Revolution; Light is a wave: Revisiting the outcome of light's particle nature experiments

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Photoelectrons, Compton shift, de Broglie Wavelength, Wave number, polarization, Planck Waves and etc.

Abstract: The main purpose of this effort is to re-examine results of experiments, the Photoelectric Effect, the Short Wave-Length-Limit X-rays and the Compton Effect which confirmed the particle nature of light in early 20th century. Our analysis proves those experiments' conclusion that light behaves as particle is not correct. As a result of our findings, we have proposed a new wave model for light energy waves.

Introduction

The proponents of the theory which suggested; that light has a dual nature, both a particle and a wave were biased in favor of particle nature. Many performed experiments to support a view that light waves indeed behave sometimes as a particle in certain phenomena. In other experiments the results were such that they were lead to believe that light is a wave. Physicists, Einstein included, used results from several experiments to validate this dual nature of light. We will again discuss details of three effects; the Photoelectric Effect, the X-ray emission and the Compton Effect. A closer re-examination of the results from experiments investigating each of the above effects will reveal that the conclusion that light consists of photon particles is not appropriate. Our observation is based on the fact that the outcome of the experiment would not be different even for the wave model of light. Let us now look at the details of each of the experiments and explain why their results provide a contrary conclusion; light is a wave.

Before we investigate the details of the experiments, let us state an equation from Max Planck which characterizes the energy content of light waves. By the 1900's, evidence indicated that energy possessed by individual photons of light waves of frequency ν is expressed by relation

$$\mathbf{P_{hoton} = h \times \nu} \qquad \textbf{(1.1)}$$

Here h is known as Planck's constant.

1.0 The Photoelectric Effect

In this section, we shall describe the Photoelectric Effect and examine details of the experiment to characterize the effect. Hallowach discovered that an insulated Zinc plate connected to a gold leaf electroscope will lose its charge, when it is exposed to a beam of ultraviolet light. The plate in Hallowach's experiment was supposedly negatively charged at the beginning. He suggested that the metal surface started leaking electrons by a process in which they were ejected from atoms of metal by ultraviolet light particles. The effect was termed as the Photoelectric Effect. The ejected electrons were called photoelectrons, which were only observed when the frequency of UV light was above a certain threshold. In Figure 1.1, a pictorial description of the photoelectron emission event is displayed.

About the same time frame as Max Planck in 1900's, Leonard studied the Photoelectric Effect experimentally [1]. Figure 1.2 shows an experimental arrangement to study the effect. His apparatus consisted of a long evacuated glass tube fitted with two electrodes and a window to expose one of the electrodes to ultraviolet light. The electrodes were an emitting electrode (E) anode, and a collector (C) cathode. A varying potential difference of a selected value was applied between the two electrodes. When the material from the surface of the E electrode was exposed to UV light of suitable frequency, electrons were ejected from the surface in spite of the negative potential on it. The electrons with excess kinetic energy will move towards the collecting electrode. The electrons overcame the negative potential. As the value of potential difference increased (more negative), fewer electrons were able to reach the collector and contributed to decreasing the current. An ammeter included to monitor the Photoelectric current started dipping and was completely reduced to zero when voltage of sufficiently high negative value was applied. The voltage at which Photoelectric current reduced to zero was known as stopping potential. At the stopping potential, the kinetic energy of electrons will be exactly equal to work done by stopping potential to prevent any current flow.

$$\mathbf{eV_0 = \tfrac{1}{2}\, m_e\, V^2_{max}} \qquad \textbf{(1.2)}$$

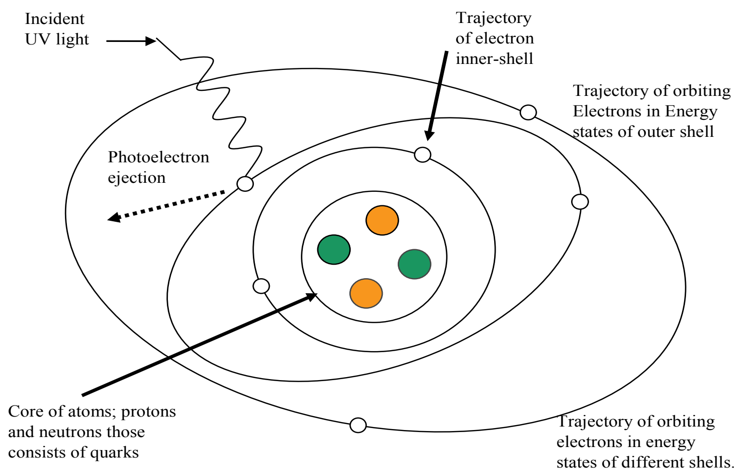

Figure 1.1 Photoelectron emissions by incident light on a clean metal surface. When electrons in metal target emitter E are exposed to UV light they absorb quantum of energy and escape for conduction of current to collector C.

1.1 The Laws of Photoelectric emission

Experimental observations from the results of the experiments were recognized as the laws of photoelectron emission.

1. It was discovered that below a minimum threshold frequency ν_0 for the incident light no photoelectrons are ejected regardless of intensity of light (see Figure 1.3)

2. The threshold frequency ν_0 is the characteristic of the metal being used as a photo emitter. This fact is true even if the value of stopping potential is zero. Of course a higher value of stopping potential will require UV light with higher frequency than threshold frequency $\nu_{0,}$ also known as critical frequency to initiate and sustain the Photoelectric Effect (See Figure 1.4).

3. It was found that for a given value of frequency ν or wavelength λ for ultraviolet light, there is a spread of photoelectrons energies down to zero. However the maximum kinetic energy K_{max} of photoelectrons does not depend on intensity of light but varies linearly with ν. The energy K_{max} does depend only on the frequency of exposing radiation (Figure 1.3).

4. Experimentally it is verified that high intensity of incident light results in larger amount of photoelectron ejection and a corresponding increase in the Photoelectric current, but not more energy per electron (Figure 1.5).

5. The emission of photoelectrons starts as soon as the UV light is exposed to the metal. It has been found that time lag between UV exposure and emission of photoelectrons is less than 10^{-8} s.

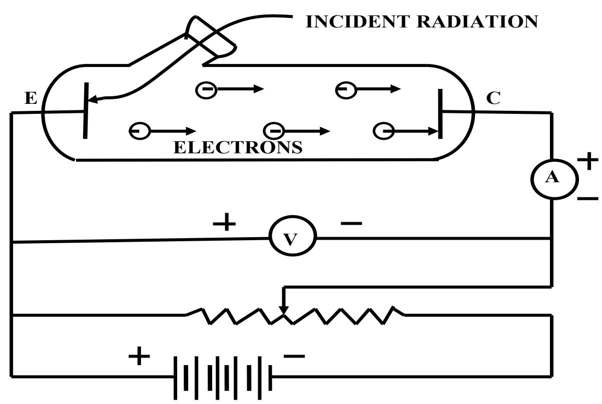

Figure 1.2 Leonard's apparatus to demonstrate Photoelectric Effect.
(Courtesy Satish Gupta,"Modern's abc of Physics," Modern Publishers, 2006).

1.2 Einstein's explanation for the Photoelectric Effect

To explain the results of the above experiments, Einstein postulated that the energy carried by a photon of radiation of frequency ν is $h \times \nu$. According to his theory, the emission of a photoelectron was as a result of the interaction of a single photon with an electron, in which the energy of the photon was completely absorbed by the electron. It is well known that to remove an electron from an atom of the metal requires a certain minimum amount of energy ω, called the work function of the metal. Thus when an electron absorbs energy from a photon, an amount of energy at least equal to ω is used up in liberating the electron and the difference is available to accelerate to speed $V_{max.}$ Thus the equation

$$\frac{1}{2} m_e V^2_{max} = \hbar \times \nu - \omega \qquad (1.3)$$

Here m_e is mass of electron
V_{max} is maximum velocity of photoelectron
ω is work function of the metal
h is known as Planck's constant
ν is frequency of UV light

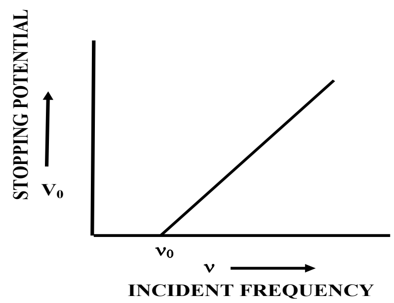

Figure 1.3 Stopping potential is in volts numerically equal to the Maximum kinetic energy of photoelectrons in eV

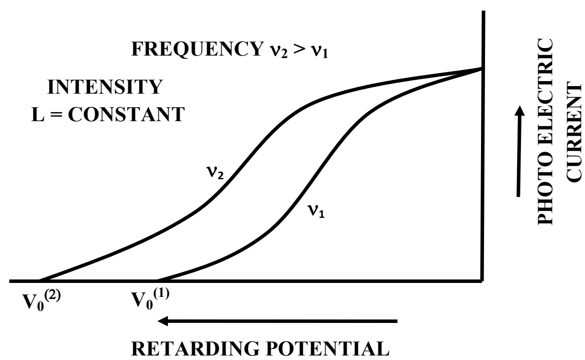

Figure 1.4 Higher frequencies of UV light exposure results in higher kinetic energy photoelectrons.

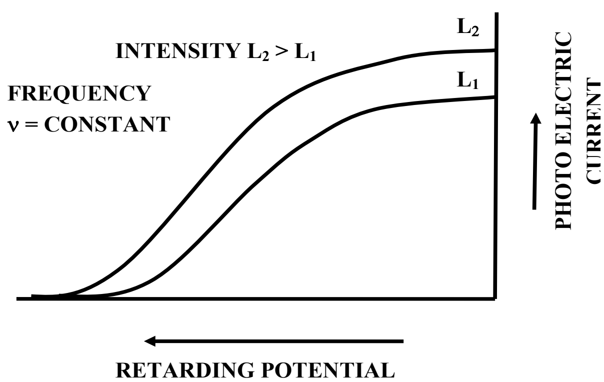

Figure 1.5 Brighter lights produce more current, not more energy photoelectrons.

The work function of the metal is a characteristic of the metal, which does not depend on the frequency or nature of radiation. Sometimes it is called the threshold energy of the metal. If ν_0 is the frequency that corresponds to the threshold energy of the metal, then

$$\boldsymbol{\omega = h \times \nu_0} \qquad (1.4)$$

Substituting ω in (1.3) we get

$$\mathbf{h \times \nu_0 = h \times \nu + ½\, m_e\, V^2_{max}} \qquad (1.5)$$

The above relation is called Einstein's photoelectric equation. From his equation, it is evident that the number of photoelectrons ejected will be large when the intensity of radiation is increased. This is because the Photoelectric Effect constitutes the one photon, one electron interaction phenomena. We agree with Einstein's photoelectric equation and theory. However, we do not agree that energy carried by UV light waves of frequency **ν** is contained in particle photon. The reason is that according to equation (1.1), the energy **h × ν** is carried within a cycle of propagating light wave. This energy particle described by Einstein, the photon does not have rest mass and static center of gravity. Therefore we believe that photon is not a particle, even though photoelectrons absorb energy from UV radiation in precise quantum amounts. In the following, section, we shall investigate photoelectron ejection in more detail.

1.3 Photoelectric Effect and Max Planck's quantum particle electron model.

We offer the following detailed explanation for laws of the Photoelectric Effect. Our analysis is predominantly based on Planck's model for radiation from quantum particle electron [2]. Plank's hypothesis stated that whenever an electron is involved in any energy exchange process; it will emit or absorb energy making a transition from one quantum state to the other. The entire energy difference between the starting and the final states in the transition is emitted or absorbed as a single quantum of radiation. Thus the law for energy of radiation came into existence.

$$\mathbf{E = h \times \nu} \qquad (1.6)$$

We believe that the work function difference model in Einstein's equation is simplistic view. A more detailed analysis reveals that the kinetic energy K_{max} depends on the frequency and not the intensity of incident light. The reason is that the ejected electron from a specific orbit absorbs light energy in a quantized maximum amount at the frequency of light exposed. The quantity of energy absorbed by an orbiting electron is a function of de Broglie wave length representing the electron in specific orbit. At frequencies of the light corresponding to, at, or above de Broglie wave length, the electron may absorb more energy required to alter the quantum state of the electron. We believe that higher frequency radiation waves penetrate in to deeper inner shells and knock off electrons from interior orbits after those electrons absorb energy than lower frequency of light can penetrate. The kinetic energy of electrons from inner orbits is higher than the electrons in outer orbits because the orbital speed of electrons in interior orbits is higher than electrons in exterior orbits. The fact that light having a frequency below threshold ν_0 does not result in any ejection regardless of intensity proves that below the frequency, light energy is not absorbed by electrons in any orbit. Therefore the results of this experiment do not prove that light consists of photon particles.

Further, it was observed that time-delay between initial light illumination and onset of photoelectron ejection current is so short 3 X 10^{-9} sec (< 10^{-8} sec) that it can't happen with the wave model of light. From our point of view, the onset time delay is still very high compared to the period of the light wave, which is few femto seconds (1.25-2.5 Fs, Table 1.1 for visible light range). We believe that the photo electrons may be ejected after they absorb wave energy over several cycles of light waves.

Table 1.1 Light wavelength λ (10^{-9} m), frequency ν (10^{12}), period (10^{-15}) & coeff. σ_{water}

	WAVE-LENGTH λ		PERIOD	FREQUENCY ν	REFRACTIVE INDEX σ OF WATER	
COLOR	Angstroms	Nano m.	Femto sec.	Tera Hertz	Real Part	Orthogonal
Violet	3800-4300	380-430	1.266-1.429	790-700	1.345	2.11 e $^{-10}$
Blue	4300-5000	430-500	1.429-1.667	700-600	1.342	3.30 e $^{-10}$
Cyan	5000-5200	500-520	1.667-1.724	600-580	1.339	4.31 e $^{-10}$
Green	5200-5650	520-565	1.724-1.887	580-530	1.337	8.12 e $^{-10}$
Yellow	5650-5900	565-590	1.887-1.961	530-510	1.335	3.53 e $^{-09}$
Orange	5900-6250	590-625	1.961-2.083	510-480	1.333	1.41 e $^{-08}$
Red	6250-7400	625-740	2.083-2.469	480-405	1.331	3.48 e $^{-08}$

In 1905, Einstein re-derived Planck's results by assuming oscillations of Electromagnetic radiations in the cavity of a black body oscillator were themselves quantized. He proposed that quantization was a fundamental property of light and radiation which led to the concept of the photon particle. From our school of thought this is an error. We believe quantization is a fundamental property of quantum real particle electron [2]. The radiation of every type of energy inherits this property from its creator. Regardless of the quantized nature of radiation interaction with particles, we proved that lack of mass and center of gravity properties restricts to qualify a radiation entity to be a particle. Therefore, the photon is an imaginary particle and it does not exist in reality. It is imperative scientists should invent special rules to handle interactions between particle and wave entities. In the next section, we shall discuss the details of short wave-length limit X-rays experiment. Again we shall show that the results and conclusion of the experiment do not prove the fact light consists of particles.

1.4 The Short-Wavelength-Limit X Rays

The focus of this section is to describe details of Short Wave-Length-Limit X-Rays experiment. In this experiment, usually a metal target is struck with high energy accelerated electrons in range of 5-50 KV; one obtains what is called as Bremsstrahlung (German for "deceleration radiation") spectrum [3]. It has been discovered that the spectrum is continuous and covers a wide range of wave lengths. The energy from colliding electrons is absorbed by electrons in orbits and re-emitted in the form of X-rays. In Figure 1.6 the concept behind this radiation event is displayed. A fact that is not explained by classical mechanics is that X-ray emission is sharply cut-off at a certain minimum wavelength or maximum frequency (we have avoided photon use intentionally). The cut-off frequency of X-rays only depends on accelerating potential and does not depend on the type of metal target. The minimum wavelength λ_m corresponding to maximum frequency of the X-ray is the same for all metals and varies linearly with the accelerating potential of colliding electrons according to a law verified by Duane and Hunt [4].

$$\mathbf{1/\lambda_m = [e/(h \times C)] \times V_0} \qquad \textbf{(1.7)}$$

Define $\nu_m = C/\lambda_m$, we have

$$\mathbf{h \times \nu_m = e \times V_0} \qquad \textbf{(1.8)}$$

Maximum energy of X-ray emission = Kinetic energy of incident electron

Notice that the work function does not appear in this equation because it is almost negligible in comparison to the electrons and the photon energies involved (order of 0.1 percent). In Figure 1.7 relative intensity of X-ray emission vs. wave length for varying electron potentials are plotted. The corresponding numerical data is included in Table 1.2. In Figure 1.8 maximum frequencies vs. accelerating voltage is displayed and the corresponding numerical data is summarized in Table 1.3.

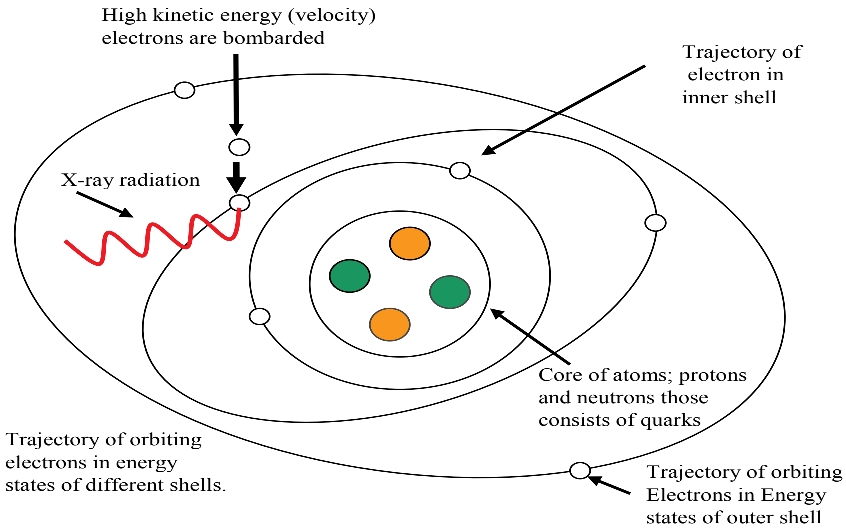

Figure 1.6 Radiation event caused by collision of high energy electrons. Here it is demonstrated that electron with high accelerating potential may trigger an orbital transition event and release X-rays.

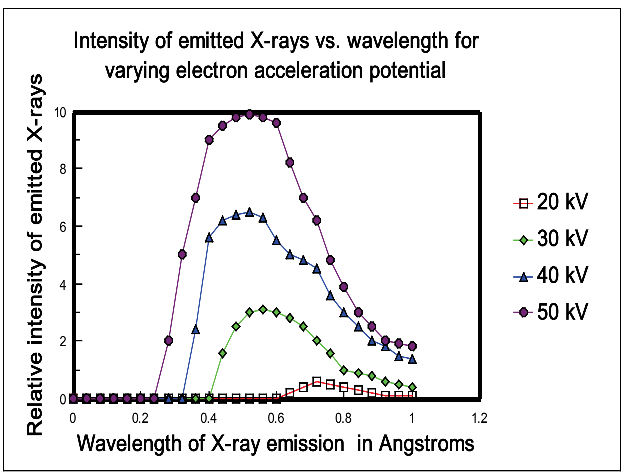

Figure 1.7 Bremsstrahlung spectra: electrons of various energies striking metal target. X-rays are emitted when electrons with high acceleration potential are collided with a metal target [Data of C. T. Ulrey, Phys. Rev. 11, 401 (1918)]

The phenomenon described in graphs resembles the Photoelectric Effect in reverse. The kinetic energy of striking electrons is transformed into the X-ray radiation. It was discerned that the maximum possible frequency of the X-ray corresponds to the kinetic energy of an incident electron which is converted into the energy of a single photon of the frequency. The energy from the striking electron was absorbed by electrons in orbit and emitted in the form of the X-rays. Therefore, for a given accelerating potential, intensity of the X-rays peaks at some wave length and is cut-off at some highest frequency. This frequency, at which peak intensity occurs, increases with increase in accelerating potential and so does the cut-off frequency.

Table 1.2 X-ray emissions versus cutoff frequencies for various eV acceleration.

Wavelength X-ray Ang.	Rel. Intensity at 20 kV Acc.	Rel. Intensity at 30 kV Acc.	Rel. Intensity at 40 kV Acc. .	Rel. Intensity at 50 kV Acc.
0.0 – 0.24	0	0	0	0
0.28 – 0.32	0	0	0	2
0.32	0	0	0	5
0.36	0	0	2.4	7
0.4	0	0	5.6	9
0.44	0	1.6	6.2	9.5
0.48	0	2.5	6.4	9.8
0.52	0	3	6.5	9.9
0.56	0	3.1	6.3	9.8
0.6	0	3	5.5	9.6
0.64	0.2	2.8	5	8.2
0.68	0.4	2.5	4.8	7
0.72	0.6	2	4.5	6.2
0.76	0.5	1.6	3.6	4.8
0.8	0.4	1	3	3.9
0.84	0.3	0.9	2.5	3
0.88	0.2	0.8	2	2.5
0.92	0.1	0.6	1.8	2
0.96	0.1	0.5	1.5	1.9

The above mentioned interpretation of the data is not consistent with Planck's quantum model for electron particle. Our explanation of this event is similar to the explanation of the Photoelectric Effect based on the quantum model for electron particle. The electrons with the highest kinetic energy (highest accelerating potential) produces the highest frequency X-rays because the high energy electrons penetrate deep in electron shell orbits. The electrons bombarded in orbits closer to the nucleus have higher speed and spin momentum than the electrons in outer shell orbits. As indicated in Figure 1.6 the excited electron in the inner orbits absorbs the energy from bombarded electrons and re-emits the excess energy in form of the X-rays. The maximum frequency of the X-ray is a function of the quantum energy state (speed in orbit and spin momentum) and the wave number of the electron from which the energy is released. The fact this maximum frequency is linearly increasing with accelerating potential of the electron makes sense. Since the energy content of emitted X-ray waves can be quantized, it is not accurate to model, emitted X-rays as photon particle. Further, we had mentioned that X-ray energy waves radiated in the event do not have rest mass and center of gravity. Therefore our conclusion that the X-rays are waves and not a photon particle is correct.

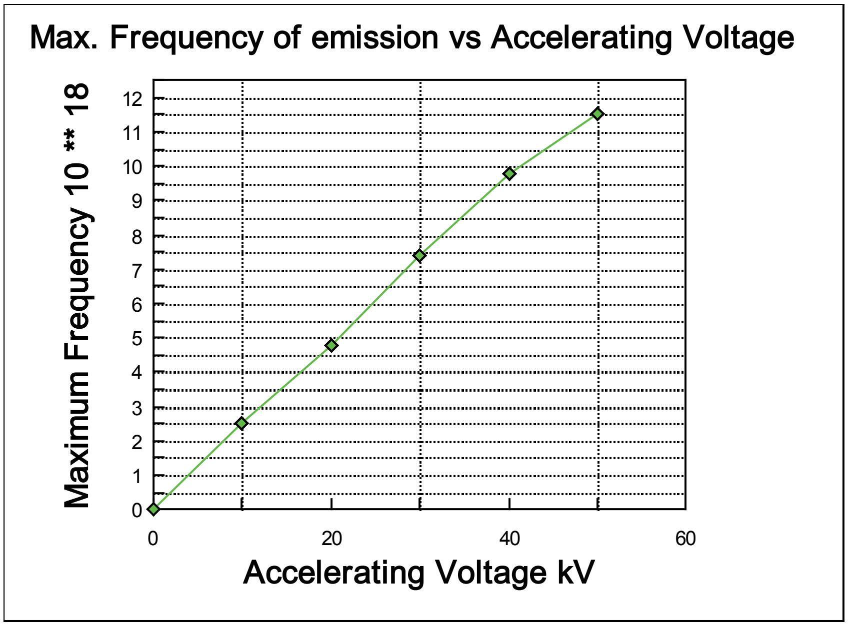

Figure 1.8 Maximum frequency of emission vs. accelerating voltage. Maximum frequency of emitted X-rays is directly proportional to accelerating potential of striking electrons. [Data of C. T. Ulrey. Phus. Rev. 11, 401 (1918).]

Table 1.3 Maximum frequency of X-ray vs. accelerating potential.

Accelerating Voltage V (kV)	Max. Frequency 10 ** 18 Hz
0	0
10	2.5
20	4.8
30	7.4
40	9.8
50	11.5

Next we shall describe details of an experiment the Compton Effect, discovered by and named after its inventor. Though proponents of dual particle and wave nature of light impressively utilized the Compton' Effect to justify their conclusions and belief, our position is firm. We will convince you that light are indeed a wave in all the phenomena and experiments. We admire the efforts of Compton to come up with a brilliant argument such as this. Briefly, his experiment is about absorption of energy from a light wave (photon) by an X-ray photon to decrease the frequency of X-ray from one regime to a different value in a quantized quantity.

1.5 The Compton Effect

In this section we shall illustrate the details of an experiment describing the Compton Effect**.** Compton demonstrated that a photon carries radiant energy and a linear momentum. Collision events between the X-ray photons and free electrons can be analyzed using the energy and the momentum conservation laws of relativistic particle dynamics. In 1919, Einstein concluded that a photon of energy E travels in a single direction and carries a momentum = E/C = hf/C. In 1923, Arthur Compton (1892-1962) and Peter Debye (1884-1966) independently carried Einstein's idea of photon momentum further. Compton showed that when an X-ray photon collides with free electrons; the X-ray photon suffers a loss of energy. The loss is manifested as an increase in wavelength of the X-ray by precisely the amount corresponding to an elastic collision between two particles (please see figure 1.9). The resulting scattering of X-rays and the recoil of electrons an effect resembling the collision between two particles, is known as the Compton Effect.

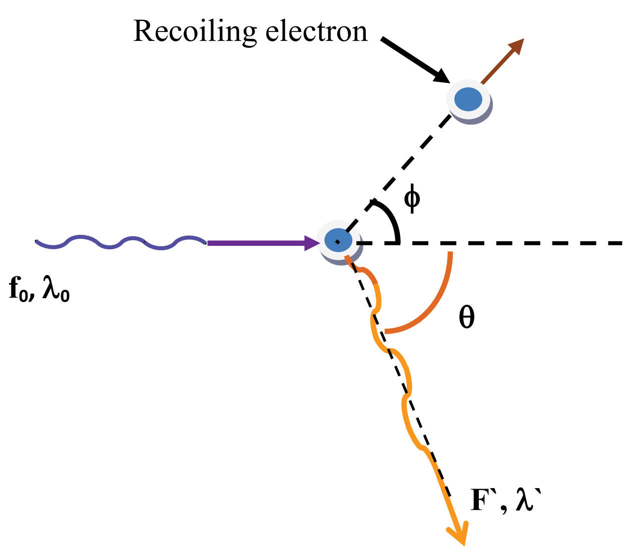

Figure 1.9 The collision between X-ray wave with electron displaces it while X-ray is scattered. (Courtesy of Serway & Jewett, Physics for Scientist and Engineers).

In 1922, Compton and his coworkers realized the classical wave theory of light failed to explain the scattering of X-rays from electrons. According to classical mechanics, electromagnetic waves of frequency f_0, incident on electron should have two effects:

1. Radiation pressure should cause acceleration of electrons in the direction of the radiation.
2. The oscillating field of X-ray should set electrons in oscillation at frequency f`, where f` is the frequency in the frame of the moving electron.

The apparent frequency f` of the electron is different than f_0 because of the Doppler's effect. Each electron first absorbs radiation as a moving particle and then reradiates as a moving particle, thereby exhibiting two Doppler shifts in the frequency of radiation. Because different electrons move at different speeds after the interaction, depending on the amount of energy absorbed from the incident electromagnetic waves, scattered wave frequency should show a distribution of Doppler shifted values in relation to angle of approach. According to the quantum electron particle model this observation is not correct. We believe electrons in orbit shall absorb a precise quantum of energy from EM-wave and re-radiate by precise amount by processes described by us, selective absorption and emission. We shall ignore quantum particle description for the time being. Contrary to see distribution, Compton discovered that at a given angle of approach only one frequency of radiation is observed in scattered spectrum. Compton explained this observation by stating that the EM waves were behaving like photon particles having energy hf and momentum hf/c. Figure 1.9 shows the quantum picture of the collision between the X-rays and the electrons. In this model, the electron is recoiled after collision by angle ϕ in a billiard ball fashion with respect to approaching radiation while the frequency shifted radiation is scattered at an angle θ.

Compton plotted the data and the results of the measurements from his experiment. The X-rays, scattered from a graphite target were analyzed with a rotating crystal spectrometer. The intensity was measured with an ionization chamber that generated a current proportional to the intensity. The incident beam consisted of a monochromatic X-ray of wavelength $\lambda_0 = 0.071$ nm. The current values were plotted vs. the wavelength for different values of scattering angle θ. The graphs showed two peaks, one at λ_0 and other at λ`. Based on these data, Compton derived the following relationship between differences in the wavelengths at which the peak occurs and the scattering angle θ.

$$\boldsymbol{\lambda` - \lambda_0 = [h/ (m_e C)] (1- \cos\theta)} \qquad \textbf{(1.9)}$$

where m_e is mass of the electron.

This expression is known as the Compton shift equation. The factor **$h/(m_e C)$** is called the Compton wavelength of the electron, has current value of 0.00243 nm.

Now let us analyze the details of physical facts behind the effect. We do not contest Compton's equation and his theory behind it. However it is important to note that in a special case of a graphite target, the electron wavelength and the velocity of recoil is characterized by 0.00243 nm. Further, according to quantum electron particle theory, electrons are orbiting in many different orbits in atoms of a graphite target at different speeds and not always at speed c as in the equation. Even though the change in wavelength of scattered X-rays corresponds to the difference between electron energy at the start of collision and kinetic energy of recoil electron, it does not prove that X-ray radiation consists of particle photons. Once again our conviction is that an X-ray wave carries energy but has no rest mass. Also, radiated X-ray waves do not have center of mass. Hence, this experiment fails to prove light and X-rays consist of photon particles.

The analogy between the X-ray and the electron collision event, and the billiard ball collision is not perfect. In this X-ray collision event, the direction of orthogonal components of momentum vectors of the recoil electron and the scattered X-rays are non-zero, though the orthogonal component of momentum vectors for the electron and the X-rays at the start were zero. In a billiard ball collision event, if a Q ball had zero momentum in a direction normal to the travel, the momentum component of target ball normal to the motion will have zero value if Q ball hits straight to the target ball. In this sense the motion of billiard balls completely obeys rules of Newtonian classical mechanics. Next we shall look at the physical details for propagation of light waves based on wave-particle model of current theory.

1.6 Light: particle-wave dual model, old theory

In the mid—Century, James Clerk Maxwell (1831-1879), a Scottish theoretical physicist, developed the electromagnetic theory of light waves. His famous four equations established transverse propagation of light and all other electromagnetic waves. According to his theory, an ordinary beam of light consists of a large number of waves emitted by atoms of the light source. Each atom produces a wave having some particular orientation of the electric field vector E, corresponding to the direction of atomic vibration. Because all directions of vibration from a wave source are possible and are equally probable, the resultant light wave is unpolarized and is superposition of all the individual electric field vectors.

In Figure 1.10, schematic diagram of a light wave propagating along Z-axis with velocity c along with associated Electric Field and Magnetic field is displayed. A linearly polarized beam of light can be obtained by removing all waves from the beam except those whose electric field vectors oscillate in a single plane. Since light is originated from vibrations of atoms which had electric charges, it created a changing electric field. According to Ampere-Maxwell law, a changing electric field creates a magnetic field by the electric current. Therefore light waves consist of two transverse fields E and B that are orthogonal to each other and orthogonal to the direction of propagation of the light waves. One question that puzzles us, is that while light waves consists of transverse electric and magnetic fields, why light waves are not affected by strong electric or magnetic fields directed in any orientation. It is found that the trajectory of light waves is not affected in the presence of very high energy electric or magnetic fields to the slightest extent. We imply Maxwell's model and electromagnetic wave theory of light has no answer to this question. The insensitivity of the light waves to both the electric and the magnetic fields leads us to believe that Electromagnetic wave model may not accurately predict behavior of light waves.

Nevertheless, we shall continue our discussion of Electromagnetic wave nature of light and present the analytical details of the model. We shall utilize popular Maxwell equations to describe the electric and the magnetic fields associated with light waves. We can see that the light waves can be fully described by a wave number and angular frequency parameters of atoms generating the vibrations. The beauty of Maxwell's equations arises from the fact the equations were able to compute speed of light in vacuum with two parameters the permittivity and the permeability of free space. Einstein and others were convinced that speed of light should be treated as a universally accepted constant whose value is now determined to be 2.99792×10^8 m/s. Maxwell was able to show this value is exactly equal to $(\mu_0 \times \varepsilon_0)^{-1/2}$ for $\mu_0 = 4\pi \times 10^{-7}$ **T. m/A** and $\varepsilon_0 = 8.85419 \times 10^{-12}$ **$C^2/N.m^2$** in free space. He assumed the permittivity and the permeability constants are invariant, free space moving or rest. It is difficult for anyone to comprehend free space and the universe will move even if the universe is of infinite size without surface and boundary [2]. From our perspective, the universe is open and infinite. However, when a segment of the universe is set into motion, the constants should vary. Ignoring the fact that light waves are not affected by electric and magnetic fields, an electromagnetic wave model for light waves was developed by Maxwell.

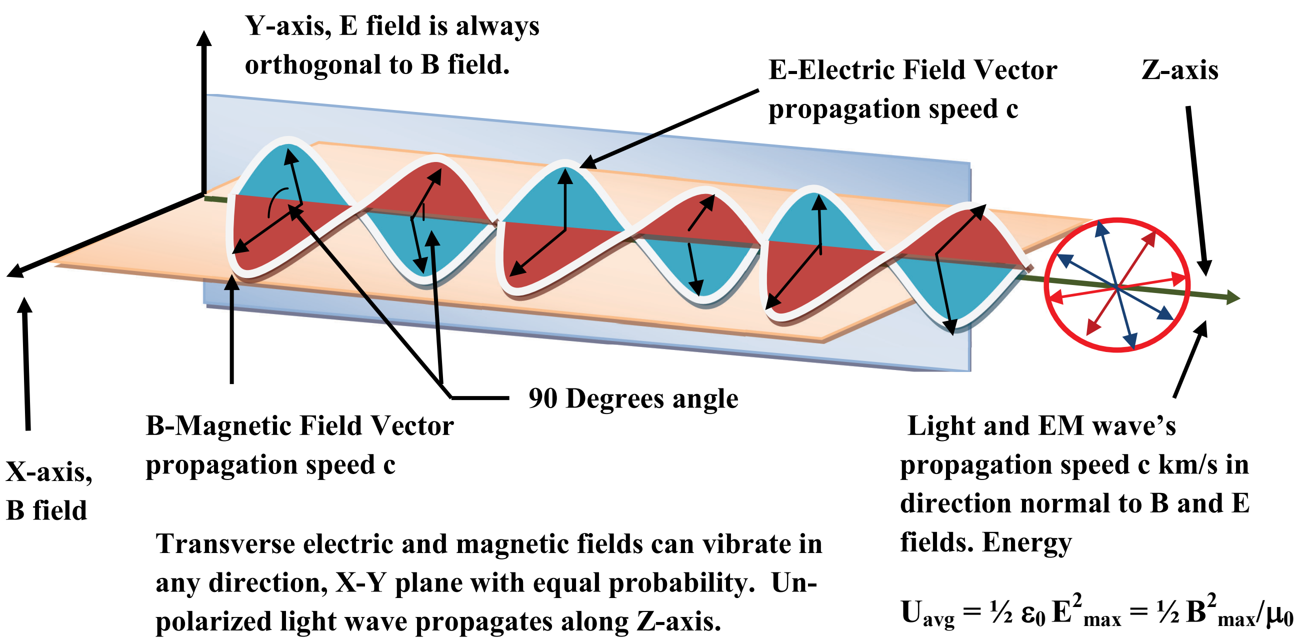

Figure 1.10 Schematic diagram of a light wave propagating at velocity c in Z direction with associated electric field vector E in X-Y plane and magnetic field vector B in Y-Z plane.

From Maxwell's laws one can derive the equations of field vectors E and B. We shall state the results (For details readers are advised to see [5]).

$$\mathbf{E} = \mathbf{E}_{max} \cos (kz-\omega t) \tag{1.10}$$

$$\mathbf{B} = \mathbf{B}_{max} \cos (kz-\omega t) \tag{1.11}$$

Where E_{max} & B_{max} are maximum values of the fields
k is angular wave number $k = 2\pi/\lambda$
ω is angular frequency $\omega = 2\pi\nu$

Also

$$\boldsymbol{\omega/k = E_{max}/B_{max} = E/B = c} \quad (1.12)$$

and

$$\mathbf{c = (\mu_0 \times \varepsilon_0)^{-1/2}} \quad (1.13)$$

Where μ_0 permeability of free space
ε_0 permittivity of free space

In above equations, one should note parameters k angular wave number and ω angular frequency are related to electron motion rather than atomic vibrations. From the description of instantaneous values of E and B fields, one can arrive at the total instantaneous energy content of a light wave that is sum of energy carried by electric wave and magnetic wave. The total energy of light wave is given by expression

$$\mathbf{U_{avg} = \tfrac{1}{2}\, \varepsilon_0\, E^2_{max} = \tfrac{1}{2}\, B^2_{max}/\mu_0} \quad (1.14)$$

Also, intensity of the light wave from above equation is computed from equation

$$\mathbf{I = c\, U_{avg}} \quad (1.15)$$

Where c is speed of light wave

From Maxwell's model and equations for light waves it is clear that he applied plane electromagnetic wave equations to light waves by assuming light waves are the same as the electromagnetic waves. The inventions of the photoelectric and the photovoltaic effects lead scientists to agree with Maxwell that light waves are indeed electromagnetic waves. However, as mentioned before, light waves are not affected by electric or magnetic fields and do not induce or produce coupling effects exhibited by the electric and the magnetic fields. We imply that a changing light wave does not produce or induce phenomena which varies or alters light energy elsewhere. Therefore a separate model to describe light waves is required, which should be different from the electromagnetic wave model.

In 1905, Einstein took it for granted that Maxwell's equations are correct in the generalized frame of reference and assumed that speed of light in his equation was a universal constant. With his Photoelectric Effect laws, he established that light consists of photon particles that carried energy $h \times \nu$ in packets of waves of frequency ν. However neither special relativity from Einstein nor Maxwell's field equation explained how the energy $h \times \nu$ of light waves relates to the strength of Electric field and magnetic field vectors. From our point of view, the speed of light is not constant in a mobile frame of reference [2]. In a mobile free space the value of permittivity and the permeability constant should vary and accordingly speed of light should be different.

$$\mathbf{c_m = (\mu_r \times \varepsilon_r)^{-1/2}} \qquad \mathbf{(1.16)}$$

Where μ_r permeability of free space when it is moving
ε_r permittivity of free space when it is moving
and c_m is speed of light in mobile frame of reference.

The ambiguous behavior description for light, sometimes as a particle and occasionally as a wave, previously prohibited the creation of a consistent model that matched the actual behavior. As stated earlier, a photon particle with finite energy lacks rest mass and does not possess center of gravity. Therefore, particle photon is an incomplete description for light energy. It will be evident from our explanation in the next section, that we are able to model light as a wave.

1.7 Quantum solution; wave model for light

The purpose of this effort is to model behavior of light that is accurate, matches reality, and does not suffer from any ambiguity. As explained in section 1.6, previously developed models over the period of the past century had raised many questions and do not provide satisfactory answers to the physics community. The model proposed by us will answer all previously unanswered questions. We believe that light consists of a luminous energy wave that is propagating in a longitudinal direction. The energy of the wave is carried in transverse direction. From the Photoelectric Effect, Einstein concluded that an electron in an orbit will absorb or release energy from light waves in precise quantity (he called energy of photon).

$$\mathbf{h \times \nu} \qquad \mathbf{(1.17)}$$

where h is Plank’s constant
and ν is frequency.

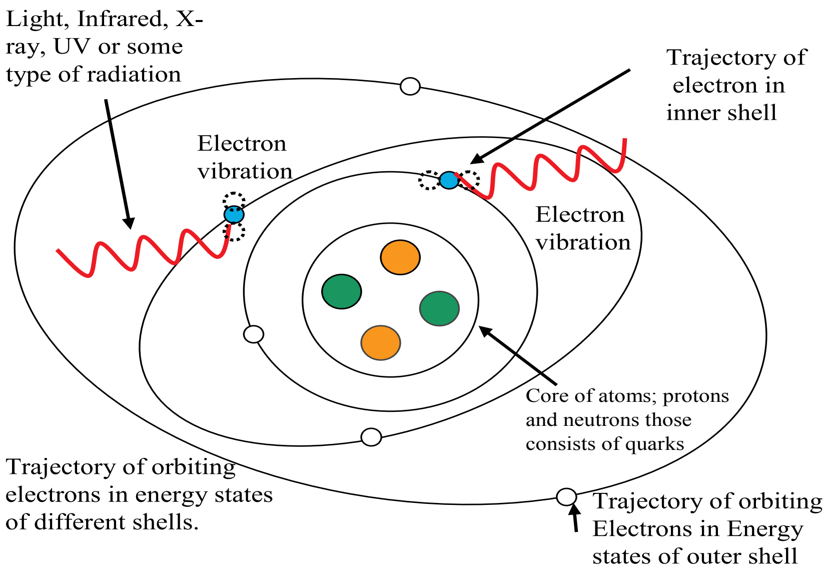

Figure 1.11 Schematic of electron vibrations producing radiation energy waves.

We agree with equation (1.17); however we believe it is not accurate to label a light wave as a particle photon. In reality, an electron absorbs an energy of precisely the amount **h** × **ν** before it is ejected in a time frame of one cycle of radiation. Thus at any frequency **ν** of radiation, an electron shall dissipate energy of **h** × **ν** units**.** According to the quantum particle theory proposed by Max Planck, an electron in an orbit will change its state after either it will absorb or release definite quantum of energy h. He confirmed this fact by studying black body radiation phenomena. An excellent discussion of his work may be found in Serway & Jewett [5]. When one combines his theory with the Photoelectric Effect from Einstein, the true model for light waves may be originated. We propose that light energy waves will be created when vibrations occur in electrons of atoms that provides the source of energy. In Figure 1.11, schematic diagram of electrons in orbit with associated vibrations for creating light energy waves from a source is displayed. Since according to Schrodinger's equation, the position of quantum particle electron at any time can only be defined as probability density function in shells of electrons, one can only predict position and phase of created radiation with some probability. This adds a lot of uncertainty in phase determination of periodic radiation signal.

Now let us derive new model for light waves which we have appropriately labeled as Planck Waves. We would like to add this name along with various parameters such as Planck's constant, Planck's time and etc. to value his enormous contribution to quantum physics. Since the electrons in orbits have a negative charge e, a vibrating electron sets up a time varying luminous field during light or radiation emission event. Since at this frequency of mechanical vibrations, no electric charge properties are visible, we shall name the field created by vibration as an illumination field. The energy carried in a cycle of this field a luminous vector L should correspond to **h** × **ν** units as per Einstein's light wave energy model. It is observed that luminous field created by every light source produces non-coherent, multi-polarized, randomly oriented energy waves. The waves emitted from different electrons are uncorrelated both in time and space. In figure 1.12, we have displayed three dimensional representations for a propagating light wave for vibrations from two electrons to describe a situation. From the diagram it is obvious the energy waves radiated from vibrations of two electrons will not have any phase relationship.

One could easily see the differences between new quantum model vs. old dual wave and particle model of light waves. The main difference is that the old model described light as electromagnetic waves whose energy is expressed by equation (1.14). The new model characterizes the light as luminous waves with energy $h \times \nu$ units. In the old model the light waves consists of propagating electric and magnetic waves those were in planes that are at 90 degrees angle to each other. Also the direction of vibration of electric and magnetic field waves were normal to the direction of propagation of light waves. According to new model light waves consists of mechanical waves created by vibrations of electrons in any plane at random. Therefore light waves originated from any source of light do not have a fixed known phase relationship with any reference. Further light waves created from any source of light are always unpolarized. There is no procedure exist that allow to produce polarized light without first producing unpolarized light. Usually polarized light is obtained when unpolarized light is passed through some short of filtering process.

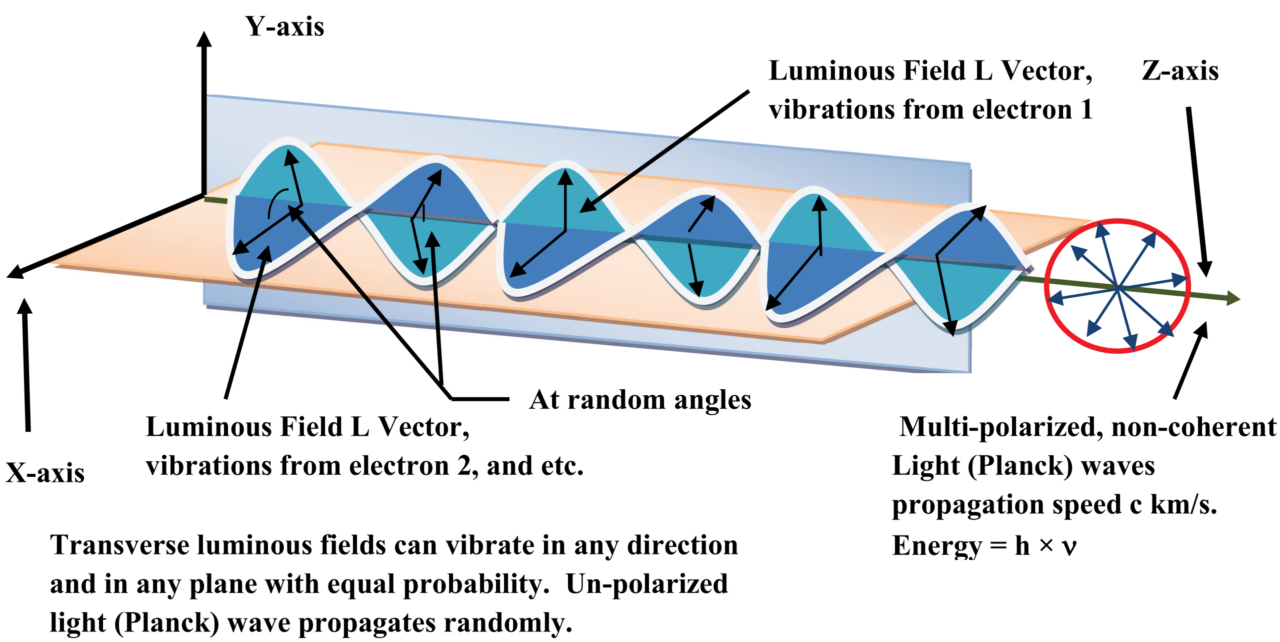

Figure 1.12 Three dimensional representations for propagating light wave (New model).

The scientific community will be surprised if our prediction that light waves are mechanical vibration energy waves similar to sound waves proves correct. Our belief is substantiated by the fact light wave illumination field emitted from electrons in orbits is immune to any charge effects or magnetic fields. It is found that electromagnetic waves can be redirected with strong electric or magnetic fields. In our opinion, the entire energy (**$h \times \nu$**) of light waves is carried by intensity vector L. Further, it is discovered that a beam of unpolarized light may be transformed into polarized light by various techniques. Four common methods are polarization by Selective Absorption, Polarization by Reflection, Polarization by Double Refraction and Polarization by Scattering. It is important to know one can't alter polarization characteristics of light under influence of high intensity electric or magnetic fields. None of the methods to polarize light relies on application of electric or magnetic energy to a beam of light. Therefore, we propose that light waves are not electromagnetic waves. This conclusion may be very difficult for many physicists to swallow. We will do our best to validate our theory. For increase in speed (bandwidth) and security of information often information is transmitted over optical fiber channels. Recent advances in technology, allows controlling polarization of light waves signals on the channels based on encoded encryption mechanisms. The technique is known as quantum encryption. From newly proposed model for light waves, we provide the following expression for parameters related to the light waves.

Speed of light c

$$\mathbf{c = \nu \times \lambda} \qquad \textbf{(1.18)}$$

Where c is true speed of light [2]

The instantaneous illumination field wave is given by

$$\mathbf{L = L_{max} \cos (kz - \omega t + \phi)} \qquad \textbf{(1.19)}$$

Where L_{max} are maximum values of the fields
k is angular wave number $k = 2\pi/\lambda$
ω is angular frequency $\omega = 2\pi\nu$ and
ϕ is phase angle for light wave origination.

The energy carried by light wave

$$\mathbf{U_{avg} = h \times \nu} \qquad \textbf{(1.20)}$$

Obviously, from our new model it is evident; more research is required to perfect a model for the energy of light waves. We hope the ideas developed in this white paper, will evolve and open doors for many inventions in the near future.

1.8 Conclusion

Detailed analysis of the Photoelectric Effect, the Short Wave-Length-Limit X-ray emission and the Compton Effect proves those effects do not provide enough evidence to support the premise that light consists of photon particles. Our explanation on results of those experiments demonstrating the effect further clarifies the idea that these experiments do not necessarily prove that light energy consists of photon particles. From this white paper's points of view, we claim that entire spectrum of electromagnetic radiation consists uniformly of waves with different wavelengths and completely characterized by wave properties. We have successfully developed a model for light waves energy that is consistent with the laws invented by Planck and Einstein. Further, we show that light Planck waves are not electromagnetic in nature. Here we have successfully derived new model for light waves based on principles of quantum physics.

In Einstein's life time there were many discoveries yet to be made. Now in modern times, physicists from around the world made those discoveries. It is our responsibility to take in to account the facts and then correct understanding to describe behavior of light properly. Finally our sense of accomplishment would not be complete until we offer a well deserved tribute to the greatest scientist Albert Einstein's legacy in new millennium such as this. Therefore we hope you will be satisfied and welcome this effort.

We suggest a modification in the Compton Effect experiment. In his apparatus, he should employ X-ray source of variable frequency. One would discover the energy of recoil electron and the velocity will be different for each wavelength of X-ray. At a particular frequency the recoil velocity will be maximum an effect similar to the Photoelectric Effect. At that frequency one will discover the shift in scattered X-ray wavelength is maximized also.

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