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Light's Infinitely Variable Energy Velocities in View of the Constant Speed of Light

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ABSTRACT

The discovery of Einstein's hidden variables was presented at the previous "Nature of Light" meeting, and revealed that Max Planck's famous quantum formula was incomplete.[1] The complete quantum formula revealed a previously hidden energy constant for light, 6.626 X 10^{-34} J/osc (the energy quantum of a single oscillation of light) and a measurement time variable. The "photon" is a time-based collection of sub-photonic elementary particles, namely single oscillations of light. An understanding of the *constant* speed of light as well as the *relative and additive* velocities of light's energy quantum is now possible. What emerges is a remarkably fresh and yet classical perspective.[2-7]

Einstein's three-dimensional light-quantum model applied to the recently discovered energy constant suggests the constant energy of an oscillation of light is distributed along its wavelength and is absorbed and emitted as a whole quantum. In a vacuum, light's oscillations travel at the constant speed of light (Lorentzian) regardless of their wavelength. The time-rate (velocity) with which the whole energy quantum of an oscillation is absorbed or emitted varies with its wavelength. The longer the wavelength, the longer it takes for the entire oscillation energy to be absorbed. Light's infinitely variable energy velocities are consistent with the Galilean principle of relative and additive velocities. A realistic mechanism for superluminal absorption and emission becomes apparent and a new corollary is found:

> *Light propagates from every transmitter at the same speed, but reaches receivers at different* ***frequencies****, depending on the relative difference between the speed of the transmitter and receiver.*

Keywords: Light, oscillation, energy, Galilean transformation, Lorentz transformation, speed of light, superluminal

1. INTRODUCTION

The relationships between matter, light, and their speeds and velocities have been the focus of discussion for several centuries.† Galileo Galilei enunciated his principle of relativity for velocity in his *"Dialogue Concerning the Two Chief World Systems"* in 1632. He gave the example of a ship moving with smooth continuous motion, and the observer shut up in the cabin below, *"You will discover not the least change in all the effects named, nor could you tell from any of them whether the ship was moving or standing still. In jumping, you will pass on the floor the same spaces as before, nor will you make larger jumps toward the stern than toward the prow even though the ship is moving quite rapidly, despite the fact that during the time that you are in the air the floor under you will be going in a direction opposite to your jump. ... The cause of all these correspondences of effects is the fact that the ship's motion is common to all the things contained in it and to the air also."* From this example emerged Galileo's principle of relativity: Any two observers moving at constant speed and direction with respect to one another will obtain the same results for all mechanical experiments.

From this idea of relative velocities emerged the further principle of additive velocities. Consider an observer standing on the shore watching a ship sail past (Figure 1., below). A passenger is standing motionless on the rear of the ship. Because *"the ship's motion is common to all the things contained in it"*, the velocity of the passenger, relative to the

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† Speed is the rate of motion in space, and velocity is the speed in a particular direction.

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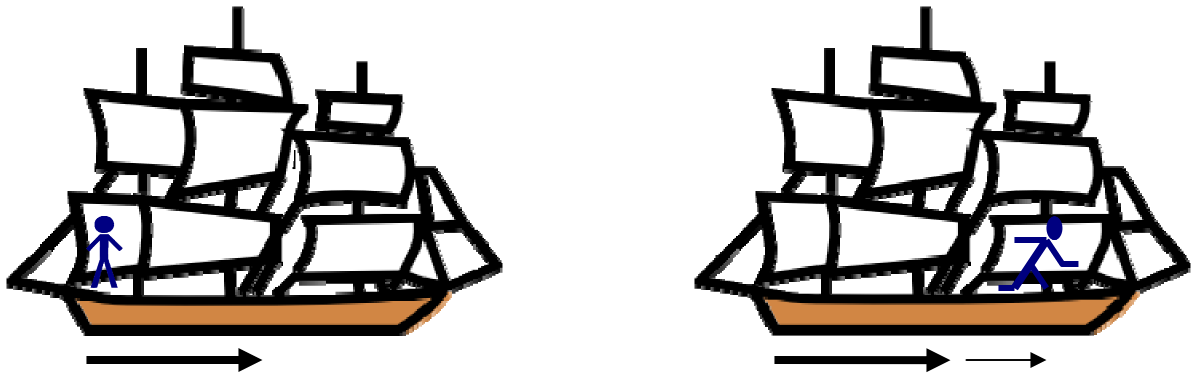

a. b.

Figure 1. Galilean relative and additive velocity. a. Observed from the shore, the velocity of the motionless passenger on the ship is equal to the velocity of the ship. b. The velocity of the passenger running toward the front of the ship, relative to the shore, is the ship's velocity plus his own running velocity.

observer on the shore, is the velocity of the ship. Imagine now, that as the ship sails past the observer the passenger starts running from the back of the ship to the front. The velocity of the passenger relative to the observer on the shore, is the velocity of the ship ***plus*** the passenger's running velocity. In other words, the total velocity of the passenger relative to the shore is the ship's velocity plus their own running velocity. This is the Galilean transformation. Velocities are relative and additive.

Galileo was interested not only in the velocities of ships, people and mechanical items, but also in the speed of light. It is said he attempted to measure the speed of light by taking bright, covered lanterns to the tops of hills, uncovering the lanterns, and attempting to correlate the distance between the lanterns with the speed of light. The experiment failed due to the crudeness of the technology available to him and the fact that the light traversed the distance between the two (2) hill tops in 20 microseconds.

Later in that century, the Danish astronomer Ole Christensen Rømer performed astronomical observations based on another proposal of Galileo's. The King of Spain had offered a prize for whoever devised a method to determine the longitude of a ship at sea, out of sight of land. Galileo had proposed using the eclipses of the moons of Jupiter as a timing and navigation tool for this purpose. Galileo was unsuccessful with the method, but Rømer took it up several decades later. While performing his observations on Jupiter's moon Io, Rømer noticed that as Earth approached Jupiter the times between Io's eclipses became shorter. When the Earth moved away from Jupiter, the intervals between Io's eclipses grew longer. He proposed that these differences were "*due to light taking some time to reach us from the satellite; light seems to take about ten to eleven minutes [to cross] a distance equal to the half-diameter of the terrestrial orbit".*[9] This placed the speed of light at about 2.20 X 10^8 m/s, some 25% lower than the current accepted value.

Isaac Newton was quite aware of Galileo's proposed navigational method and of the Danish astronomical observations as well. In his *"Principia"*, he stated, *"For it is now certain from the phenomena of Jupiter's satellites, confirmed by the observations of different astronomers, that light … requires about seven or eight minutes to travel from the sun to the earth."*[10] This gave a speed for light of about 3 X 10^8 m/s, remarkably close to the current accepted value.

By the late 1800's, several scientists including Joseph Larmor and Hendrik Lorentz were working on concepts related to light and the luminiferous ether. In the wake of the Michelson Morley experiments - ostensibly showing there was no luminiferous ether – Lorentz attempted to defend the ether theory by suggesting that light and space contracted when light was traveling against the flow of the ether[11]. This suggestion was the source of the Lorentz transformation, i.e., the idea that the velocity of light is constant and independent of the velocity of the source. This bold new idea contradicted, of course, the Galilean principle of relativity.

This conflict between the Galilean transformation on the one hand, and the Lorentz transformation on the other, greatly troubled the young Albert Einstein. Einstein had a deep and abiding respect for Lorentz, and said of him, *"For me personally he meant more than all the others I have met on my life's journey."* Einstein was determined to find a way to reconcile the work of the two great masters, Galileo and Lorentz. He formulated the special theory of relativity and published it in his 1905 paper, *"On the Electrodynamics of Moving Bodies"*. According to Einstein, *"the principle of the constancy of the velocity of light is compatible with the relativity principle"*.[12]

That same year, Einstein also published his Nobel prize-winning paper on the emission and transformation of light, which included his explanation of the photoelectric effect. He began the paper by proposing that the energy of light is "*discontinuously distributed"* or localized in space in small packets he called *"quanta"*.[13] "The *"energy of light is discontinuously distributed in space ……[and] consists of a finite number of energy quanta localized at points of space that move without dividing, and can be absorbed or generated only as complete units."*

Einstein then went on to apply his light-quanta idea to the photoelectric effect, which had been first observed by Heinrich Hertz. (Hertz had observed that when a metal was illuminated with light of a high enough "threshold" frequency, electrons were ejected from the metal. Increasing the intensity of the light increased the number of electrons ejected, while increasing the frequency of the light increased the kinetic energy and velocity of the ejected electrons.) Einstein declared that, "*The simplest conception is that a light quantum transfers its entire energy to a single electron…"*. He then showed that the threshold frequency ("ν_{th}") provided just enough work energy to free the electron from the metal and allow it to be ejected (i.e., the work function "$h\nu_{th}$"). For frequencies of irradiating light ("ν") higher than the threshold frequency, the difference between the threshold work energy and the light's energy was transformed into electron kinetic energy ("K"). The electrons were ejected at greater velocity according to the relationship,

$$h\,\nu \;-\; h\,\nu_{th} = h\,(\nu - \nu_{th}) = K \tag{1}$$

where "h" is Planck's action constant.

Since one quantum was absorbed per electron, the more quanta absorbed by the irradiated metal (higher intensity) the greater the *number* of electrons ejected.[‡] Many in the scientific community welcomed the proposed mechanism for the photoelectric effect, based as it was on simple additive and subtractive aspects of energy and velocity. There was great opposition however to Einstein's light-quanta theory. The proclamation by Arthur Compton many years later that the scattering of X-rays was a quantum phenomenon finally ended the debate in Einstein's favor.[14]

A few years later, in 1908, Einstein's former classmate and Swiss theoretical physicist Walter Ritz proposed that light propagates from every transmitter at the same speed, but reaches receivers at different speeds, depending on the difference between the speed of the transmitter and receiver.[15] Under Ritz's Galilean theory, a beam of light shot from the bow of a moving ship would reach an observer faster than if the ship were motionless. The speed with which the light would reach the shore was the sum the speed of light "c" and the speed of the ship. Ritz was opposed to Lorentz's contraction/ether ideas as well as Einstein's relativity ideas. Later that year Ritz and Einstein carried on a debate in Germany's *"Physical Journal"* on electromagnetic radiation and thermodynamics. Ritz died a short time later, at the young age of 31.

The debate on the velocity of light continued after Ritz's untimely demise. In 1913, Dutch mathematician and astronomer Willem de Sitter published a "proof" of the constancy of the velocity of light.[16] De Sitter argued *"it is easily seen that the hypothesis of Ritz leads to results which are absolutely inadmissible. ... the velocity of light is independent of the motion of the source. Ritz's theory would force us to assume that the motion of the double stars is governed not by Newton's law, but by a much more complicated law, depending on the star's distance from the earth, which is evidently absurd."*

In 1924, Louis de Broglie finished his doctoral thesis on the quantum theory.[17] He commented on the lack of "*an isolated quantity of energy"* which, were it available, could be used to model light with a classical mechanical approach. Instead of having an isolated quantity of energy, he explained, one was forced to always associate light with a frequency. Frequency was infinitely variable, and thus the energy of photons was infinitely variable. De Broglie tried to reason his way through the quantum quagmire by drawing on the unique concepts of Einstein.

[‡] Millikan later showed that the number of electrons ejected over a wide range of irradiating frequencies was maximal when the irradiating light matched a resonant frequency of the metal. This was so, he indicated, because the absorption of electromagnetic waves was due to resonance: absorption by the metal of irradiating light was maximal at resonant frequencies, and absorption was proportional to the number of electrons ejected, thus the number of electrons ejected was maximal at resonant frequencies.

Einstein had proposed that light waves were actually small quanta of energy localized in space, and as such behaved like particles. De Broglie flipped the idea on its head and proposed that if waves could have particle-like properties, then particles could have wave-like properties. He applied both Galilean relativistic dynamics and the Lorentz transformation in his formulations and came to a startling result. Using relativistic dynamics he found a "phase" velocity greater than the speed of light, but with the reciprocal Lorentz transformation he found a "group" velocity slower than the speed of light (Table 1., below).

Galilean Relativistic Dynamics	**Lorentz Transformation**
$\nu = m_0 c^2 / h \sqrt{1-\beta^2}$	$\nu = m_0 c^2 \sqrt{1-\beta^2} / h$
$V = c / \beta$	$V = c \beta$
$V > c$	$V < c$
Phase Velocity	Group Velocity

Table 1. Louis de Broglie's phase velocity and group velocity. *ν"* is frequency, "m_0" mass, "h" Planck's action constant, and "β" the ratio of a particle's velocity "V" to the speed of light "c".

Experimental advances eventually caught up with theory. De Broglie's concept of particles of mass possessing wave-like properties was shown to be valid when wave-like properties were demonstrated for electrons. Likewise, the debate on the constancy of light's speed was settled in favor of Einstein and de Sitter. By 1946, Louis Essen and A.C. Gordon-Smith had used a precise microwave cavity resonator to measure the speed of light as 2.997,92 ± 9 m/s and by 1950 had improved the precision of their measurements to 2.997,925 ± 3.0 m/s. In 1975, the 15th General Conference of Weights and Measures recommended the value 2.997,924,58 m/s for the speed of light.

2. NEW DISCOVERIES IN QUANTUM MECHANICS

The recent new discoveries in quantum mechanics indicate that the energy of a light quantum is a finite scalar value that is represented by a universal constant. The energy of light's fundamental particle is *not* infinitely variable, as previously conceptualized. The photon is not the elementary particle of light, but is instead a time-based collection of sub-photonic elementary particles, namely individual oscillations of light. The energy of light is a conserved property under classical Galilean dynamics.[21]

These discoveries have their origins in the quantum concepts and mathematical formulations of Max Planck's famous paper on black-body radiation published in early 1901.[18] Planck had been pursuing two parallel lines of research in tandem: theoretical work on "resonant Hertzian radiation" (electromagnetic waves)[18] and theoretical work on black-body (thermal) radiation. In late 1900 Planck combined those two (2) lines of research into his derivation of the long sought after black-body equation, which described the thermal electromagnetic radiation emitted by an object based solely on its temperature. He borrowed some statistical methods from Boltzmann and the energy density method of Wien, while his quantum formula, "E = h*ν",* was simply assumed as a mathematical given. This assumed quantum formula was actually an abbreviated version of a mathematical relationship Planck used in his earlier electromagnetic theory, namely: [19]

$$\delta E \approx a \; \delta t_m \; \nu \qquad (2)$$

where "a" is a generic constant and "t_m" was the measurement time for the electromagnetic ("EM") radiation. Comparison of the two formulae,

$$E = a t_m \nu \qquad (3)$$

and

$$E = h \nu \qquad (4)$$

suggests that his later constant "h" was actually the product "$a t_m$" of the generic constant and the measurement time. Investigation of the mathematical procedures used in Planck's black-body derivation confirms that indeed, Planck's famous action constant "h", is really the product of a generic constant and a time variable.

As to the identity of that generic constant, various mathematical methods and dimensional analyses§ have all lead to the same un-refuted conclusion– the previously hidden constant is an ***energy*** constant.[20] The energy constant is the energy of a single wave or oscillation of EM radiation, i.e., $\tilde{h} = 6.626 \times 10^{-34}$ J/osc.** Likewise, the time variable was the electromagnertic energy measurement time variable, "t_m", which had been hidden and fixed at a value of one (1) second due to Planck's energy density calculation. Wheen Planck arrived at the point in his derivation where he actually calculated his constant "h", it was inadvertently calculated as the ***product*** of the energy constant "$\tilde{h}$", and the hidden and fixed time variable "t_m":

$$h = \tilde{h}\, t_{m,} \qquad \text{where } t_m = 1 \text{ second,} \tag{5}$$

hence
$$h = 6.626 \times 10^{-34} \text{ J sec} = (6.626 \times 10^{-34} \text{ J})\,(1 \text{ sec}). \tag{6}$$

Unwinding the energy constant and time variable from the action "constant" product provides the complete quantum formula:

$$E = \tilde{h}\, t_m\, \nu \tag{7}$$

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§ Reproduced from Chapter 1., The Fundamental Physics of Electromagnetic Waves, in *Electromagnetic Waves*:[22]

"Proof of these facts are found in Planck's 1901 blackbody paper, in which he described the experimental data and mathematical methods he used:

"*§11. The values of both universal constants h and k may be calculated rather precisely with the aid of available measurement. F. Kurlbaum, designating the total energy radiating into air from 1 sq cm of a black body at temperature t° C in 1 sec, by S_t found that:*

$$S_{100} - S_0 = 0.0731 \text{ watt/cm}^2 = 7.31 \times 10^5 \text{ erg/cm}^2 \text{ sec"} \qquad \text{(Underlines added)}$$

Instead of multiplying Kurlbaum's time-based power measurement by the measurement time to obtain total energy (as Planck had done in his earlier work), he converted the power measurement to energy density by dividing by the speed of light "c" (3×10^{10} cm/sec), according to Wien's method:

"*From this one can obtain the energy density of the total radiation energy in air at the absolute temperature*

$$\frac{4 \bullet 7.31 \times 10^5}{3 \times 10^{10}\,(373^4 - 273^4)\text{"}} = 7.061 \times 10^{-15} \text{ erg/cm}^3 \text{ deg}^4$$

The time variables in the numerator and denominator cancelled out and Planck was seemingly able to address energy independent of time. Dividing by the constant speed of light however, is the same as multiplying by time:

$$\frac{E/t\,s^2}{c} = \frac{E}{t\,s^2} \times \frac{t}{s} = \frac{E}{s^3} \qquad 12.$$

where "s" is distance. In this case the time value by which the power measurement was multiplied was the constant "one second" unit time of the constant speed of light. Planck seems to have been unaware that by using Wien's energy density calculation he was actually causing the infinitely variable measurement time to be fixed at a constant value of one second. He also seems to have been unaware that the fixed time variable was subsequently hidden in the final calculations of his action constant "h":

$$h = 6.626 \times 10^{-34} \text{ Joules seconds} \qquad 13.$$

His action constant is actually the *product* of a true universal constant - "$\tilde{h}$" - and the fixed, hidden measurement time variable, "t_m".

$$h = \tilde{h}\, t_{m,} \qquad \text{where } t_m = 1 \text{ second} \qquad 14.\text{"}$$

** Notably, the incomplete mathematical notation adopted by Planck - which omitted units for oscillations - is no longer necessary and the energy constant is given in proper and complete mathematical notation as energy per oscillation. See reference No. 20 for further discussion of units and dimensionality.

Analysis of the oscillation energy constant over time and space (e.g., frequency and wavelength) demonstrates that the energy of a single wave (oscillation) of electromagnetic energy is constant regardless of its frequency or wavelength. The energy of a single oscillation of light is a property of light which is constant over a shift in time or space. Oscillation energy is thus a classically conserved parameter of light, and the energy constant is universal.[21]

The discovery of the hidden time variable and energy constant has many implications for practical applications of quantum mechanics. One of these is better understanding the velocity and speed characteristics of light, both in free space and upon the absorption and emission of light by matter. De Broglie based his "photon" phase and group velocity concepts on the time-based energies calculated by Planck's abbreviated (and incomplete) quantum formula. He was unaware of the existence of the "*isolated quantity of energy"* he sought. Neither was de Broglie aware that the action "constant" was really the product of light's energy constant and a fixed, hidden time variable. None of the early quantum pioneers realized that if the measurement time was changed to half a second, the "photon" energy was halved. Likewise, if one arbitrarily doubled the measurement time to two (2) seconds, the "photon" energy doubled. To paraphrase Gilbert Lewis who coined the term "photon", "*The energy of an isolated photon, divided by the Planck constant, gives the frequency of photons [in an arbitrarily fixed one second measurement time].*[22]

An energy quantity which depends on an arbitrarily fixed time period, as "photon" energy does, cannot represent the fundamental particle of light. Such a construct produces a zoo of particles, each with differing energies. Contrast "photon" energy to other universal constants and parameters such as the charge of the electron, the mass of the proton, or the speed of light. The photon is not the elementary particle of light, but rather is a ***collection*** of sub-photonic, individual light oscillations.

The elementary particle of light is the single oscillation. Consistent with Einstein's and Compton's concepts of the localized energy of light, the constant and invariant energy of a light oscillation is easily visualized as being localized in a discrete area of space on the order of its wavelength. Decades ago, when quantum concepts regarding light's speed, absorption and emission were being formed, there was no finite and scalar amount of energy which could be considered in terms of light's speed and velocity. The recently discovered energy of a single oscillation of light, 6.626×10^{-34} J/osc, is the *"isolated quantity"* of energy which allows consideration of these matters now.

3. THE SPEED AND VELOCITIES OF LIGHT

Application of recent discoveries in oscillation theory to the velocity of light and its interactions with matter suggests two (2) types of speeds associated with light: 1) a constant translational speed for an oscillation of light traveling through space *in vacuo*, and 2) a directionally variable speed for light's energy during its absorption and emission from matter, which depends on the oscillation's variable time period "τ" and wavelength "λ".

For purposes of exploring this conjecture further, we shall admit of three (3) basic premises. The first two (2) originated with Einstein, and the third draws from recent discoveries in oscillation theory:

1. The speed of light *in vacuo* is constant;
2. The energy of light is physically localized in space in a volume on the order of its wavelength; and
3. The energy constant for light is 6.626×10^{-34} Joules per oscillation.

3.1 The Constant Wave Speed of Light

Consider two (2) oscillations emitted in parallel by an emitter at rest relative to the speed and direction (velocity) of the oscillations. The oscillations have differing wavelengths and time periods such that the wavelength and time period of the first oscillation "λ_1 and τ_1", are considerably greater than the wavelength and time period of the second oscillation "λ_2 and τ_2",

$$\lambda_1 >> \lambda_2 \quad \text{and} \quad \tau_1 >> \tau_2 \tag{8}$$

Next consider that the two oscillations are traveling through space parallel to each other and perpendicular to the surface of a detector. The detector is at rest relative to the oscillations and their emitter. The leading edges of the oscillations are equidistant from the outer surface of the detector (Figure 2., below).

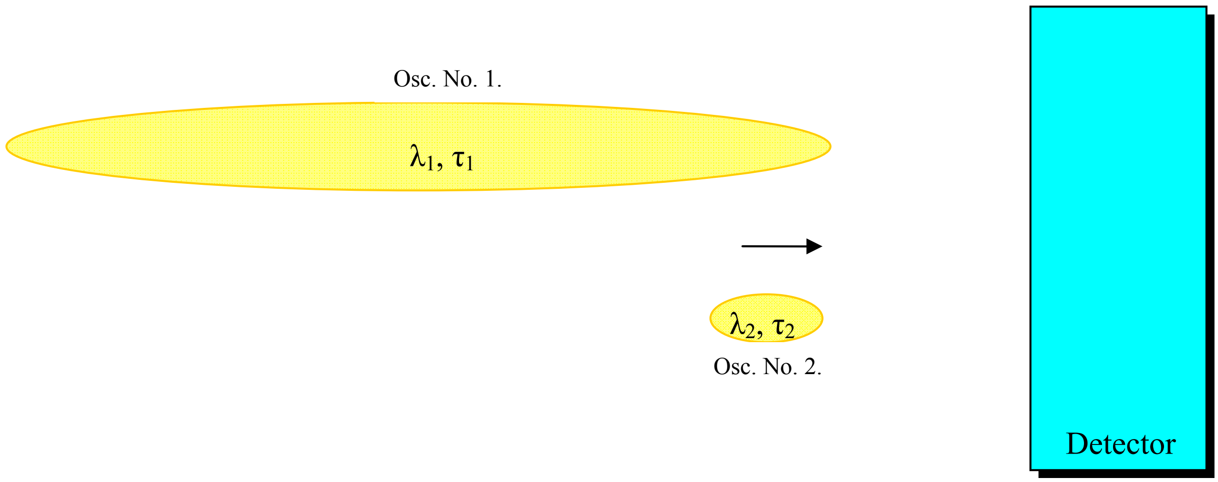
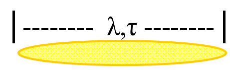


Figure 2. In the cartoon, an oscillation of light is represented by an elliptical shape, with the wavelength and time period of the oscillation equal to the length of the ellipse. The leading and trailing edges of each oscillation are traveling at the same constant speed across a vacuum towards the surface of the detector.



Although the two oscillations have different wavelengths/time periods, they both possess the same amount of energy, 6.626 X 10^{-34} Joules per oscillation, and travel in a vacuum at the same speed.

3.2 The Variable Velocities of Light's Energy Absorption and Emission

Consider next the absorption of the complete energy quantum of each oscillation. When oscillations Nos., 1. and 2. reach the surface of the detector, they maintain their forward motion, consistent with the constant speed and momentum of light. The energy quantum travels forward, entangling with the detector until the entire quantum of energy has been absorbed by the detector (Figure 3., below). The energy quantum of oscillation No. 2., is absorbed long before that of oscillation No. 1.

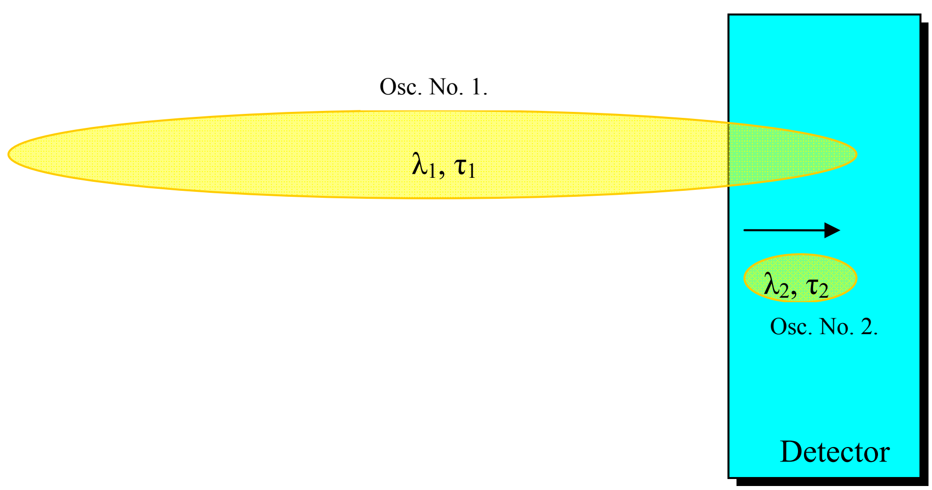


Figure 3. Oscillation No. 1. has wavelength and time period much larger than that of oscillation No. 2. The trailing edge of oscillation No. 1., has not yet reached the surface of the detector when oscillation No. 2., is completely absorbed by the detector.

Because oscillation No. 1., is much larger in time and space than oscillation No. 2., ($\lambda_1, \tau_1 >> \lambda_2, \tau_2$), only a small fraction of oscillation No. 1., has penetrated the detector at the instant in time when the energy quantum of oscillation No. 2. is completely absorbed by the stationary detector, The entire energy quantum of the shorter oscillation is absorbed more quickly than the equivalent energy quantum of the longer oscillation. The rate at which the whole energy quantum of the oscillation is absorbed depends on its time period and wavelength. The relative rate of the oscillation's complete absorption, i.e., its "energy velocity", is variable and is proportional to its frequency,

$$c_0 = c\,n \tag{9}$$

where "c_0" is the energy velocity of light's oscillation energy "$\tilde{h}$" and "n" represents a dimensionless scaling variable proportional to frequency, i.e., $n = \nu$ (1 sec). The shorter the wavelength, the greater an oscillation's energy velocity when it is absorbed (or emitted) by matter.

3.3 The Relative Nature of Light's Energy Velocities

Consider now the situation in which the detector is not motionless, but rather is traveling towards an oscillation at constant velocity. The speed of the light oscillation and its energy traveling through space is constant, and its energy velocity and frequency relative to it's emitter and original energy velocity are constant and unchanged. None-the-less, because the detector is moving *towards* the oscillation, the quantum of energy in the oscillation will be absorbed faster than if the detector were stationary. The *increase* in the velocity of the oscillation's absorption by the detector is equal to the velocity of the detector. The energy velocity and detector velocity are thus additive. The *detected* energy velocity, "c_0'", is given by,

$$c_0' = c_0 \pm V_{Det} \tag{10}$$

where "V_{Det}" is the velocity of the detector relative to the velocity of the emitter. When the detector travels towards the oscillation its velocity is additive (Figure 4., below). When the detector is traveling away from the oscillation, and must be overtaken by the oscillation, the detector velocity is subtractive.

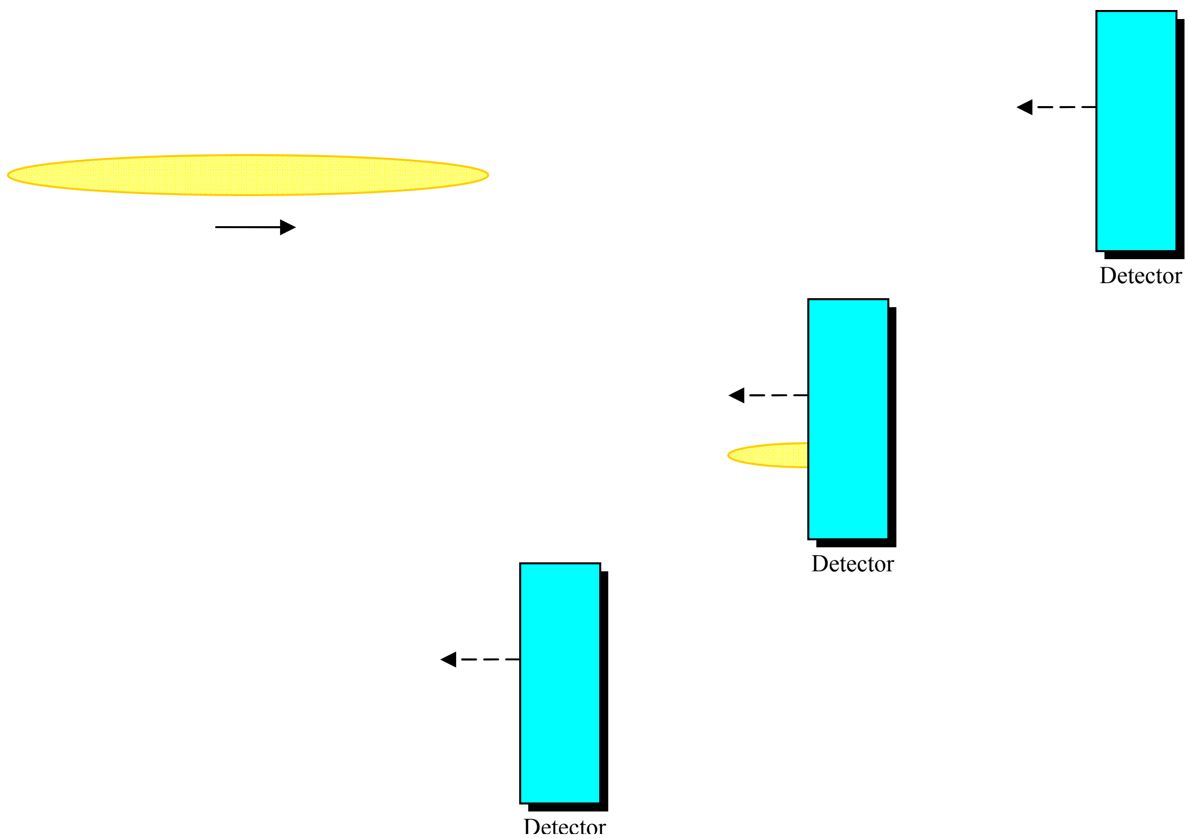


Figure 4. The additive velocity of a detector moving towards a light oscillation. The whole energy quantum of the oscillation is absorbed sooner and with greater velocity than when the detector is motionless. (Detector velocity is subtractive for a detector moving away from the oscillation.)

3.4 Light's Relative Detected Frequency

The frequency "v" sensed by a detector depends on light's relative energy velocity, i.e., the time-based rate of absorption of an oscillation's entire energy quantum. In the case of a detector traveling towards an oscillation with constant velocity, the oscillation will be absorbed in its entirety faster than if the detector were motionless. The oscillation will thus be detected at a higher frequency than the frequency at which it was emitted. Assume the emitted oscillation frequency is given by,

$$v = c / \lambda \tag{11}$$

The detected frequency, "v'", is Doppler shifted to a higher frequency by the amount dv, where,

$$v + dv = v' \quad \text{and}$$

$$c_0' = c\,(v')(1 \text{ sec}) \tag{12}$$

In the case of a detector moving towards the oscillation, *"dv"* is positive and the detected frequency will be blue-shifted to a higher frequency. In the case of a detector traveling away from a light oscillation, the value of *"dv"* will be negative, and the detected frequency "v'" will be lower and red-shifted.

4. DISCUSSION

> *"There are, at present, fundamental problems in theoretical physics… the solution of which will presumably require a more drastic revision of our fundamental concepts than any that have gone before…. The more powerful method of advance that can be suggested at present is to employ all resources of pure mathematics in attempts to perfect and generalize the mathematical formalism that forms the existing basis of theoretical physics, and after each success in this direction, to try to interpret the new mathematical features in terms of physical entities." Paul Dirac*[24]

Recent discoveries in the mathematics which formed the basis of modern theoretical physics suggest a startling new interpretation quite different from that adopted over the last century. A physical entity, the isolated oscillation of light, has been associated with a constant and invariant energy quantum, regardless of changes to the time (time period) or space (wavelength) of the oscillation. The "photon" of quantum mechanical constructs, although hypothesized to be the elementary particle of light, does not appear to be a fundamental particle afterall. Rather, it is a time-based collection of sub-photonic elementary light particles, namely oscillations. Applying this understanding to concepts on the *in vacuo* behavior as well as the emission and absorption of light by matter suggests a different interpretation of light relative to previous concepts.

Galileo indicated velocities are relative and additive. Many assumed this relativity principle applied to all manifestations of nature, including light. A few hundred years later, Lorentz suggested the speed of light was constant. The two concepts seemed irreconcilable, and so Einstein struggled with the apparent conflict between Lorentz's constant speed of light, and his knowledge of relative speeds under classical mechanics. How could both the Galilean and Lorentz transformations be true? In an effort to reconcile the two concepts, he developed his special theory of relativity.

In his 1916 book on relativity Einstein wrote, "*The special theory of relativity has rendered the Maxwell-Lorentz theory so plausible, that the latter would have been generally accepted by physicists even if experiment had decided less unequivocally in its favour. Classical mechanics required to be modified before it could come into line with the demands of the special theory of relativity. For the main part, however, this modification affects only the laws for rapid motions, in which the velocities of matter are not very small as compared with the velocity of light. We have experience of such rapid motions only in the case of electrons and ions; for other motions the variations from the laws of classical mechanics are too small to make themselves evident in practice."*

When he suggested that relativity demanded a modification to the law of classical mechanics, Einstein lacked knowledge of light's real physical entity, the isolated oscillation. He was left to puzzle over the nature of light for decades without benefit of knowing the identity of light's fundamental particle. Instead, his theories centered around photonic *collections* of light particles, mistaken for actual light particles themselves. The basis of theoretical physics inherited by Einstein and others after him was a topsy-turvy, upside down world which distorted all they saw and conceptualized.

Recent discoveries in the mathematical formalism underlying quantum mechanics promise to set the world back upright.

4.1 The Variable Velocities of Light's Energy Absorption and Emission

According to Einstein's light-quanta model, the energy of light is localized in space in a discrete three-dimensional volume of space. The experimental work by Compton and others, particularly in the higher frequency X-ray region where the physical dimensions are extremely small, has supported this spatially localized model for the energy of light. Recent discoveries indicate that the quantum amount of localized energy is much smaller than previously held, however. Light consists not of a shower of photons but rather of a shower of oscillations which are generally many orders of magnitudes smaller than "photons", energetically speaking. It is the difference between hale the size of golf balls and a fine mist.

The energy of an oscillation can be viewed as being confined in a localized volume in space, distributed along its wavelength. For visible light, for example, oscillations would be localized in a physical dimension of approximately 500 nm, X-ray oscillations in less than 0.1 nm, and radiowaves in meters. Experiment tells us that the uniform energy of an oscillation travels through a vacuum localized in a certain volume of space at a constant speed of 300 million m/sec.

The situation changes somewhat when the oscillation encounters matter. The absorption and emission of light from matter occurs at a wide range of velocities relative to its volumetric dimensions in space. Application of oscillation theory to absorption and emission of light suggests the existence of superluminal energy velocities, i.e., energy velocities faster that the "constant speed of light". Recent experiments have demonstrated superluminal effects at vacuum-matter interfaces.[25] Various mechanisms have been suggested for the superluminal effects, but all use the down-side up world of Planck's incomplete quantum formula and "photon" light particles as fundamental assumptions.

The new mathematical features of oscillation theory suggest that physical bodies emit oscillations of light with infinitely variable energy velocities. For example, for a light frequency of 1 Hz, the energy velocity is equal to the constant speed of light, "c". In other words, it takes one (1) second to absorb an oscillation that is 300 million meters long and traveling at the speed of 300 million meters per second. For light with a frequency of 20 Hz, the energy velocity of an individual oscillation, being absorbed by a detector, is twenty times faster than the constant speed of light ($c_0 = 20$ c). It takes only 0.05 seconds to absorb one of these oscillations, given that it is only 15 million meters long and yet still traveling at the constant speed of 300 million m/sec.

The effort herein to generalize the new mathematical formalism with a modified interpretation suggests that light oscillations of all varied wavelengths and time periods travel at the same constant velocity in a vacuum. When the oscillations interact with matter the oscillation continues to travel at the constant vacuum speed of light. The rate of absorption or emission of the energy quantum carried by the oscillation varies wildly, however, in line with the oscillation's length in time or space. This energy velocity can far exceed the constant speed of light in a vacuum. One should expect to see superluminal phenomena at the boundaries of matter and detectors, but not in the empty void and vacuum of space. Experiments with "superluminal tunneling" of light in certain forms of matter provide tantalizing suggestions that this concept may be true. Light velocities up to 300 times the constant speed of light have been observed at vacuum/matter interfaces and boundaries, and standard quantum mechanics under special relativity cannot explain these real physical phenomena.

4.2 The Relative Nature of Light's Energy Velocities

Thus far in the discussion we have considered the case in which the emitter of an oscillation is stationary in regards to the detector. In other words, both emitter and detector are in the same frame of reference. According to Galileo, if either the emitter or detector is moving they are no longer in the same frame of reference. Attributes of their relative interactions with the light oscillation must be considered for these different frames of reference. When the detector is approaching the oscillation of light, the oscillation will no longer be absorbed over the time period which it occupies in vacuous space relative to its emitter. The detector is not sitting passively, waiting for the complete oscillation energy to plunge into it. Instead it is moving forward, impaling itself on the moving light oscillation.

The moving detector absorbs the energy of the oscillation faster than if it were standing still, and so the energy velocity of the light becomes relative to the velocity of the moving detector. The faster the detector is moving toward the oscillation of light, the faster it will engulf and entangle the oscillation. Just as the running passenger on the ship has a relative velocity that is faster than the motionless passenger's velocity, detectors moving relative to emitters and oscillations experience differences in the energy velocity of light.

It makes little difference if the emitter is moving relative to the detector, or vice-versa, the effect is still the same. That is the beauty of relativity. The velocity at which the detector absorbs an undisturbed oscillation is different from the energy velocity at which it was emitted, when emitter and detector are moving relative to each other.

For the detector moving *towards* the oscillation, the detected energy velocity is increased. And quite the opposite, when the detector is moving *away* from the oscillation, being chased as it were by that physical entity, it takes a longer period of time for the oscillation to tunnel its way through the boundary surface and imbed itself in the detector. The amount of change in the detected energy velocity of the light is determined quite simply by the difference in velocity between emitter and detector (assuming the oscillation is undisturbed by some other force during its transit between emitter and detector). If the detector is moving towards the oscillation at the rate of one million meters per second, the velocity of the energy's absorption will be increased by one million meters per second. Were the detector to be running away from the oscillation, the energy velocity would be decreased by that same amount. An oscillation of light emitted with an energy velocity of 500 million m/sec, encountering a detector traveling directly towards it at the rate of 100 million m/sec, will acquire the relative detected energy velocity of 600 million m/sec upon its rendezvous with the moving detector. The velocity of the energy and the velocity of the detector are additive. Now a velocity of 100 million m/sec is very fast – one third the velocity of light in a vacuum – and one rarely encounters detectors traveling at those speeds in everyday life. The relative velocities of planets, suns and spinning galaxies hurtling towards each other can produce quite large relative velocities however, and some superluminal events have been detected astronomically.[26]

The additive nature of light's energy velocity appears to apply not only to simple emitters and detectors, but also to particles of matter entangled with absorbed light as well. Clues to the relative nature of energy and velocities for both matter and light were present in the photoelectric experiments that Einstein considered while formulating his great light-quanta theory. The energy velocity of the light falling on the boundary surface of the metal plate used in the experiments was additive with the velocity of the escaping electrons. There was a direct relationship between the frequency of the light absorbed by the metal plate, and the velocity of the escaping electrons (Figure 5., below),

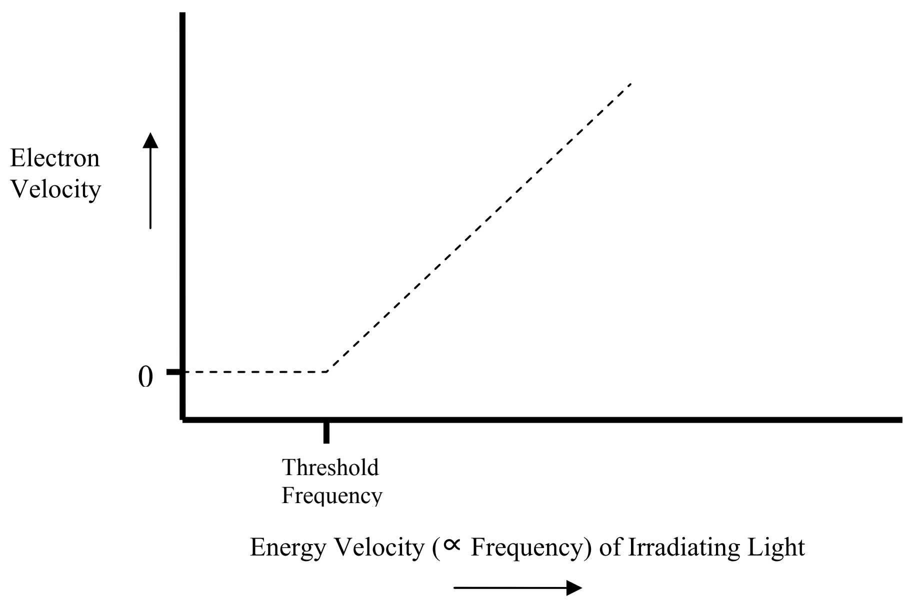


Figure 5. The Photoelectric Effect. Light irradiates a metal plate. Below a certain threshold frequency, no electrons are freed from the metal plate. At the threshold light frequency electrons are ejected from the plate with velocity proportional to the energy velocity (and frequency) of the irradiating light. Increases in the intensity (number of oscillations) strking the metal plate do not increase the velocity of the ejected electrons, but instead increase the *number* of ejected electrons. The energy velocity of the irradiating light is additive with the escape velocity of the electrons.

The higher the incident light frequency and energy velocity, the greater the electron velocity. The energy velocity "detected" by the metal plate was additive with the velocity of the ejected electrons. If the energy velocity of light did not play a major role in its effects on absorbing matter, a change in the frequency of the light would not have changed the electron velocity. More electrons would have simply been emitted at a higher frequency of light. Increases in the intensity of the light increase the *number* of ejected electrons however. The relative aspect of light's energy velocity - additive with electron velocity - is thus further revealed by this lack of change to electron velocity when the intensity of the irradiating light is changed.

The photoelectric effect supports the oscillation interpretation of quantum mechanics.

4.3 De Broglie's Phase Velocity

The variable "energy velocity" for light is proportional to its frequency, and thus for frequencies great than 1 osc/sec the energy velocity is greater than the constant speed of light. This concept in some ways mirrors de Broglie's concept of phase velocity, where $V > c$. In de Broglies's phase velocity formulation, frequency is proportional to the Lorentz factor,

$$\sqrt{1 - v^2/c^2} \ .$$

In the oscillation theory presented herein, the scaling factor "n" for energy velocities is proportional to frequency, rather than to Lorentz's factor, however. This represents a departure from the Einstein/de Broglie mechanical and relativistic approach. This departure may be justified in light of the manner in which Einstein derived and applied the Lorentz factor in his special theory of relativity.

In his derivation of the Lorentz factor Einstein began stating,[23]

> *"A light-signal, which is proceeding along the positive axis of x, is transmitted according to the equation*
>
> $$x = ct$$
>
> *or*
>
> $$x - ct = 0 \qquad (1).$$
>
> *Since the same light-signal has to be transmitted relative to K_l with the velocity c, the propagation relative to the system K_l will be represented by the analogous formula*
>
> $$x' - ct' = 0 \qquad (2).$$
>
> *Those space-time points (events) which satisfy (x) must also satisfy (2). Obviously this will be the case when the relation*
>
> $$(x' - ct') = \lambda\,(x - ct) \qquad (3).$$
>
> *is fulfilled in general, where λ indicates a constant; for, according to (3), the disappearance of (x - ct) involves the disappearance of (x' - ct')."*

From this beginning, Einstein next used his constant "λ" to formulate his constants "a" and "b". He then used "a" and "b" to determine velocity (Einstein Eq. (6)),

$$\mathbf{v} = \frac{bc}{a} \qquad (6).$$

Finally, Einstein used the velocity relationship from Einstein Eq. (6) to derive his relativity relationships for displacement "x" and travel time "t",

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t' = \frac{t - \frac{v}{c^2}x}{\sqrt{1 - \frac{v^2}{c^2}}} \quad . \quad . \quad . \quad (8).$$

Looking closely at the very beginning of his derivation (previous page above, Einstein Eqs.(1) and (2)) one sees that the sums "x – ct" and "x′ - ct′ " are equal to zero. The two (2) zero sums were then set equal to each other by the factor "λ" in Einstein Eq. (3). Simplified, Einstein Eq. (3) yields,

$$0 = \lambda \times 0 \tag{13}$$

A factor multiplied by zero is indeterminate. An infinite number of values can be multiplied by zero to give the product "zero". Einstein's constant "λ" is indeterminate. He used this indeterminate factor to derive his constants "a" and "b", and then used *those* indeterminate constants to derive his relativistic equation for velocity (Einstein Eq. (6)). Finally, he incorporated that indeterminate formula for velocity into both the numerators and denominators of his relativity equations (Einstein Eq. (8).).

Significant interpretational reliance has been placed on the fact that undefined values are produced when velocity "v" in the Lorentz factor equals the speed of light. This serves as the basis for declarations that nothing can travel as fast (or faster) than the speed of light. Using the Lorentz factor, a velocity equal to the speed of light produces a zero in the denominator, making it impossible to define a value for either displacement "x" or time "t".

It seems reasonable to hold that the use of indeterminate constants in the derivation of a factor (such as the Lorentz factor), may subsequently result in the anomalous production of undefined values. (If one begins by improperly multiplying by zero, it should come as no surprise to find one's self dividing by that same zero later on.) The Lorentz factor in the special relativity formulation does not necessarily represent the real behavior of physical entities in accurate mathematical terms. It may be more appropriate to use a scaling variable to represent the proportional displacements in space and time for differing frames of reference, such as "x/x′ = m" and "t/t′ = m", where,

$$x = mx' \quad \text{and} \quad t = mt', \tag{14}$$

such that

$$x = ct \quad \text{and} \quad mx' = mt' \tag{15}$$

This suggests that the idea that it is impossible to match or exceed the speed of light may be based on a mathematical anomaly. There appear to be no mathematically rigorous limitations on the speeds of physical entities relative to the constant speed of light in a vacuum.

CONCLUSION

In vacuum, light's oscillations travel at the constant speed of light (Lorentz) regardless of their wavelength. The time-rate (velocity) with which the whole energy quantum of an oscillation is absorbed or emitted varies with its wavelength. The longer the wavelength, the longer it takes for the entire oscillation energy to be absorbed. Light's infinitely variable energy velocity is consistent with the Galilean principle of relative and additive velocities. The constant energy of light in a vacuum is consistent with the Einstein/Lorentz hypothesis.

The detected frequencies of light oscillations are subject to blue and red Doppler shifts, just as the whistle of a train sounds higher as the train approaches, and lower after it passes. At small relative velocity differences between emitter and detector, the frequency shift will be barely perceptible. At higher velocities, such as those associated with the thermodynamics of thermally energetic electrons, atoms and molecules, or with the motion of stars and galaxies, the frequency shift is measurable.

Although Ritz did not have the advantage of knowing about the constant energy of light's oscillations, his theoretical proposal regarding light's speeds was startlingly close to the interpretation suggested by oscillation theory. Ritz proposed that light propagates from every transmitter at the same speed, but reaches receivers at different *speeds*, depending on the difference between the speed of the transmitter and receiver. Modifying Ritz's theory to bring it into line with the tenets of oscillation theory, one finds instead,

> *Light propagates from every transmitter at the same speed, but reaches receivers at different* ***frequencies****, depending on the relative difference between the speed of the transmitter and receiver.*

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