow particles, $v_p v_\Psi = c^2$ implies arbitrarily fast Ψ velocities, an impossibility if Ψ assumes any physical properties.

Physicists accepted Eq. (2) because of this: Planck's derivation can use h with matter, Einstein's photoelectric model uses h with light, so de Broglie and others assumed that h was universal in relating frequency to energy in either matter or light. Planck and the author (ER) assert that h is about matter not light. $\boldsymbol{h}$ is about kinetic energy, not mass-equivalent energy. Near-infinite v_Ψ leads to a non-physical Ψ that supposedly guides particles. If Ψ is not physical, what is it? All this has led to a bizarre[10] metaphysical view of the world. If we assume any reality to the Ψ wave and any version of special relativity, the specific form of either Eq. (1) or (2) or both must be abandoned.

There are also problems with Schrödinger's wave function Ψ applied to the free electron. TRM embraces Schrödinger's original charge density expression $-e\Psi^*\Psi$ with its envelope of Ψ to create interacting charge elements. An objection to this charge density interpretation was put forth by Lorentz:[11] a mechanism still needs to be created in order to account for the stability of free wave packets. What keeps the wave packets from spreading? In a classical wave analysis, a stable wave packet requires an infinite sum of just the right Fourier components maintained in some very artificial sense. The response to this situation has been the acceptance of Born's particle-oriented probability interpretation of Ψ. TRM offers a wave-oriented alternative by allowing a wave packet to spread out, and to load up to a threshold.

Consider the model of light particles, photons. If photons are modeled as a localized Fourier wave packet, how could they have a photon energy at $\epsilon_L = h\nu_L$, where ν_L is only one frequency of light, whereas a packet requires an infinite sum of frequencies? And obviously, if a wave is a distribution of particles, how can experiments with low "particle" rates display wave-interference? These issues and others suggest that localized intact particles of charge or light are not what is happening at all. The alternative is to develop non-classical properties of the charge-wave in order to explain particle-like effects.

1.2. Point of departure

Consider a model that leads to a modification of de Broglie's Eq. (1). For the reader to understand this modification, much history, theory, and experimental interpretation that you may have acquired in the language of quantum physics will need to be reviewed with the particle-bias removed.

Consider a model emphasizing the charge-wave difference-frequency effect evidenced in Balmer's equation of the hydrogen spectrum. Here we depart from conventional wave packets by replacing λ_Ψ in de Broglie's equation with λ_g, the half wavelength of a modulator wave M that will generate and

absorb light; see **Fig. 1**. Subscript g is for group, also called an envelope. The modulator M oscillates at the light frequency ν_L such that $\nu_L = \nu_{\Psi 2} - \nu_{\Psi 1}$, suggested by the Balmer equation. With low quantum numbers the Balmer equation places pairs of ν_Ψ too far apart to contain an envelope of Ψ cycles that actually looks like **Fig. 1**. The modulator wave exists nevertheless, and beat pictures like **Fig. 1** will be used for graphical effectiveness. Envelope length λ_g, beat frequency ν_g, and group velocity v_g, are important here because each half M cycle fits one spatial dimension of a three dimensional pulse. The pulse is described by action, charge, and mass, with maximum values at *h, e*, and m_e. These values, during the atom's non-transition state, only need to occupy a single spatial dimension in an envelope of length λ_g. If the longitudinal component of this charge-wave is wrapped around an atomic nucleus (a loading center), the transverse component is available to extend to neighboring atoms in space. In most applications below, we may describe a sample section of the wave function as a non-complex sine wave traveling in the *x* direction, $\Psi(x, t) = \sin 2\pi[(x/\lambda_\Psi) - \nu_\Psi t]$. Incorporating these ideas, we postulate a replacement for Eq. (1) in the case of the charge-wave as:

$$h = m_e v_g \lambda_g . \qquad (3)$$

The wavelength of the group was considered in G P Thomson's book[73], *The Wave Mechanics of Free Electrons*, page 127. He explains that removing the high frequency component and using only the

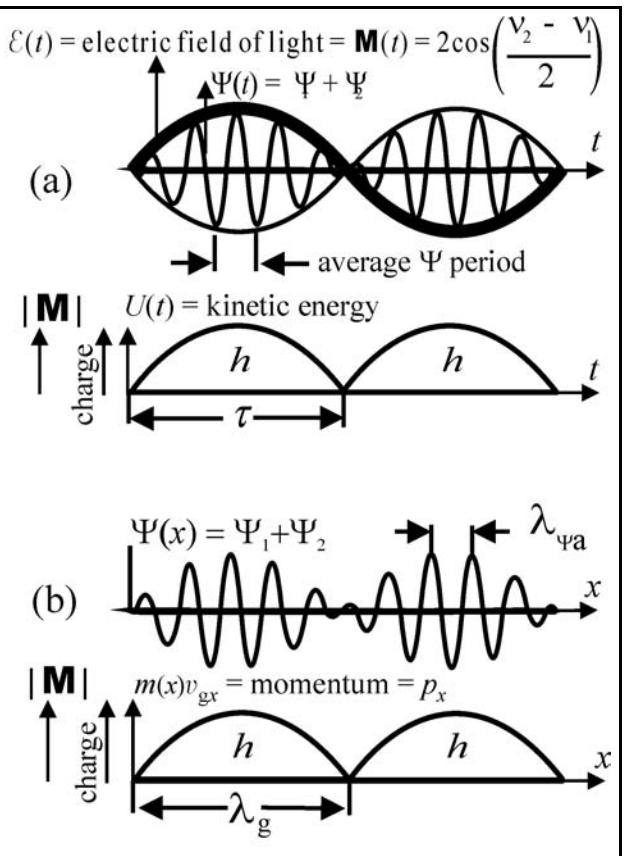


Fig. 1 Charge wave in one dimension.
(a) Time graph. (b) Space graph.

heterodyne wave does not affect the motion of "particles." In other words, either wavelength definition (λ_g or λ_Ψ) would be consistent with experiment.

In order to explain a charge diffraction pattern constructed from a summation of single events, we allow the charge-wave to spread out and lose intensity in spherical waves to an arbitrarily feeble "zero-point" level. A great insight was offered by Planck in his "second theory."[12-18] There, instead of using energy strictly quantized at $h\nu$, energy was limited to a maximum at $h\nu$. Continuous values of energy were internally allowed but not detected, as in Planck's drawing reproduced in **Fig. 2**.

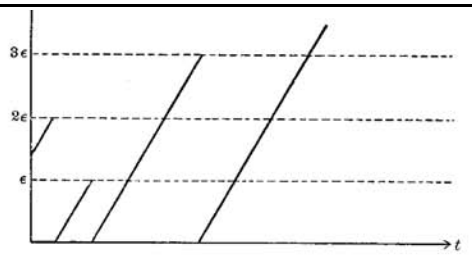


Fig. 2 From Theory of Heat Radiation, Planck Published by Dover.

Unfortunately, this idea was rejected by the scientific community and even questioned by Planck himself,[15] perhaps because this theory was never developed to explain the photoelectric effect. If this threshold concept is applied to our seemingly fixed constants, it solves the puzzle. In TRM, action, charge, and mass all may attain their maximum value h, e, and m_e per Ψ envelope (a beat) for each dimension of space. Our physical constants h, e, and m_e will still have individual meaning, but they are properties of the full Ψ envelope associated with measurables in atomic and collision phenomena.

With spherical wave fronts, if we keep velocity and wavelength intact, the action per volume, charge per volume, and mass per volume must all thin out. It might then seem impossible for a wave model to explain particle-like effects. The problem is handled by recognizing ratios in our equations of free-space electron experiments. Equation (3) makes more sense in free space after recognizing a constant[4] $Q_{h/m}$ = (action/mass) = h/m_e such that $Q_{h/m} = v_g\lambda_g$. Similarly, for other phenomena in free space, we require constants $Q_{h/e}$ = (action/charge) = h/e, and $Q_{e/m}$ = (charge/mass) = e/m_e. Charge, action, and mass vary but the ratios and thresholds (the constants) are fixed properties of the wave. Physics has deciphered the constants h, e, and m_e only from experiments upon an ensemble of atoms in a solid state, such as in black body spectra and Millikan oil drop experiments. In describing those experiments these constants were independently determined and the Q ratios do not appear. When a Ψ envelope is at its maximum amplitude, at threshold, defined by $\epsilon = h\nu_L$ and $h = p\lambda_g$, it describes an electron quantity of charge, but this charge value is only independently measurable in a situation resembling solid state atoms. Independent measurement of e means that h or m is not borrowed from another experiment. At threshold one may integrate the envelope-shaped unquantized mass over one λ_g in one dimension of space in the direction of the primary velocity of the wave to derive the usual quantized electron mass. Transverse action at right angles to propagation will be used to explain

spreading waves and fields of interaction.

A charge diffraction experiment will not readily distinguish between Eq. (1) or Eq. (3). Why? Because electron diffraction relies on Bragg diffraction which uses half wavelengths constructively interfering, and half wavelengths have the same shape as wave envelopes. Using Eq. (3), the above Q ratios, and $eV = m_e v_g^2/2$, where V = electrical potential (volts), the usual experimental equation can be re-expressed: $\lambda_g = d \sin\theta = (h/m_e)(2eV/m_e)^{-1/2} = Q_{h/m}(2VQ_{e/m})^{-1/2}$. Q ratios allow charge-waves to thin out and diffract. The threshold values (h, e, m_e) explain particle-like effects. Use of λ_g is consistent with v_g. For m_e, a resistance to acceleration of a full wave envelope is just as valid as particle mass. The mass constant need not be interpreted as a particle because it is in a ratio with other constants. Our constants can be interpreted as maximums.

Equation (3) is consistent with Eq. (1) in the special case of a standing wave in an atomic orbital. In a standing wave $\lambda_g = \lambda_\Psi/2$. This factor of two is not noticed as an error in Schrödinger's mechanics because in a standing wave, energy is contributed from two Ψ wave components going in opposite directions. The two types of envelope, the beat and the standing wave, either part-of or free-of an atom, are seemingly molded by the same internal mechanism: the maximum action in a one-dimensional envelope is h, and the maximum action in a three dimensional envelope is h^3. To picture action in three dimensions (three directions), mark space in a three dimensional grid of action envelopes. The maximum action per spatial dimension in this theory is h.

One may protest: *the author is not being fair to remove the particle, because we measure only particle events, not waves, and therefore there is just as much evidence for particles as for waves, which forces dualism.* If history has shown unfairness, it has been at the expense of a wave interpretation. A particle existing in time before an event is only a popular assumption. The method of adding properties to the wave to explain particle-like properties is long overdue. The treatment is symmetrical (fair) because we do not just abandon the particle-component of quantum mechanics, we also abandon the probability wave. In developing the non-classical wave we can describe its properties in a combination of semi-classical visualizable terms, something quantum mechanics does not do, and we make progress. We are not giving up particles altogether. The loading centers are particles and they can remain stable at a threshold state. We are exploring a model where matter has two states: (1) a wave state where the matter-wave can spread out indefinitely, and (2) a particle state where the internal wave structure holds itself together. This is different from quantum mechanics where a particle has wave properties.

Is there a non-linear medium to mix in? The Balmer formula clearly points out a simple difference-frequency relationship, not non-linear mixing. There may indeed be a non-linear function to be developed that causes envelope functions. Non-linear mixing would deliver a frequency twice as high. There *is* a twice-high frequency: that of the occurrence of beats. Examine the modulation term found in a simple trigonometric identity [see Eq. (7)]; this first step requires no non-linear medium. Admittedly, there are strange non-classical and non-linear effects here, and a non-linear treatment may be required to explain the inner nature that causes a matter-wave to form beats and envelopes.

1.3. Shot noise

If each half of the modulator wave defines a one dimensional charge envelope, the density of charge will pass by in a beat shaped pattern, as shown in **Fig. 1.** An experiment confirming beat shaped electron waves is revealed in the analysis of shot noise in electron tubes. The equation developed by Schottky[20] for the maximum current in shot noise is

$$I_n = (2I_a e/\tau)^{1/2} \qquad (4)$$

where I_a is average current, and τ is sampling time. To understand shot noise, make τ the smallest allowable time, the time of one λ_g of action, one beat. Then e/τ becomes the current of one beat, which also equals average current, $e/\tau = I_a$. Solving for average current yields $I_a = I_n/\sqrt{2}$. This is the amount of pulsation expected from beat shaped waveforms. Therefore shot noise may be readily interpreted as a direct expression of the charge-wave modulator function implied by Eq. (3).

Shot noise has also been used as a method[21] of determining *e*. Electron and photon particles are often called upon to explain pulses from a photomultiplier tube (PMT), but here also shot noise has been shown[22] to be the primary noise source. It is the beat shaped envelope of the charge-wave interacting with atoms in the anode that generate this noise. In this argument, we are not sure whether the noise originates from whole charge-wave beats leaving the cathode, or from beats reaching threshold at the anode, or from both.

1.4. Compton Effect

A wave-oriented derivation of the Compton effect further justifies the concept of Eq. (3). A wave derivation was outlined by Schrödinger,[23] and Allis,[32] and was also described by Compton and Allison[9] using the usual de Broglie equation. Compton and Allison describe a set of standing waves that acts like a moving Bragg diffraction grating. The problem with their method is that a standing wave requires two oppositely traveling components, and the backward traveling component was theorized using stationary charge-waves in a moving laboratory frame of reference. Such a laboratory-frame charge-wave can be going in any direction and will add to the forward component charge-wave to create only a very weak standing wave. The use of forward-moving wave groups implied by Eq. (3) removes this problem.

Referring to **Fig. 3**, charge may be from any source, free or bound, but may be accelerated by an incident x-ray in one direction. We use the standard Bragg diffraction equation $\lambda_L = 2d \sin(\phi/2)$. From Eq. (3), the spacing of a diffraction grating, made of charge beats is $d = \lambda_g = h/(m_e v_g)$; put this into the Bragg equation. Solve for v_g and insert in the Doppler shift equation $\Delta\lambda_L/\lambda_L = (v_g/c) \sin(\phi/2)$. Simplify using trig identity $\sin^2\theta = [1 - (\cos 2\theta)]/2$ to yield $\Delta\lambda_L = (h/m_e c)(1 - \cos\phi)$, which is the Compton effect equation.

The Compton effect is popularly taught using conservation of particle momentum to convey that this effect is strong evidence for particles. The only thing remotely particle-like in the above derivation were the h and m_e terms. Notice we have the ratio $h/m_e = Q_{h/m}$, and that allows action and mass to individually thin-out (lower amplitude) while the ratio itself is preserved. We do not measure h or m_e in the experiment; only the ratio. So the *message of the experiment* should be written $\Delta\lambda_L = (Q_{h/m}/c)(1 - \cos\phi)$**.** The particle-like property is manifested when the wave reaches the h threshold value, and the wave property is expressed by the Q ratio being preserved while the wave spreads out.

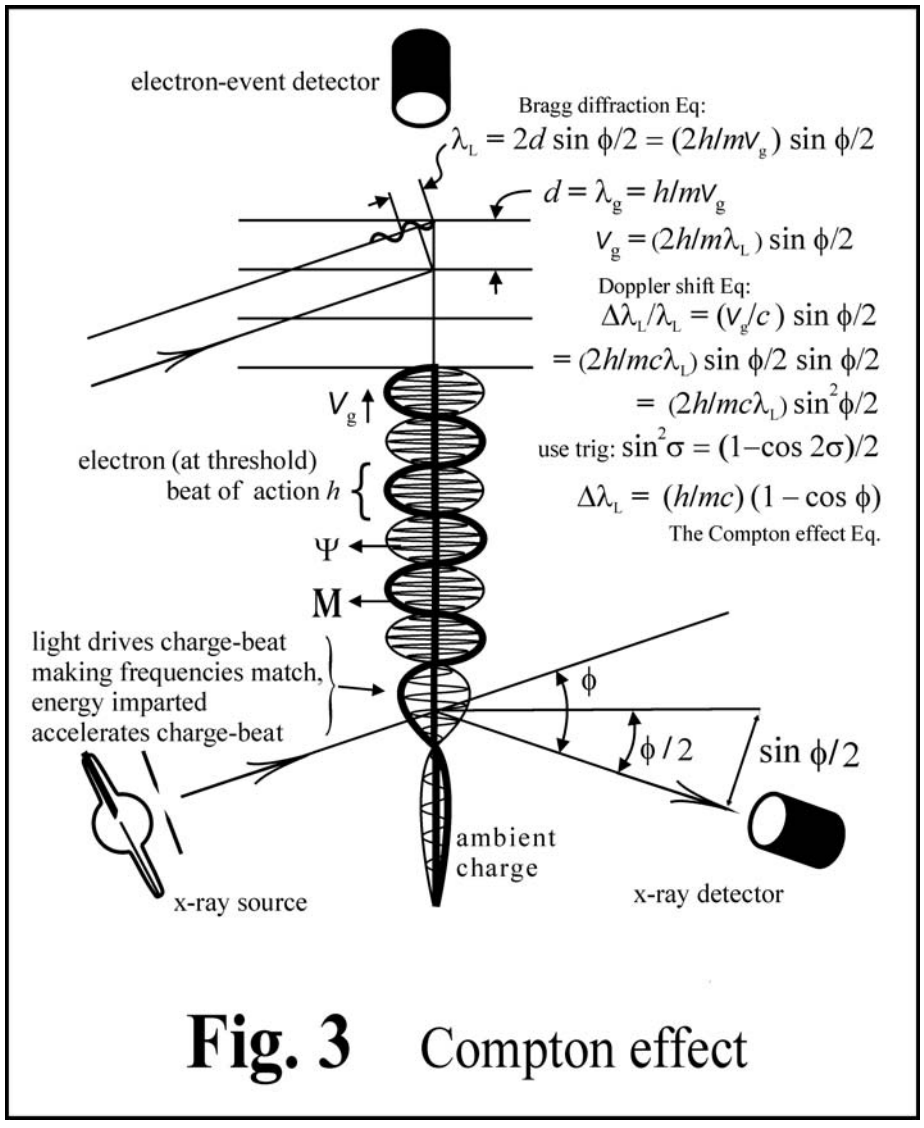


Fig. 3 Compton effect

A famous test involving the Compton effect is the experiment of Bothe & Geiger,[9, 24, 25] where a scattered electron event and an x-ray arrival event are simultaneously detected after an x-ray beam interacts with hydrogen. The experiment was designed to detect simultaneous events and was intended to test a semi-classical model developed by Bohr, Kramers & Slater.[26] The theory of Bohr et al was about spherical x-ray wave fronts that induced electron events on a statistical basis whereby momentum was only conserved on the average and not for each electron event. The statistical nature of the theory predicted that electron events would not be synchronized with photoelectron events. The results of the

Bothe-Geiger experiment showed that the rate of synchronized events happened more often than chance, but not as often as would be expected from a purely particle model either. The partial particle-like results of the Bothe-Geiger experiment was enough to shoot down the Bohr et al model, and all writings afterward took on an even stronger particle-biased attitude. But take notice: the assessment by Bothe and Geiger[25] was only reservedly in favor of the particle model of Compton, since their data showed that only sometimes the events are synchronized, and mostly they are not. From the Bothe-Geiger experiment,[9, 124, 25] approximately only one in 2000 events were simultaneous before calculating detector inefficiency, and the corrected rate is 1/11. If it really was particles this rate would be higher because we already accounted for detector inefficiency. Many experiments have been done to research simultaneity in the Compton effect. Except for a 1936 work of Shankland,[25] they all[27] seemed to miss the point, and concentrated instead on how many nanoseconds within which a pair of events are simultaneous. In search, there was no report later than 1936, giving any number for the degree of simultaneity among all events.

Furthermore our literature is flooded with commentary falsely reporting that this experiment indicates a one-to-one correspondence between photon and electron events. A similar situation persists in the way the scientific community misrepresents the message of the Compton-Simon experiment.

The issue of simultaneity in the Compton effect is a good example of how the particle-bias has influenced the transmission of information from experiment to our textbooks. In the paper by Compton and Simon,[28] in their abstract they write: "It has been shown by cloud expansion experiments previously described, that for each recoil electron produced, an *average* of one quantum of x-ray energy is scattered by the air in the chamber." Amazingly, Compton[29] and many authors afterwards, did not accurately relay the message of this experiment to us. They[29] told us that momentum is conserved in *each* detector event, like colliding classical particles. A billiard-like model is unfounded because the *average* nature of the effect is demonstrated by the high rate of non-simultaneous events recorded in both the Compton-Simon and the Bothe-Geiger experiments.

1.5. Derivation of the photoelectric effect equation

Our alternative to the de Broglie equation provides for a better derivation of the photoelectric effect equation. If one attempts to use the de Broglie-Einstein equations to convert from $\lambda_\Psi = h/m_p v_p$ to $h\nu_L = m_p v_p^2/2$ there is a factor of two error. Towards resolving this problem, recall Balmer's 1884 equation for the hydrogen spectrum, and write it in its most simple form,

$$\nu_L = \nu_{\Psi 2} - \nu_{\Psi 1} \qquad (6)$$

where ν_L is the usual light frequency and ν_Ψ are matter wave frequencies. This suggests that the frequency of light is a result of internal atomic difference frequencies. Theories of difference frequencies and beats in the atomic electron have been explored,[7, 30-32] most famously by Schrödinger,[74] and also by Allis & Müller,[32] who accepted de Broglie's theory. The proposed TRM theory has the advantage in showing how light waves can fit with charge beats: one wavelength of light covers two beats. The light wave may intersect the charge-wave via a modulation term that operates upon an average frequency term, as described by the trigonometric identity:

$$\Psi_{total} = \Psi_1 + \Psi_2 =$$

$$\cos 2\pi \left[(x/\lambda_{\Psi 1}) - \nu_{\Psi 1}\, t \right] + \cos 2\pi[(x/\lambda_{\Psi 2}) - \nu_{\Psi 2}\, t \,] =$$

$$2 \cos 2\pi \left[(x/\lambda_{\Psi a} - \nu_{\Psi a}\, t\right] \cos 2\pi[\Delta(1/\lambda_{\Psi})\, x/2 - \Delta\nu_{\Psi}\, t/2 \,] \quad (7)$$

Here the "a" subscript refers to an average frequency and wavelength. Referring to **Fig. 1 (a)**, the modulation wave fits the beat and oscillates at:

$$\nu_L = v_g /2\lambda_g = \nu_o\,, \quad (8)$$

where ν_o is a modulator-wave frequency.

Consider two Ψ waves superimposed in the same direction to form a beat wave. Equation (8) as a matter-frequency is far more useful than Eq. (2) because it shows the direct relation between light and charge-waves. From Eq. (7), the modulation of Ψ determines light frequency by $\Delta\nu_{\Psi} = \nu_{\Psi 2} - \nu_{\Psi 1} = \nu_L = v_g /2\lambda_g$ **.** In this theory light interacts with the charge-wave according to Eq. (8) in all situations, and the difference frequency phenomena observed in the atom is really due to a property of the charge-wave. For anything periodic, like our wave beats,

$$\nu_g = v_g /\lambda_g\,. \quad (9)$$

Substitute Eq. (8) into Eq. (9), and use Eq. (3) to remove λ_g to get:

$$h\nu_L = m_e v_g^2/2\,. \quad (10)$$

Equation (10) applies to the way kinetic energy is added to an electron wave in an atom during the photoelectric effect, and conversely how x-rays are produced from kinetic energy of electron waves by the Duane-Hunt rule. The derivation shows how the kinetic energy of one beat of the charge-wave is $h\nu_L$ **.** Add a potential energy term W if the wave-group escapes a potential: $h\nu_L = m_e v_g^2/2 + W$**.** Equations (3), (8), (9), and (10) are part of a self consistent base set of equations that effectively replaces the very similar looking set developed by de Broglie and Einstein (see Table 1).

In experiment we may replace the kinetic energy term with eV because only V and ν_L are measured. To visualize the photoelectric effect, write the ratio $e/h = Q_{e/h}$ in the experimental equation. With an escaping electron-wave thinning into space, the charge/action ratio is preserved.

It is informative to revisit Einstein's derivation in his "heuristic"[43] paper. It is subject to doubt because Wien's black body equation was used at its foundation, and we know that doesn't fit experiment. After experimentally substantiating Einstein's equation, Millikan wrote in 1916: "Einstein's photoelectric effect equation...cannot in my judgment be looked upon at present as resting upon any sort of a satisfactory theoretical foundation."[49] Sommerfeld in his 1928 *Wave Mechanics* says: "We must admit that Einstein's law, like the Bohr frequency condition which is related to it, is not actually derived, but is included in the basic assumptions of wave-mechanics."[70] In other words, people knew the equation worked, but were not clear as to why it worked.

A history of alternative theories of the photoelectric effect is useful. Store-and-accumulate burst-mode theories were explored by Lenard, Planck,[12, 15, 17, 18, 33] Sommerfeld and Debye,[34] and Schrödinger,[5, 7, 30] and were later called loading theories.[9, 13, 14, 35, 36] The loading theory called for a gradual accumulation of unquantized internal energy within the atom with a whole electron charge released explosively at thresholds of kinetic energy $h\nu$. Referring to a calculation of the photoelectric effect using a low intensity x-ray pulse, Sommerfeld wrote of year long accumulation (response) times which were not observed.[35] With a cooled PMT, or from the data of other[37-39] experiments, you can see for yourself that this idea [*a long response time does not exist*] is not true. Please understand that the mean time between the onset of light and current emission does increase as intensity decreases. Also the time from light-onset to stable current does increase as intensity decreases. Reported short response times quote a minimum time until the smallest detectable current. Arguments reporting a short response time only eliminate a simplistic subset of the loading theory that ignores the idea of a preloaded state. They unfairly assumed that the atom was always in the un-loaded state at time zero when the experiment started. Sommerfeld, and nearly everyone else, failed to consider the possibility of: (a) a pre-loaded state, (b) a non-particle charge release, and (c) *h* as a threshold. To his credit, Sommerfeld fully understood the conflict between the photon model and light's wave properties and wrote: "...the idea of light quanta appear quite out of the question. Modern physics is thus for the present confronted with irreconcilable contradictions and must frankly confess its *non liquet*."[35]

The reason for quantized light is quantized charge. The idea that charge is thresholded, instead of quantized, has not been found in the author's detailed search. There are flaws in experiments and the arguments behind them that claim a whole electron of charge is emitted at once. Derieux[37] using mercury drops, and Kelly[38] using non-conducting drops, balanced small charged droplets in the very same apparatus Millikan used in his suspended oil drop experiments. They irradiated the drops with ultraviolet light, and recorded apparent accumulation times before a sudden velocity change of the drop was measurable. It seems true that a whole charge is emitted at once, but it is unfair to assume that this experiment is telling us that the charge maintains itself in space outside the droplet as a particle electron. To further complicate the situation these experiments were done in air, so oxygen or mercury in the surrounding atmosphere could have easily ionized and attached to the droplet to cause the effect. We cannot tell whether the sudden change in the droplet's velocity is caused by a charge difference caused by a crash landing of an external ion, or by an emission of an electron from the drop. If it is possible to re-do the experiment in vacuum, we may learn about the loading effect. Either way, those experiments do not force the idea of a free space quantum of charge, nor does it eliminate the idea of a pre-loaded state of bound kinetic energy in a charge-wave.

Consider a model of the atom by taking the beat graph of **Fig. 1** and wrapping it in a circle. Light can excite such a full beat and add momentum to it, but more momentum cannot fit in the *h* envelope, so part or all of the atomic charge-wave must escape somehow (similar to the model of Sommerfeld 34). Consider that charge can either bleed off in sub-*h* envelopes in a continuous mode, or after a loading cycle a whole electron charge can escape in a burst-mode and spread as a directed wave. In either form of wave release, its initial frequency and velocity has been set by the charge-wave in an atomic transition where the beat difference-frequency is fixed. Notice the photoelectric effect experiment only measures ν_L and $V_{stopping}$ from which we calculate λ_g and ν_g. As energy enters and leaves atomic transition stage beats, the velocities and difference-frequencies are set, and that sets the parameters of the escaping wave.

One may protest: "*clicks" on a PMT show the particle nature of light, and these clicks make "equally loud clicks less and less often as the light gets dimmer."*[40] The reason for invoking photons is our model of electrons. If an electron has a pre-loaded state, a whole photon did not need to assemble itself from space in a collapse of the wave function. This grotesque collapsing-wave model should have guided us away from photons. We must question the assumed particle structure of free-space charge. It is only the particle *model* that says PMT clicks are particles of light. To understand the photoelectric effect in terms of its *e*/*h* ratio removes the necessity for whole electrons to be released. Also, talk of PMT clicks, as being equal clicks, is another gross misrepresentation of our experimental data. Even if monochromatic light is used, it is just not true. **Figure 4** shows the wide distribution.

One may protest: *how can a charge-wave spread out and be a wave if "the electron" is always measured quantized at e*? Some methods of measuring *e* require lots of atoms in an ensemble effect. The nuclear wave function can exert influence to give the quantized charge. This includes the Millikan oil drop, and shot noise methods. Other methods that are not an ensemble effect are in free space, and the ratio effect is at play. The Aharonov-Bohm experiment uses *e*/*h,* so if you think action is quantized, charge will be quantized also. When J. J. Thomson "discovered"[42] the particle electron he used e/m_e. If the mass is quantized the charge will be quantized. Attempts to measure *e* in free space will always find charge in a ratio with another value of the wave (*h* or m_e), and the two internal values will thin-out in proportion to cause the illusion that *e* is preserved.

In a solid state ensemble of atoms, thresholds *e*, *h*, and m_e can be stable. That is why we can independently measure these constants when free of the ratio effect. The atom favors stable and full envelopes of charge-waves. In a stable atom, charge envelopes are at full *e* and we can call the charge-wave an electron. Other conditions outside the atom, such as accelerating fields or beam collisions, can also force this full state to be reached. Here we realize that an atomic frequency is set by a full *h* standing wave of a stationary state, described by $\epsilon = h\Delta\nu_\Psi$ and $h = m_e v_g \lambda_g$, the wave shaping equations, where ϵ is the energy of an envelope of charge-wave. The transition state is a beat wave,

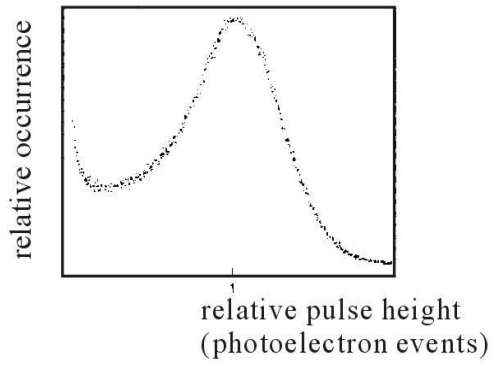


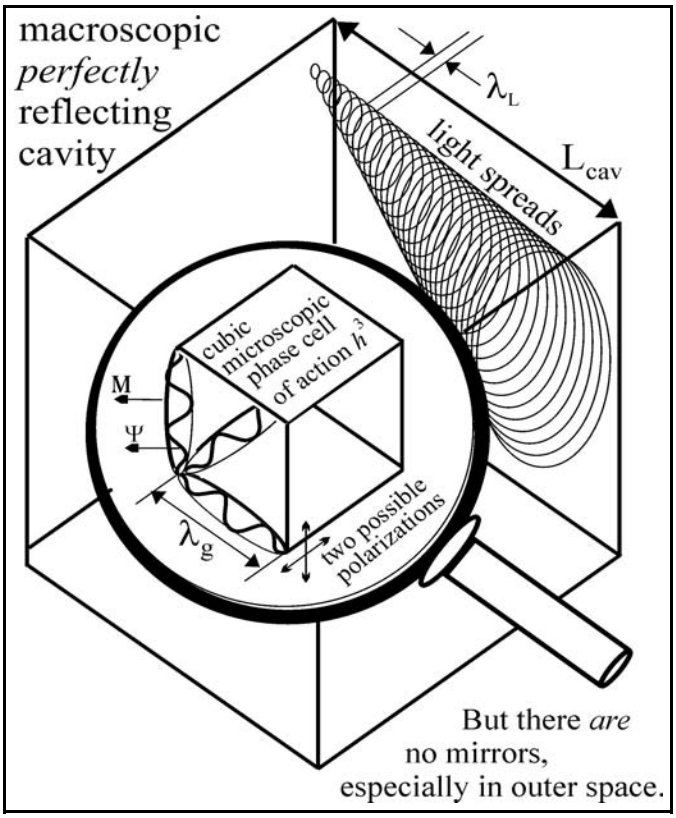
Figure 4. Typical "single electron spectrum." Resolution 67% FWHM. Peak to valley ratio 2.8:1. From *Photomultiplier tubes principles and applications*, Philips Photonics, pg 2-8 (1994).

also described by the wave shaping equations. All means of detection involve waves shaped in atoms by threshold *h*.

One may protest: *in the photoelectric effect, how can the atom respond to an arbitrary frequency if atomic frequency is quantized?* Photoelectron spectroscopy, predicted by Sommerfeld, shows resonances associated with the inner electron orbitals. The outer electron orbitals approach a continuum of available modes. Thermal Doppler shifting is another source of a continuum of difference frequencies. The phenomenon of reflection tells us that either free or outer charge-waves are flexible enough to respond to an arbitrary optical waveform.

In Schrödinger's first famous paper[7] he described how zero-point action in the charge-wave is required to make a beat model of the atom work. The beat is the transition stage during absorption and emission with an envelope that couples to light. If a wave function is in the ground state, for light to stimulate the atom there must be a residual envelope at the difference frequency. A so-called zero-point action expresses itself as a weak envelope for light to interact with, in the atomic electron during a transition. Earlier treatments using beats[30-32] did not identify this function of zero-point action. TRM provides a platform for developing an intermediate state in atomic transition theory, whereas quantum theory specifies that there must be no intermediate energy (or action) state.

Amazingly, the success of equations born from thinking like a particle made us think the world really is dualistic.[2, 40, 41, 43] We show by example that a non-dualistic model can guide us to the same equations.



1.6. Planck's black body radiation equation

Concerning Planck's black body distribution, many derivations and experiments relate to a light cavity, but this does not mean the phenomenon relies on a property of light. Conventional experiment and theory will employ a macroscopic light cavity, measure its size, and then use the velocity of light in a calculation that fits experiment. With microscopic Hertzian oscillators, an experimental determination of size and velocity require additional theory and assumptions. However, that is no excuse to abandon the microscopic method and revert to standing waves of light. Black body radiation can occur without a light cavity under conditions of thermal equilibrium (absorption = emission). In equilibrium the maximum number of transition states are in progress at its temperature. The cavity construct is for maximizing the surface area coupled to light and for measuring its diameter in experiment. It may be argued that natural black bodies use the space between atoms in lieu of a light chamber. However, in cosmic microwave background (CMB) radiation, the standard model calls for standing waves of light, quantized in a bizarre photon argument, reflecting between atoms in the vast chaos of space. The fact that we measure a Planckian distribution for CMB implies the standing wave of light derivation must be abandoned. For that photon derivation to make sense there would need to be perfect mirrors at the edge of the whole universe to set up standing waves. Quantum enthusiasts preach CMB is evidence of leftovers from the big bang. There are other ways to explain things. A Doppler red shift does not force a big bang model. A red shift can be explained by gravitational or Compton effects. There are red shifts in parts of galaxies that are not explained by a Doppler shift (reported by Arp).

Data analysis does not easily imply a single model, especially when arguing from a paradoxical platform. In a black body lab experiment there are no mirrors and no standing waves of light. Light spreads spherically and will not reinforce in a standing wave except under extraordinary laser-perfect conditions. Transitions between energy states of matter generate light, and that is what the derivation should describe.

Planck derived his distribution many ways, including standing waves of light, but most of his methods were modeled upon oscillating charges.(12) Unfortunately, Planck did publish in his last book, *Theory of Heat* (1932), a derivation employing standing waves of light.

The derivation by TRM of the black body spectrum uses standing waves of charge, in a simple modification of a popular photon-oriented derivation by Bose. Here we recognize that beats of momentum will pulse in half wavelengths of the modulator wave M, and that the frequency of light is due to this material modulator wave. Therefore the frequency of light equals the frequency of a charge oscillator, $\nu_L = \nu_o$, where the o subscript is for wavelengths of the charge-wave at $2\lambda_g$. Taking an integral number n of wavelengths to equal the size L_{cav} of a cubic light cavity, write expressions for frequency of both light and charge: $\nu_L/n = c/n\lambda_L = c/L_{cav}$, and $\nu_o/n = v/n\lambda_o = v/n2\lambda_g$. Since the frequencies are equal,

$$c/L_{cav} = v/2\lambda_g . \qquad (11)$$

Here λ_g is the size of a microscopic cubic lattice of electronic phase cells (beats). We will drop subscripts on ν. The three dimensional method of Bose(44) with phase cell elements at h^3 is embraced,

except that our phase cells are in the charge-wave, not light. A number of phase cells $N(\nu)$ is calculated as the ratio of phase volume per phase cell element h^3, where (phase volume) = (spatial volume of λ_g^3) (three dimensions of momentum) = h^3**.** Momentum p_q in a spatial direction q is taken as the momentum of one beat with a transverse coupling to the optical field.

The charge-wave asymmetry that generates light is perpendicular to its direction of travel. Two dimensions of asymmetry of the charge-wave must be accommodated, since it is a transverse wave. Therefore there are two directions q of momentum to be used below in a summation. Spherical coordinates of $\rho\ \theta\ \phi$ will be used in a volume integral. Using ρ for x in Eq. (3), and from **Fig. 1**:

$$p_\rho = h/\lambda_{g\rho} = 2h/\lambda_{o\rho} = 2h\nu_\rho/v_\rho\,. \qquad (12)$$

$$\int N_q(\nu_q)d\nu_q = (\textit{phase volume})\,/\,h^3 =$$

$$\lambda_g{}^3\left(\int_{\rho=0\text{ to }\rho} p^2 d\rho \int_{\theta=0\text{ to }2\pi} d\theta \int_{\phi=0\text{ to }\pi} \sin\phi\, d\phi\right)/h^3 =$$

$$\lambda_g{}^3\,(4\pi \int_\rho p_\rho{}^2 d\rho\,)\,/\,h^3 =$$

$$\lambda_g{}^3 4\pi \int_\rho (2h\nu_\rho/v_\rho)^2\, d(2h\nu_\rho/v_\rho)\,/h^3,$$

$$\int N_q(\nu_q)d\nu_q\,/\,\lambda_g{}^3 = 32\pi\int \nu_\rho{}^2 d\nu_\rho/v_\rho{}^3.$$

Accounting for the two transverse dimensions $q = x, y$ gives:

$$\int N(\nu)d\nu/\lambda_g{}^3 = 64\pi\int \nu^2 d\nu/v^3.$$

The charge-wave representation is easily transformed back to the experimentally verifiable light-wave representation by substituting for $\lambda_g = v_q L_{cav}/2c$ from Eq. (11);

$$\int N(\nu)d\nu\,/(v_q L_{cav}/2c)^3 = 64\pi \int \nu^2 d\nu/v^3,$$

$$\int N(\nu)d\nu\,/L^3{}_{cav} = 8\pi \int \nu^2 d\nu/c^3.$$

To get energy density we multiply by Planck's expression for the average energy element $\epsilon_{ave} = h\nu/(e^{h\nu/kT} - 1)$. For this component, a more straightforward derivation than Planck's was developed by Einstein.(45)

Planck's lectures (Ref. 68 p. 160) show a similar Boltzman factor summation, that may have inspired Einstein's. Note the energy element $\epsilon = h\nu$, that Einstein modeled in this(45) paper was in matter, not the electromagnetic wave. We get the familiar equation that can be related to black body measurement:

$$U/L^3{}_{cav} = {}_0\int^\infty \rho(\nu)d\nu = {}_0\int^\infty 8\pi h\nu^3 d\nu/[c^3(e^{h\nu/kt} - 1)] \quad (13)$$

where $U = \int N(\nu)\,\epsilon_{ave} d\nu$**.** Equation (13), with c present may give a false impression that modes of light are the physical mechanism responsible for the form of the equation. Its form relates to experimental measurement not its physical mechanism. In this special case we do not use the experimental equation

to tell us the physical mechanism. Instead we use the messages from other experiments to guide us to the physical mechanism. Ignoring the experimental method is something to be done only with great caution. Here it is well justified, and it is the only such case among the key experiments treated in this essay. The reverse scenario implies that this and other experiments will need to be interpreted in terms of light particles. With this overview, the charge-wave is the less artificial physical mechanism.

In the above derivation, the concept of h as a threshold is a consistent but not a required concept. Think of transition-state beats existing at threshold h. Various derivations of the black body equation, such as those of Einstein[43, 46, 47] and Poincaré,[16] have attempted to "prove" that energy must exist only in quanta. Aside from the faulty logic of using particle oriented assumptions to "prove" a particle model, these attempts are shown invalid by Planck's second theory[12, 14, 15, 17, 18] of 1911 whereby he derived the black body distribution from unquantized energy (see **Fig. 2**). Planck's 1911 method was unquantized because it allowed sub-$h\nu$ energy to load up. Although Planck's 1911 model used quantized emission, it is not a quantum model in the modern sense of the word because he called for non-quantized absorption.

Planck's work may have seemed incomplete by others because it was not compatible with the photon model of the photoelectric effect. However, there is nothing wrong with Plank's 1911 model in the context of black body phenomena.[14, 48] If anything was incomplete it was Einstein's photon model for the photoelectric effect because of its failure to include the wave properties of light and charge. This point was elaborated upon by many greats in physics including Planck,[15,16] Bohr (Ref.16 pg. 191), Lorentz,[16] Sommerfeld,[35] Millikan,[13, 49] and Schrödinger.[30] Therefore Planck's threshold model is as good as any for black body. Also note that Planck's second theory predicting zero-point action[17] has influenced low temperature physics.

The message of the black body experiment if taken alone can be manipulated to favor models of thresholds, matter quanta, or light quanta. By expanding the threshold idea to action, charge and mass, so that it also explains the photoelectric effect, the incompleteness of the threshold model is removed. In TRM our key experiments are telling us that electronic oscillators are composed of Ψ envelopes with a threshold level described in each spatial dimension by:

$$\epsilon = h\nu_L = h\nu_o = h v_g / 2\lambda_g = h\nu_g / 2 = h\Delta\nu_\Psi \,. \quad (14)$$

1.7. Charge diffraction and proposed *wave limit relations*

A method of generating Heisenberg's uncertainty principle $\Delta p \Delta x \geq h/4\pi$ is to substitute the de Broglie equation into a Fourier wave packet equation, $\Delta(1/\lambda_\Psi)\Delta x \geq 1/4\pi$, where $\Delta(1/\lambda_\Psi)$ is the range of wave numbers and Δx is the size of the envelope. The necessity of concocting just the right infinite set of component waves to create this wave packet has always been artificial and unsatisfactory. Since TRM uses λ_g instead of λ_Ψ, it guides us away from the Fourier construct and removes that problem. We will derive an uncertainty principle in an analysis of charge diffraction similar to Heisenberg's,[2] but without particles. A plane wave beam in the z direction passes through a slit of width d; see **Fig. 5**. Fraunhofer diffraction predicts $\lambda_z = d \sin\alpha$. If you use the particle method, you would write Δp for a

deflection component of momentum that happened to a particle. Instead we write the x component of wave momentum,

$$p_x = p \sin \alpha \,. \qquad (15)$$

Here we see that an initial transverse component of momentum may be infinitely small in the case of a plane wave. However, by interacting with an aperture a transverse component becomes set as a measurable. The slit sets the wavelength in the transverse direction by constricting the length of the charge-wave in that direction: $d = \lambda_{gx} = h/p_x$. As charge is forced through a slit, the threshold effect explains mutual repulsion of like charge and will limit the current. For the electronic charge wave, such a construct lets you visualize the Pauli exclusion principle, charge repulsion in a CRT beam, and space charge. Using Eq. (3) for p in Eq. (15), and using the Fraunhofer equation, reveals

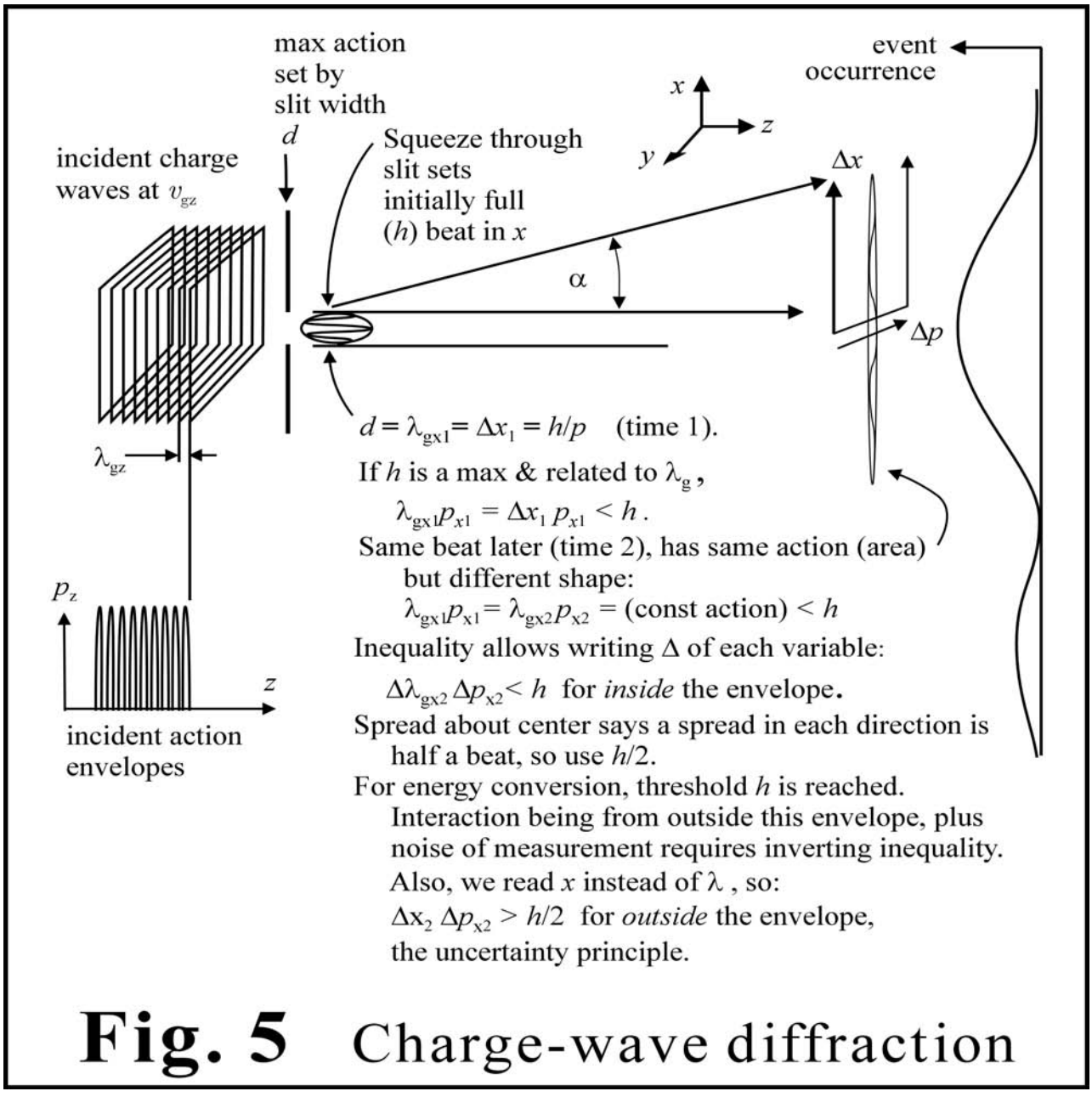


Fig. 5 Charge-wave diffraction

$$p_x = (h/\lambda_{gz}) \sin\alpha = h/(d \sin\alpha) \sin\alpha = h/d = h/\lambda_{gx} \quad (16)$$

Therefore instead of writing uncertainty of a particle we write the component of the beat in the transverse spatial dimension:

$$m_e v_x \lambda_{gx} = h\ , \qquad (17)$$

where v_x is the group velocity of Ψ waves in the x direction (the velocity of M).

Similarly, a transverse component of the wave in time may be derived using Eq. 14 ($\epsilon = h\nu_g/2$), $1/\nu_{gx} = \tau_x$, and labeling the dimension, to obtain

$$\epsilon_x \tau_x = h/2\ . \qquad (18)$$

The charge wave, as well as light, has momentum. This essay explores the idea that momentum is a property of these non-classical waves, and that particles are not necessary. We can use the ratio property $Q_{h/m} = h/m_e$ to aid in understanding how mass is distributed in the wave, and re-write Eq. (17) as:

$$v_x \lambda_{gx} = Q_{h/m}. \qquad (19)$$

Equation (18) can be similarly converted, using $\epsilon_x = m v_x^2/2$, to get

$$v_x^2 \tau_x = Q_{h/m}\ . \qquad (20)$$

Equations (17) and (18) can be converted to express limitations of measurement from noise and distortion by inserting the inequality symbol. By substituting the confining distance Δx in place of λ_{gx} in Eq. (17), and by realizing the energy element ϵ from Eq. (18) is a maximum, we may write

$$p_x \Delta x_{gx} \geq h \text{ and } \epsilon_x \tau_x \geq h/2\ . \qquad (21)$$

Equations (21) are not about our model of the wave itself, which is better expressed by Eqs. (19) and (20). Equations (21) are similar to the conventional Heisenberg uncertainty principles of measurement, but to remove confusion we rename Eqs. (21) the *wave limit relations*. The subscripts and meaning of the symbols are slightly different from Heisenberg's because we do not want to encourage particle thinking. Equations (21) were derived from charge diffraction but are applicable to full beats or standing waves of area h. These full beats are envelopes of charge, either in a stable atomic field or after being accelerated to fullness by a potential or collision. In free space, where beats of charge can spread in traveling spherical wave fronts, Eqs. (19) and (20) are more appropriate.

Infinitely small changes of frequency or wavelength are always allowed, so within a microscopic system we may visualize:

$$\Delta p \Delta \lambda_g \le h \quad \text{and} \quad \Delta \epsilon \, \Delta t \le h \,. \qquad (22)$$

Equations (22) are not about measurement; they are for understanding how Eqs. (19) and (20) describe the threshold effect and its wave shaping function.

To understand the inner workings of the charge-wave, use *h* as a maximum. To count events, use *h* in an equality. To calculate attainable accuracy of measurement, use *h* as a minimum. To account for charge-wave diffraction, the free beat of the charge-wave needs to spread out in space. The wave will spread to a feeble all-present zero-point energy, arguably necessary for the atom to work. This explains and predicts cosmic dark matter. The shaping functions, $h = \epsilon / \Delta\nu_\Psi$ and $h = mv\lambda_g$, are expressed when action pushes upon threshold *h*, and that has eluded us to misinterpret our experiments and think action is always quantized. In this model action is limited at threshold *h* when integrated over a group wavelength in each dimension of space, and action can exist below the threshold but is not directly detectable.

Before charge diffraction was discovered, the model of the particle electron was a very strong belief, and the quantum hypothesis was popular. Allowing sub-*h* action to explain wave properties modifies the quantum hypothesis. But this idea is at odds with the word "quantum," so this physics should be given a new name: perhaps *unquantum* physics.

1.8. Is the electromagnetic field quantized ?

An experimental demonstration of electromagnetic field quantization was claimed by Clauser[50] in 1974, who writes:

> "That a photon is not split in two by a beam splitter is certainly 'old hat,' and it may seem surprising that we have gone to the effort to test this prediction experimentally. What is in fact more surprising is that evidently no such experimental test has heretofore been performed… ."

Briefly, Clauser's experiment uses a two-$h\nu$ emission Hg cascade. A beam splitter catches light and sends it to two photomultiplier tubes (PMT) that are instrumented to detect coincidence. The experiment showed no coincidence rate beyond chance, supporting the interpretation that a "photon" took one path or the other at the beam splitter. Clauser concludes "The classical (unquantized) Maxwell equations thus appear to have only limited validity."

Toward re-examining the message of this experiment consider: (a) in a similar experiment that uses a Ca cascade, "That each photon is polarized can be seen from the Kocher-Commins experiment,"[51] and (b) the beam splitters were polarized by a factor of two,[50] and (c) there was no mention by Clauser of pulse height discriminators.

The classical alternative to photons would be that light is emitted in an initially directed pulse of

classical energy, with an initial energy of $h\nu$**.** The detection mechanism would work by the loading theory with an acknowledged pre-loaded state. Another condition for the loading theory to work is that there needs to be an adjusting mechanism for resonant absorption from incoming radiation slightly out of tune. This idea is readily demonstrated with musical strings.

The classical alternative to photons was never given a chance to show itself in this beam splitter experiment for two reasons:

1) The initial polarization of pulses released from the Hg atom source were randomly oriented with respect to the beam splitter's polarization such that the polarized optics attenuated the pulse more at one PMT than another. In other words, simultaneity was thwarted in the presence of the energy imbalance caused by the polarized beam splitter.

2) Standard use of pulse height discriminators would count only the most often occurring pulse heights as shown in the distribution of **Fig. 4.** The discriminator window would need to be wide. A narrow window would remove coincident detection.

The fact that PMTs have such a wide a pulse height distribution in response to monochromatic light is a clue that PMTs are not a fair detector to attempt to make the distinction between the classical and quantum mechanical interpretations of light. If a wide discriminator window setting was used, one could argue that noise-photons were causing coincidences. If a narrow discriminator setting was used it would eliminate the classical alternative.

In any case, there was no excuse for using polarized optics in this experiment. In spite of his "it can be shown"[(50)] argument that polarization does not matter, which was never shown, Clauser's 1974 work is widely referenced[(52)] and has been represented in the scientific community as a factual[(53)] statement of the physical reality of photons. In my year 2000 search, I found only one repeat of an experiment of its type, done by Grangier[(54)] et al who failed to discuss anything about polarization in their optics or anything about their discriminator settings.

The acceptance of the photon interpretation of this beam splitter experiment is the source of an amazing mass-hysteria. Related coincidence experiments are referred to as tests of Bell's inequalities, hidden variable tests, and Einstein Podolsky Rosen (EPR) inspired arguments. A beautiful computer study[(55)] has shown that a classical electromagnetic field model can explain violation of Bell's inequalities. We already know from long path length interferometry[(56)] that light behaves classically. TRM shows, by a consistency argument applied to many experiments, how the standard model of "the electron" must be corrected, not Maxwell's electromagnetic field. Lack of a consistent model of charge and light has led the physical science community into a "violent irrationality,"[(57)] to the point where scientists are driven to question if indeed any "real physical situation" exists at all.[(58)]

2. APPLYING THE MODEL

2.1. Spin

Standing waves with counter propagating components are solutions[5] to the Schrödinger equation. Such wave components are applicable to a standing wave model of charge (electron) wrapped around the nucleus. From an atomic electron gaining energy upon entering a Stern-Gerlach magnet, the Bohr magneton will be derived. We will see that spin phenomena is far simpler to understand if an intrinsic angular momentum in the electron wave function envelope is taken as one $\hbar$ instead of $\hbar/2$. In TRM, "spin" in solids refers to a standing charge-wave envelope in a relatively slow orbit around the nucleus in the presence of a magnetic B field.

Confusion in understanding spin arose from a misleading analysis of the Stern-Gerlach experiment: they assumed that an intermediate state, corresponding to an undeflected beam, does not exist. We measure a whole Bohr magneton $\mu_B = e\hbar/2m_e$ from each deflection[59] from the center line, but the particle biased mindset imposed that each spinning particle electron had an angular momentum $\boldsymbol{L}_s = \hbar/2$ using the following flawed argument:

> There is no undeflected beam, so one thinks there is no electron state that corresponds to a non-spinning state. The quantum hypothesis applied to the particle implies that the energy difference between the two particle states, deflected-up and deflected-down, must be $\hbar\omega$. Since there were two states, each must have had only half a quanta, $\hbar\omega/2$. So in spin theory each deflection indicates that the particle underwent an energy change $\boldsymbol{\epsilon}_{s\ theory} = \boldsymbol{L}_s\omega = \hbar\omega/2$, giving $\boldsymbol{L}_s = \hbar/2$. From the magnetic calculation, $\boldsymbol{\epsilon}_s = \mu_B B = e\hbar B/2m_e = \hbar\omega/2 = \boldsymbol{\epsilon}_{s\ theory}$. But then $\omega = eB/m_e$, which does not fit Larmor theory, cyclotron theory, or the equation used in experimental Zeeman spectral shifts. So we need to insert an anomalous correction factor $g = 2$ to make $\boldsymbol{\epsilon}_s = g\boldsymbol{L}_s\omega$.

This anomalous g factor, and also the failure to account for kinetic energy converted upon entering the magnet, are strong reasons to re-examine popular theory.

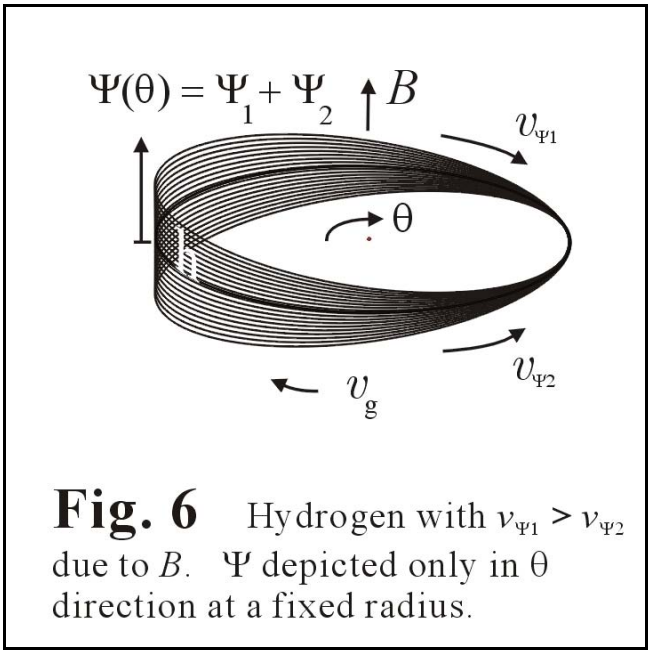


Fig. 6 Hydrogen with $v_{\Psi 1} > v_{\Psi 2}$ due to B. Ψ depicted only in θ direction at a fixed radius.

Model the atomic electron as a standing wave of two counter-rotating Ψ components. There is no centripetal force in this model; instead integral numbers of half wavelengths of the action envelope fit around a circumference, similar to de Broglie's atom model. In a Coulomb field it is natural to shape this wave in a circle as shown in **Fig. 6**. We can derive one of Bohr's postulates by fitting an envelope length to a circumference, $\lambda_g = 2\pi r$, and insert into Eq. (3), $(m_e v_g)(2\pi r) = h$, to get angular momentum $m_e v_g r = \hbar$.

There are two kinds of angular momentum states, orbital and intrinsic (spin). Intrinsic angular momentum states only exist when a magnetic field is present; the field may be either external, or from the atom such as with spectrum splitting of the 3P shell of sodium. Therefore orbital angular momentum states represent energy stored in the atom that do not require an internal or external magnetic field. In elements with magnetic moment there is a *B* field from the nucleus, and there is a residual spin state, useful for explaining how *g* departs from 2. In this model, "electron spin" effects exist in an independently generated magnetic field or when traveling at relativistic velocities where a wave asymmetry is expressed.

One may protest: *the phenomena of polarized electron beam scattering proves the electron is a particle.* An argument by Mott and Massey,[60] the developers of polarized electron theory, shows that a charge-wave's magnetic moment is impossible to detect unless the wave is accelerated to relativistic velocities. They go on to show that since it is impossible to detect the magnetic moment, it is meaningless to say it exists under these conditions. In short, "polarized electrons" are a relativistic effect. I respond: you do not need particles; a polarized wave component can emerge during relativistic velocities. True, the wave function is not a transverse wave, but at relativistic velocities any asymmetry in the beat can cause an asymmetric diffraction that may seem like polarized electrons. One form of asymmetry is that the beat's wave front may not be parallel to the Ψ wave-front (phase wave). The Ψ wave determines direction of travel.

The following model will be justified analytically. In the Stern-Gerlach experiment, the intermediate undeflected state that people say does not exist, would exist if there were no applied magnetic field. In TRM, with no magnetic field an electron wave has zero spin. With no external magnetic field *B,* spin does not go to zero because the nuclear magnetic field still supports a moment μ_B with angular momentum $\hbar$ as a slow orbiting low-energy standing wave. Zero spin is the non-deflected state in the Stern-Gerlach experiment. The initial circular standing wave would gain energy upon entering a Stern-Gerlach *B* field, and as the energy increases the standing wave would re-orient and rotate μ_B in the direction parallel to the magnet. As *B* increases, the difference-frequency of the charge-wave's component Ψ waves increases.

If the circle of standing wave action is perturbed by an external *B* we can calculate the flux $\Phi = \int \boldsymbol{B} \bullet \mathrm{d}\boldsymbol{a} = \boldsymbol{B}\pi r^2$. Take d/d*t* of both sides and use Faraday's law $\mathrm{d}\Phi/\mathrm{d}t = \int \boldsymbol{E} \bullet \mathrm{d}\ell = \boldsymbol{E}\, 2\pi r$, therefore electric field $\boldsymbol{E} = (r/2)\mathrm{d}B/\mathrm{d}t$. Multiply both sides by *e* to convert to force, and use $F = m_e \mathrm{d}v_g/\mathrm{d}t$ to get $\Delta v_g = erΔB/2m_e$, which is the increase in velocity of the envelope after adding the *B* field upon entering the Stern-Gerlach magnet. The energy increase of entering the *B* field is reflected in a spectral frequency change $\Delta\nu = \Delta v_g/2\pi r = e\Delta B/4\pi m_e$. The energy increase becomes (+ or –):

$$U = h\Delta\nu_L = e\hbar B/2m_e = \mu_B B. \qquad (23)$$

The Δ on B were dropped because the initial B from the nuclear magnetic field is negligible. This derives the intrinsic magnetic moment of the atomic electron wave as a full Bohr magneton starting from an angular momentum of one $\hbar$. Therefore, in disagreement with popular writings, Schrödinger's discussion of standing waves can be used to predict spin phenomena, and such effects in the atom can be explained to a first approximation without relativistic complexity.

The above understanding of Stern-Gerlach also helps to understand "electron spin" resonance. In ESR an external B field drives more energy into a molecular electron-wave circular loop. An energy emission would not revert to a spin-zero state because spin-zero could not exist in the B field; but the opposite spin state could exist. Therefore spin flip energy transitions are allowed. From Eq. (23), the energy of a spin flip is

$$h\nu_L = \Delta U = (+\mu_B B) - (-\mu_B B) = 2\mu_B B = g\mu_B B. \quad (24)$$

A spin-flip can be understood from a frequency standpoint where the frequencies of Ψ components of opposite wave direction (clockwise/counter-clockwise) get exchanged. The energy added to an atomic electron wave in a magnetic field, as in Eq. (23), can be understood as a pair of counter rotating Ψ waves where their difference frequency represents the ESR frequency shift of the spin. Therefore Eq. (23) can be written $U = h\Delta\nu_L = h(\nu_{\Psi 1} - \nu_{\Psi 2}) = \mu_B B$, and Eq. (24) can be rewritten as

$$h\nu_L = \Delta U = h[(\nu_{\Psi 1} - \nu_{\Psi 2}) - (\nu_{\Psi 2} - \nu_{\Psi 1})] =$$

$$2h(\nu_{\Psi 1} - \nu_{\Psi 2}) = 2\mu_B B = g\mu_B B . \qquad (25)$$

Equations (24) and (25) derive the "anomalous" g factor in a manner consistent with the Stern-Gerlach experiment. These experiments and others are telling us that if the electron wave were in a state of zero magnetic field it would have no spin (no angular momentum due to magnetic field), and within a magnetic field it will have a spin of $1\hbar$. Removing anomaly is straightforward after removing the artificial particle model.

The above model of a spread-out electron is also consistent with the results of ESR spectroscopy of larger molecules. The ESR experiment tells us the electron wave must be spread out over a large molecule in order to interact with several nuclear magnetic moments all at once. A small point-electron would visit magnetic domains sequentially, and that would smear the spectrum. So point electrons just do not work for ESR. It is only the point electron model that implies the spin ½ construct. Another reason for a spin ½ electron construct is that there are $2l + 1$ orbital states, and physicists thought the same symmetry should apply to electron spin. This clarification of the g factor and other arguments in this essay tell us the spin ½ construct should be made a thing of the past.

Adjusting the idea of quantized action to a maximum of action is consistent with the exclusion principle, and provides a way to visualize the exclusion principle. **Fig. 7** graphs the ground states and first excited states of a wave of two electrons of charge in a helium atom. A full envelope constitutes

an electron. In the ground state the two envelopes would share the same orbital system, shown in **Fig. 7**(a). Higher excitation can be stored by making the pictured orbital rotate. **Fig. 7**(b) shows the superposition of two envelopes with the same set of difference frequencies at the same velocity (orbital radius) that add to one envelope with an action greater than *h,* and is therefore not allowed. In **Fig. 7**(c) the electron waves having different *n* are at different radii and velocities, and do not superimpose in space. The case of **Fig. 7**(b) is consistent with the Pauli exclusion principle for the atom. These *n* integers are usually called *quantum numbers*, but in this theory with frequency quantized, instead of energy, a more descriptive term would be *harmonic numbers*.

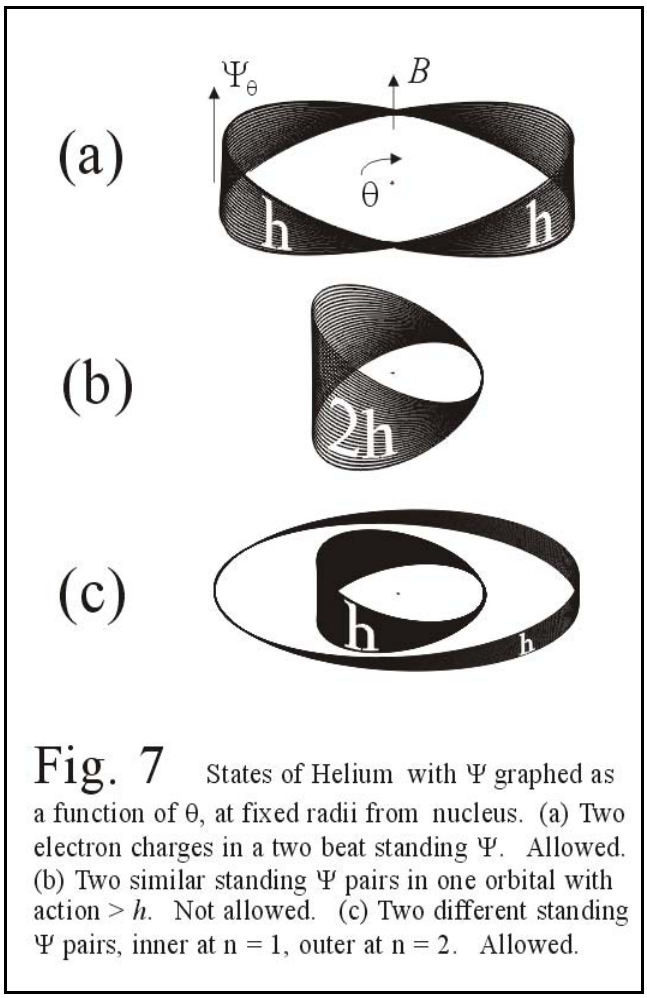


Fig. 7 States of Helium with Ψ graphed as a function of θ, at fixed radii from nucleus. (a) Two electron charges in a two beat standing Ψ. Allowed. (b) Two similar standing Ψ pairs in one orbital with action > *h*. Not allowed. (c) Two different standing Ψ pairs, inner at n = 1, outer at n = 2. Allowed.

2.2. Atom diffraction

Admittedly, this section contains some conjecture, but proposes an experiment to resolve the issue. Atom diffraction has been demonstrated(61) and described using the usual de Broglie equation; of course here we use Eq. (3) instead. Even diatomic molecules were claimed to diffract. If the atom is a thing, then perhaps it needs a wave to guide it. However, that has the problem of "collapse of the wave-function." Therefore under conditions that display diffraction (free-space matter waves unbound by the solid state) *it* must not really be a thing as we know it at all. Experiment shows that if an atomic matter-wave is in the process of interfering with itself, and it is forced to exchange energy in response to a laser pulse, the interference pattern is destroyed.(62) This told me: previous to an atom expressing

itself as a particle, it must have been a wave. A test of coincidence events at the interference pattern will determine if the wave is physical or purely mathematical. I expect coincidences will surpass chance in element-wave diffraction.

A future test would be to do a Stern-Gerlach deflection experiment and read if atomic detection events in the opposing bands are in-coincidence at rates surpassing chance. If there are coincidences we will learn that the atom is not always a ring with a center. However, since there is interaction with the magnet, a ring will form, it will have a center, and I predict there will be no coincidences.

Another alternative to consider, using the model of the atom of **Fig. 6**, is that a non-interacting atomic structure may not require three orthogonal dimensions of space to exist, because the ring of action only needs to be a two-dimensional structure. The extra dimensions are free to guide the two dimensional atom in an interference pattern.

Wave methods are not foreign to nuclear scattering; an early wave method of calculating Rutherford scattering was reported by Landé.(63) In solids, a simple use of Eq. (3) should reveal the relation between atomic spacing and vibrational momentum in a nuclear standing wave, shared between adjacent atomic centers. In diatomic molecule diffraction, the two nuclear wave packets would be aligned side by side so that the wave functions aimed in the direction of travel add under the same envelope, making the mass double and the wavelength half. The transverse action-wave determines the beam-width of the longitudinal wave, therefore it is not a three dimensional particle until it loads up to threshold in the solid state absorber. In other words matter has two states: a matter wave that can spread out (wave), and a loading center of matter waves (particle).

2.3. Pair production and annihilation

The way charge-waves fit on the light wave in **Fig. 1** suggests that the phase difference from beat to beat, a sign parity, may be connected to charge polarity. An understanding of this mechanism is

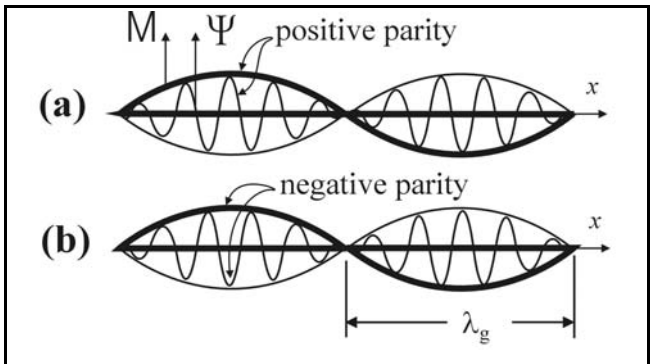


Fig. 8 Matter and antimatter. Shown in special case where $v_1 \simeq v_2$. (a) Two positron beats. (b) Two electron beats.

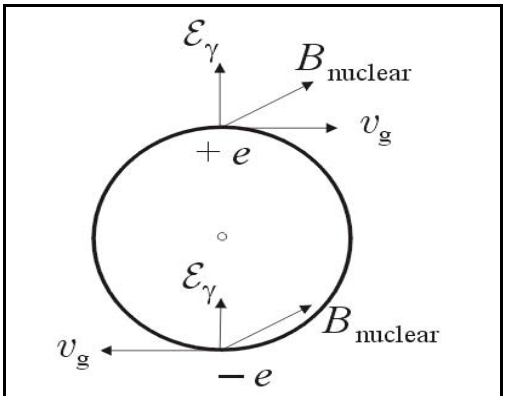


Fig. 9 Fields of matter-antimatter pair captured by a proton.

gained by examining pair production and annihilation. We assume an accelerated beat of charge radiates stored energy, and conversely energy from the electromagnetic field can be driven into the beat. A positive going electric field of a gamma-ray adds energy to the negative beat formation of the electron beat [see **Fig. 8**(a)], and to the positive beat formation of the positron beat [see **Fig. 8**(b)]. Recall that these figures are visually inaccurate (but mathematically valid) because they illustrate ν_Ψ frequencies close together, which may not be the case. To drive energy into both the electron wave and the positron wave, the phase relationship between Ψ and the driving gamma electric field need to be opposite. This requirement will be satisfied if the Ψ wave is wrapped in a circle containing two beats. Drawing such a circle of Ψ in **Fig. 9** shows that magnetic fields generated by the charges are parallel. Here we try to visualize how a proton in its particle state can act like a catalyst in pair creation. The strong magnetic field of a proton can align such a circle of Ψ starting from ambient zero-point energy density of Ψ**.** We will calculate a radius for the circle of Ψ in the process of generating both charge polarities.

From electron cyclotron resonance $\nu_\gamma = eB/2\pi m_e$ we can obtain the frequency of a gamma ray. Then use ν_γ in the usual way to convert the mass of an electron positron pair to energy:

$$2m_e c^2 = 2h\nu_\gamma \approx 1 \text{ MeV} . \qquad (26)$$

Solving for B yields the magnetic field necessary for cyclotron resonance, $B = 8\text{x}10^6$ T. Use two beats

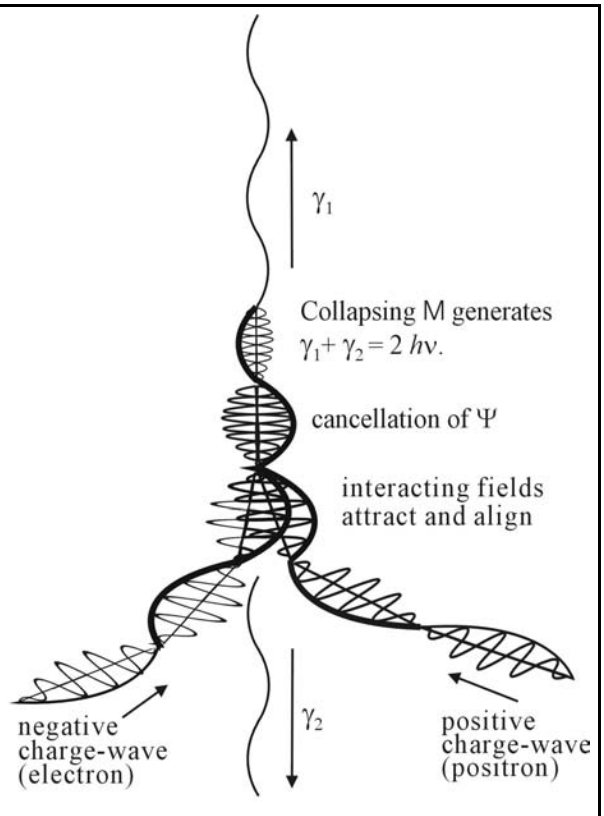


Fig. 10 Charge pair annihilation

per circumference for λ_g and use Eq. (3) to find $\lambda_g = 2\pi r/2 = h/m_e v_g$. Equation (26) is not the same as Eq. (2) which uses ν_Ψ. The situation only looks like particles because in high energy collisions, action quickly reaches full h, and the frequency is so high that narrow beam pulses are more particle-like. Recall the relation for centripetal force and magnetic force: $m_e v_g^2/r = e v_g B$. Solve the previous two equations for r and equate them to eliminate r, then solve numerically, $v_g = (eBh/\pi\, m_e^2)^{1/2} = 18\text{x}10^6$ m/s. Now use $r = v_g/2\pi\nu_\gamma = 2.3\text{x}10^{-14}$ m. This is close to the accepted size of the proton. If a ring of wave-function is stabilized by the field of a proton, two beats can absorb energy from the same electric field until each beat reaches threshold h. Pushing threshold, the whole wave-train will become unstable and can release the positron-electron pair. One can contemplate a method of applying this magnetic alignment model toward accelerating catalysis of targeted molecules.

In pair annihilation, by using Ψ cancellation instead of charge cancellation, we see just how the gamma-ray is formed; see **Fig. 10**. Cancellation is due to opposite Ψ phases, within the M envelopes generating the gamma-ray. The M wave describes the instantaneous gamma-ray electric field. As Ψ cancels, the M envelopes cancel. The two M envelopes from the positron and electron waves represent charges and will attract and align with each other. As the Ψ waves cancel to the zero-point level, the accelerated collapse of charge will radiate light. Our model tells us that the sign of charge is determined by a Ψ-to-light phase relationship (a parity of Ψ), and that mass is identified in the absolute value of the modulator function M of the wave function as shown in **Fig.1**. Our model tells us

$$m \propto |\mathrm{M}|\,, \qquad (27)$$

and we can predict that antimatter will not have negative mass.

3. SUMMARY

3.1 Theoretical misconceptions according to TRM

There were many great truths in the early works of electron theory and quantum mechanics and we respect their work highly. To remove duality, TRM seeks truth by identifying partial misconception. According to TRM:

- J. J. Thomson had no evidence of the wave properties of cathode rays, so his particle model had great influence. His great truth was that a conserved *e/m* ratio for charge indicates something particle-like. Realizing wave properties we need not embrace a particle electron model.
- Though Planck did not describe black body theory in terms of particles, greats like Einstein,[43, 64] Lorentz,[66] Heisenberg,[2] and Born-(Ref. 67 p. 80) applied their own photon-oriented point of view in their teachings of Planck's work. This had the effect of replacing Planck's original model with a photon-oriented model in much of our literature. This photon-oriented model, often called Planck's postulate, was not used by Planck. Planck's works quantized (1901) and thresholded (1911) energy in Hertzian oscillators (see ref 12 pg 136) and did not quantize conversion of energy to light. Planck's great truth of 1901 was misinterpreted by others, and his great truth of 1911 was not appreciated.

- Einstein was insightful enough to generate the photoelectric effect equation, but the photon model was "heuristic"[43] (something you do without understanding) because it ignored the wave properties.
- De Broglie had it right to attempt a matter wave, but its apparent experimental confirmation led us to accept his derivation and interpretation of his wavelength equation, even though it was founded on duality and an arbitrarily fast phase velocity.

In each situation above, the theory responded to an experimental message that suffered in its interpretation due to a particle-model bias. The particle model influenced assumptions used in experimental interpretation. The experimental message then reinforced the particle model in a sinister positive feedback. With this particle mindset firmly in place pre-dating the discovery of electron diffraction …**oops!** See? The term "electron diffraction" connotes that it somehow really is a particle. Our very language favors the particle so much that it is no wonder that the wave model has been beaten into a ghost wave.

3.2 Distortion in models and experimental description commonly found in our literature:

- describing the Compton effect as collisions of classical particles.[29] Experimentally, too small a fraction of event pairs are simultaneous.[24]
- saying we measure the momentum of an electron.[2] We measure the wavelength.
- saying the photoelectric effect measures the kinetic energy of *an electron* (Ref. 13 p. 238, Ref. 65 p. 19). It measures frequency and potential.
- emphasizing an extremely short photoelectric effect delay-time and saying such time is not a function of intensity.[71, 65] The *average* delay time is a function of intensity and the number of detector atoms.
- describing a photon *hitting* a phototube.[40, 71, 65] This imagery is the particle model talking, not the experiment. The noisy pulse rates can be calculated from a wavelike shot noise equation.[21, 22]
- stating PMT pulse uniformity.[40] It is a wide pulse amplitude distribution.[69]
- talk of measuring *e*/*m* of the *electron*.[42] They have measured voltages and fields, and then used a particle model to try to "prove" the particle model. Since it diffracts, it is really a charge-wave.
- It is a distortion to state that the Stern-Gerlach experiment measures $\hbar/2$ angular momentum of the electron[72] It measures the Bohr magneton and two spots.
- To talk of ballistically "shooting" electrons or photons from a source is a false assumption in experimental analysis because the theory of particles guided by waves has always had many problems.
- It is a distortion of history and physics to describe Planck's black body theory as if it requires light quanta. Planck argued against light quanta, and Planck and others have derived that theory without light quanta. Similarly, Bohr derived his atomic model without light quanta, in the sense that the electromagnetic field need not be quantized.

3.3 Experimental predictions

The Millikan oil drop photoelectric effect should be somehow engineered to run in a vacuum to distinguish if the sudden velocity change effect is due to an electron emission or to an ion attachment. TRM predicts that charge emission may have a continuous mode.

The Clauser experiment needs to be repeated with optics that would not unbalance a polarized $h\nu$ emission through a beam splitter. TRM predicts the photon energy will split and that the electromagnetic field is not quantized. This experiment would eliminate either TRM or QED.

3.4 Summary of theory

In dealing with paradox, a deep level of humility is required. Expressions like "*discovered* the *correct* equation," "the *right* model," or "a physical *proof*" should be avoided. These expressions make no sense when spoken from a paradoxical platform. It is far safer to leave proofs to mathematics. Physics is about understanding.

In this theory (the loading theory), the wavelength inversely proportional to velocity of the charge-wave is the length of an action envelope. Action, electronic mass, and charge are continuously variable but not detectable as such, up to the detectable maximums at h, m_e, and e. In free space, it is less confusing to express the ratios e/m, h/e, and h/m as a single constant, because in a spreading wave their component values per beat of action can thin-out while the ratio is preserved. The atom is characterized by difference frequencies instead of energy levels. A photoelectron event results in a charge-wave with fixed velocity and frequency upon its release from the atom. A full envelope of action in three dimensional space, fills that space up to a maximum action of h^3, and explains the exclusion principle. The electron is a maximum quantity of charge in a full three dimensional envelope of action. Zero-point (sub threshold) energy maintains low-level action envelopes for light to interact with. Particles of light are an illusion of the threshold and ratio properties of the charge-wave. The quantum hypothesis strictly excludes sub-quanta. Alternatively, if nature works by thresholds, then quantities less than the threshold are allowed and quantum mechanics is incomplete. Comparison of conventional and proposed theory is made in **Table 1**.

Table 1. **Base set of equations for quantum mechanics and the proposed Threshold-Ratio Model (new loading theory).**

	Quantum Mechanics	Threshold-Ratio Model
wave function	Ψ = non-physical probability amplitude	Ψ = inaccessible but physical wave
energy element	$\epsilon_{photon} = h\nu_L$ $\epsilon_p = h\nu_\Psi$ Quantized, in matter & light.	$\epsilon_g = h\nu_L = h\nu_g/2 = h\Delta\nu_\Psi$ Upon emission only, for light. At threshold in matter-wave.
matter wavelength	$h/m_p v_p = \lambda_\Psi$	$Q_{h/m}/v_g = \lambda_g$
matter frequency	$\epsilon_p/h = m_p c^2/h = \nu_\Psi$	$\nu_o = \nu_L = v_g/2\lambda_g$
photoelectric	$h\nu_L - h\nu_w = m_e v_p^2/2$	$\nu_L - \nu_w = Q_{m/h} v_g^2/2$
phase velocity v_Ψ	$v_\Psi = c^2/v_p$ $v_p = v_g < c$ $v_\Psi > c$ v_Ψ not physical	$v_\Psi \le c$ (or) $v_\Psi = c$ Elucidates relativity
measurement uncertainty	$\Delta p_p \Delta x_p \ge \hbar/2$ $\Delta\epsilon_p \Delta\tau \ge \hbar/2$	$\Delta p_{gx} \Delta x_{gx} \ge h$ $\Delta\epsilon_{gx} \Delta\tau_{gx} \ge h$
inside matter wave envelope	$v_\Psi > c$ Not physical	$\Delta p \, \Delta\lambda_g \le h$ $\Delta\epsilon \, \Delta\tau \le h$
angular momentum	$L_s = \hbar/2$	$L_s = \hbar$

ϵ = energy, ν = frequency, v = velocity, p = momentum, τ = time, Q = ratio shown in subscript, c = speed of light, m = mass.
Subscripts: p = particle, g = group, Ψ = inner wave, L = light or electromagnetic, e = electron, x = spatial dimension, w = work function frequency, o = modulator wave.

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