Principles of Emission Theory

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The general principles of the Emission theory of light have been the focus of this discussion. From these principles, the basic mathematical formulae are deduced, and their implications in related areas thoroughly discussed. Those areas include the Michelson-Morley experiment, the Doppler effect, the law of aberration, the effect of acceleration, and Hubble's law for distant nebulae. With regard to the Hubble law, the new concept 'Delta Effect' has been introduced and investigated at length. It is concluded that to deductions of the first order, the theory is simple and internally consistent. The justification for this exposition is the desirability of having a clear and coherent model that may serve as a conceptual basis for experimental testing and further discussion.

Introduction

There are three statements that have been made about the relation between the velocity of light and the motions of both the source and observer:

1. Velocity of light does not depend on the velocity of the source. It depends only on the relative velocity between the medium and the observer. This is the statement of the classical wave model, and it follows directly from the wave concept as applied to the wave phenomena in general. As a rule, if any thing is a wave, then its motion and the motion of its source are not additive. The wave model predicts the feasibility of determining the absolute velocity of the observer without any reference to the rest of the universe. However, it became clear, after the failure of this prediction that the statement of the wave model is partially, at least, incorrect, and must be modified.
2. Velocity of light is independent of the relative velocity between the source and the observer. This is the statement of Special Relativity. Because this statement cannot be deduced from any theoretical argument, it must be introduced as a fundamental postulate.
3. The velocity of light depends on the velocities of both the source and the observer. This is the statement of the Galilean theorem of the addition of velocities which forms the basis of the Emission theory, and it follows naturally from the particle concept.

The last two statements about the speed of light are diametrically opposed. At the quantitative level, however, there is some sort of symmetry between a compound quantity assumed to be absolute and its fundamental units to be relative, on one hand, and the same compound quantity taken to be relative and its fundamental units to be absolute, on the other hand. This symmetry is capable of rendering any indirect experimental evidence for or against either one of those two theoretical standpoints, completely inconclusive.

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Light speed as a universal constant, in the Einsteinian sense, is an integral part of the conventional research, and it is reasonable to assume that its theoretical implications have been thoroughly explored. In contrast, the notion of variability has been investigated, only occasionally, by very few individuals.

It is the main purpose of this paper to unify those previous theoretical attempts on the notion of variability, within one coherent conceptual scheme, and to explore their implications in optics and astrophysics. It should be noted that the introduction of the notion of variability, into astronomy, in particular, could be very destructive. That is not because the idea in itself is destructive, but because most of the theoretical framework in modern astronomy is built around the notion of constancy.

1. General Considerations

'Emission Theories' is often the term used to denote the works of W. Ritz, Sir J. J. Thomson, and O. M. Stewart. Proposals, on this topic, by Richard C. Tolman, and more recently, the work of R.A. Waldron on the ballistic theory, and the modification of the Ritz theory by J. G. Fox, might be included.

Emission theories are based firmly on the Galilean theorem of kinematics [Tolman, 1912]. Their scope is cross-disciplinary. They are naturally compatible with the corpuscular model, and can be made compatible with the wave model or modified version of it, by the use of auxiliary hypotheses. If only the general principles are considered, emission theories, then constitute one single theory built upon two assumptions:

1. The Galilean theorem is applicable to electromagnetic radiation.
2. Electromagnetic radiation propagates ballistically.

The second assumption can be eliminated, if the addition of velocities, in the theorem, is taken to imply ballistic propagation. The Galilean theorem itself assumes that distance and duration are absolute. Given the universal validity of the theorem, the next step is to define the basic concepts involved in its applications.

A source of light can be defined as a collection of basic emitters. Nothing, in this regard, needs to be specified about the internal dynamics of the basic emitter. In other words, the treatment of this subject from the standpoint of the Emission theory is independent of whatever concepts used to explain away radiation phenomena. To simplify the quantitative treatment to the subject matter, it should be assumed that to a reasonable degree of certainty, a basic emitter emits the fundamental elements of its radiation, with constant speed, at regular intervals of time. The speed of the radiation is constant with respect to the inertial frame of the basic emitter. Hence, in the reference frame in which the basic emitter at rest, the relation between the speed, frequency, and wavelength, is the same as in the conventional case. Except, here, the wavelength is defined as the distance between two successive elements of radiation.

The reference frames, available to a certain observer, form always a hierarchy, and can be divided into primary and secondary frames of reference. On the basis of the relative motion between two frames of reference, in absolutely abstract situation, it is impossible to determine which of the two is the primary, and which is the secondary. In real situations, however, it is possible to employ the statistical method, the principle of least action, the Bradley law of aberration, and some other methods to identify the primary frame of reference.

2. Thomson's Theorem of the Change of Velocities

This theorem is a straightforward application of the Galilean transformations to electromagnetic phenomena, and it could be derived from either the Doppler formulas, or from the equations of the energy density of light. O. M. Stewart uses the concept of 'source image' from geometrical optics, to introduce Thomson's theorem [Stewart, 1911]. Here, it is convenient, to restate this important theorem in a more general form:

A. In the inertial frame of reflecting surface, light is always reflected with the relative velocity between the incident light and the reflecting surface.

B. In the master frame, light is always reflected with the resultant of the relative velocity of the incident light with respect to the reflecting surface, and the velocity of the reflecting surface relative to the master frame.

Therefore, in the inertial frame of reflecting surface, the relative speeds of incident and reflected beams are equal, and their direction is governed by the normal rules of reflection. The observer needs to consider only apparent changes in position of the source due to Bradley effect. The case in which reflecting surface is in motion with respect to the primary reference frame of the observer, might be considered the most important. Here, velocities of incident and reflected light can be compared and consequently, changes in direction and magnitude can be observed and computed, according to the following procedure:

1. Apply the law of cosines to compute the relative speed between incident light and reflecting surface.
2. Use the law of sines to determine the direction of the relative velocity between the incident light and reflecting surface.
3. Consider the direction of the relative velocity as the angle of incidence, and employ the law of reflection.
4. Compute the vector sum of the reflected relative velocity and the velocity of the reflecting surface in the master frame, by applying, once more, the trigonometric laws above.

The Thomson theorem is indispensable in explaining away the Michelson-Morley experiment, and it can be extended to include changes of velocities by refraction in moving media. For a moving medium of refractive index n, the theorem takes the following form:

1. In the inertial frame of moving medium, light always moves with the refracted relative velocity between the incident light and the refracting medium.
2. In the master frame, light always moves with the vector sum of the refracted relative velocity between the incident light and the refracting medium, and the velocity of the refracting medium with respect to the master frame of reference.

3. The Michelson-Morley Experiment

This experiment has been designed to measure the orbital velocity of the earth around the sun with respect to the ether. A narrow beam of light is split into two beamlets by a half-silvered mirror M_1. Beamlet A proceeds to mirror M_2 and is reflected to M_1, where a portion is transmitted and a portion is reflected. Beamlet B is reflected by M_3 and a portion of it is transmitted through M_1 and combines with the reflected portion of beamlet A. Because beamlets A and B derived from the same initial beam, they are coherent, and on combining can interfere according to their relative phase. This phase relation is determined by the difference in the optical path lengths for beamlets A and B [Michelson, *et al.*, 1887)]. By applying the Thomson theorem to this arrangement, it is possible to calculate the difference in travel time between beamlets A and B, in the master frame and in the inertial frame of the apparatus respectively.

In the master frame:

During the first part of its journey, the light beam travels along the horizontal path, in the direction of the earth motion, with the resultant of its initial velocity *c*, and the velocity of its source *v*, *i.e.* $(c+v)$. With this velocity, beamlet A passes through M_1 toward M_2. At the same time, M_2 is moving away with velocity *v*. Hence,

$$t_{A1} = \frac{L + vt_{A1}}{c+v} = \frac{L}{c} . \tag{3.1}$$

Beamlet A strikes M_2, and is reflected back to M_1 with total velocity of $(c-v)$, while M_1 is approaching with velocity *v*. Thus,

$$t_{A2} = \frac{L - vt_{A2}}{c-v} = \frac{L}{c} . \tag{3.2}$$

Therefore, for a round trip along A, the elapsed time is

$$t_A = t_{A1} + t_{A2} = \frac{2L}{c} \tag{3.3}$$

The part of the initial beam that reflected by M_1 toward M_3 has a total velocity of $\sqrt{c^2+v^2}$. M_3 reflects it back to M_1 with the same velocity. The total path of B is $2\sqrt{L^2 + \left(vt_B/2\right)^2}$. Thus, for a round trip along B, the elapsed time is

$$t_B = 2\sqrt{\frac{L^2 + \left(vt_B/2\right)^2}{c^2+v^2}} = \frac{2L}{c} \tag{3.4}$$

Therefore, the time difference is $\Delta t = t_A - t_B = 0$, which is consistent with the null result of the experiment.

In the inertial frame of the apparatus:

Since the various parts of the apparatus are moving with the same speed, in the same direction, their relative motions with respect to each other are cancelled out. Therefore, the observer can notice only the Maxwellian speed of light *c*, and the given distance L. Consequently, for a round trip along A, the total elapsed time is $t_A = 2L/c$, and along B is $t_B = 2L/c$. Again, $\Delta t = t_A - t_B = 0$, a result that is in agreement with the observed outcome of the Michelson-Morley experiment.

Using astronomical source:

The same result can be obtained by the use of light from astronomical sources. Consider, for instance, using light from a source at rest in the opposite direction of the solar apex.

During the first part of its journey, the light beam travels along the horizontal path, in the direction of the earth motion, with an initial velocity *c*. With this velocity, beamlet A passes through M_1 toward M_2. At the same time, M_2 is moving away with speed *v*. Hence,

$$t_{A1} = \frac{L + vt_{A1}}{c} = \frac{L}{c-v} \tag{3.5}$$

Beamlet A strikes M_2, and is reflected back to M_1 with total velocity of (c – 2v), while M_1 is approaching with velocity v. Thus,

$$t_{A2} = \frac{L - vt_{A2}}{c - 2v} = \frac{L}{c - v}. \tag{3.6}$$

Therefore, for a round trip along A, the elapsed time is $t_A = t_{A1} + t_{A2} = \left(2L/c - v\right)$. The part of the initial beam that reflected by M_1 toward M_3 has a total velocity of $\sqrt{\left(c - v\right)^2 + v^2}$. M_3 reflects it back to M_1 with the same velocity. The total path of B is $2\sqrt{L^2 + \left(vt_B/2\right)^2}$. Thus, for a round trip along B, the elapsed time is

$$t_B = 2\sqrt{\frac{L^2 + \left(\frac{vt_B}{2}\right)^2}{(c - v)^2 + v^2}} = \frac{2L}{c - v} \tag{3.7}$$

Therefore, the time difference is $\Delta t = t_A - t_B = 0$.

The optical apparatus above can be used to measure accelerations and rotational motions within the primary and secondary frames of reference. Since each component of the earth motion involves rotation about some axis, Michelson's interferometer can be used, in principle, to measure the space motion of the earth. In practice, however, the earth rotation around its geometrical axis, is the only component of the earth velocity that has been measured with accuracy reasonably above the bar of experimental error.

4. Doppler Effect

To obtain the relevant formulae to this topic, it is convenient to start with the two simple cases of source and observer in direct approach or recession.

A. The source in motion:

Consider a source of light approaching with velocity v_s an observer at rest in the master frame. If the period of the radiation in the inertial frame of the source is T, then the period and frequency as viewed from the master are:

$$T' = \frac{T(c + v_s) - Tv_s}{c + v_s} = \frac{Tc}{c + v_s}, \tag{4.1}$$

where T' is the observed period of the radiation in the master frame of reference.

$$f' = T'^{-1} = f\left(1 + \frac{v_s}{c}\right), \tag{4.2}$$

where f' is the observed frequency. When the source is receding from the observer,

$$T' = \frac{T(c - v_s) + Tv_s}{c - v_s} = \frac{Tc}{c - v_s}, \tag{4.3}$$

and

$$f' = T'^{-1} = f\left(1 - \frac{v_s}{c}\right). \tag{4.4}$$

It should be noted, in this case, that according to the Emission theory, the motion of the source changes both the velocity and the frequency of the radiation, but it does not change the wavelength.

B. The observer in motion

If the observer is approaching with velocity v_o a source at rest with respect to the master frame, then the observed period and frequency in the inertial frame of the observer are:

$$T' = \frac{Tc - T'v_o}{c} = \frac{Tc}{c + v_o}, \tag{4.5}$$

and

$$f' = T'^{-1} = f\left(1 + \frac{v_o}{c}\right). \tag{4.6}$$

If the observer is receding from the source, then

$$T' = \frac{Tc + T'v_o}{c} = \frac{Tc}{c - v_o}, \tag{4.7}$$

and

$$f' = T'^{-1} = f\left(1 - \frac{v_o}{c}\right). \tag{4.8}$$

Thus, within the framework of the Emission theory, changes in the fundamental parameters of the radiation, due to the motion of the observer are relative and observed only in the inertial frame. There is no actual change in those parameters as observed from the primary frame of reference.

C. The source and observer in motion

Assume that a source and observer are approaching each other with velocities v_s and v_o respectively. To obtain the observed period and frequency in the inertial frame of the observer, we combine the above equations. Thus

$$T' = \frac{T(c + v_s) - Tv_s - T'v_o}{c + v_s} = \frac{Tc}{c + v_s + v_o}, \tag{4.9}$$

and

$$f' = T'^{-1} = f\left(1 + \frac{v_s}{c} + \frac{v_o}{c}\right). \tag{4.10}$$

If the source and observer are receding from each other, then

$$T' = \frac{T(c - v_s) + Tv_s + T'v_o}{c - v_s} = \frac{Tc}{c - v_s - v_o}, \tag{4.11}$$

and

$$f' = T'^{-1} = f\left(1 - \frac{v_s}{c} - \frac{v_o}{c}\right). \tag{4.12}$$

D. The general case

In order to derive the general formulae, few terms have to be defined. Line of sight is geometrically the shortest line connecting observer and source. The angle between the line of sight and the velocity vector of the source is measured counter-clockwise and equal to zero when the source is moving directly towards the observer. The angle that the velocity vector of the observer makes with the line of sight is measured in clockwise direction, and equal to zero when the observer is approaching the source directly. By definition, the line of sight is the direction of the resultant velocity of light reaching the observer from moving source. The magnitude of the resultant velocity *c'* is $c' = -\left[c\sqrt{1 - v_s^2/c^2 \sin^2 i} + v_s \cos i\right]$, where *i* is the angle between the line of sight and the velocity vector of the source. The minus sign can be omitted, since it is obvious that the velocity of light reaching the observer is always a velocity of approach.

From the given geometry, period and frequency observed in the inertial frame of moving observer are:

$$T' = \frac{Tc' - Tv_s \cos i - T' v_o \cos j}{c'} = \frac{T(c' - v_s \cos i)}{c' + v_o \cos j}, \tag{4.13}$$

and

$$f' = T'^{-1} = \frac{f(c' + v_o \cos j)}{c' - v_s \cos i} = f\left[1 + \frac{v_s \cos i + v_o \cos j}{c\sqrt{1 - \frac{v_s^2}{c^2}\sin^2 i}}\right], \tag{4.14}$$

where *j* is the angle between the line of sight and the velocity vector of the observer, after the removal of the aberration effect.

E. The case of acceleration

If a source and observer undergo uniform accelerations, a_s and a_o, then it is possible to compute the average of the Doppler shift, by averaging the sum of the initial and the final shifts in frequency. That is, $f_{av}' = f_i' + f_f'/2$. Moreover, on the Emission theory of, the acceleration of the source a_s, produces transient shift in the wavelength, by a small and constant amount Δl_{trans}, where $\Delta l_{trans} = l' - l = -\left[\frac{1}{2}T^2 a_s \cos\Theta\right]$, where Θ_s is the angle that the vector a_s makes with the line of sight.

5. Bradley Effect

Light aberration can be defined as the difference between the direction of incident light when the observer is at rest, and the direction of its relative velocity when the observer in motion. Hence, if the observed angle between the direction of incident light, and the velocity vector of the observer is *j'*, then $b = \Delta j = j - j'$, where j is the position of the source in the master frame. When the source is at rest with respect to the primary frame of reference, Bradley law for obtaining b takes its standard form: $\sin b = (v_o/c)\sin j'$, where v_o is the velocity of the observer relative to the master frame, and *j'* is the observed position of the source in the inertial frame of the observer. By the use of this formula, two kinds of stellar aberration can be obtained: the diurnal aberration and the annual aberration. The diurnal aberration is caused by the tangential velocity of the earth rotation. It always shifts, by very small amount, the positions of the stars towards the east. The shifts form a sine function that peaks at the observer's meridian. Although this sine function is symmetrical, the apparent angular distances between the stars, that produces, are systematically larger in the west than in the east of the meridian. That is because positions with higher altitude are shifted towards positions of lower altitude in the east of the meridian, and away from them in the west.

The annual aberration is the result of the tangential velocity of the earth motion around the sun. Its shift values are more significant and form two sine functions. The first has its peak value at the meridian of midnight, when the vector of the orbital velocity is pointing directly to the east. The second centres around the position occupied by the sun, where the vector of the orbital velocity is pointing towards the west. At the night side, the apparent changes in angular distances between the stars are systematically larger in the west of the meridian than in the east of it. At the day side, the reverse is true, *i.e.* they are systematically larger to the east of the sun than to the west.

The inclination of the line of sight in the direction of the motion of observer has no effect on the angle between the line of sight and the velocity vector of moving source. Thus the resultant velocity of incident light from moving source is $c' = c\sqrt{1-\left(v_s^2/c^2\right)\sin^2 i} + v_s \cos i$, where v_s is the velocity of the source, and i is the angle its vector makes with the line of sight. Therefore, the general form of Bradley law for a source and observer in motion is

$$\sin b = \left[\frac{v_o}{c\sqrt{1-\frac{v_s^2}{c^2}\sin^2 i} + v_s \cos i}\right]\sin j' \tag{5.1}$$

where $b = j - j'$.

Hence, according to this formula, the motion of a source around a local centre of gravity can produce periodic oscillations in the observed values of *b*, from minimum, when the source is approaching directly along the line of sight, to maximum, when it is directly receding from the observer. Therefore, these oscillations can be used, in conjunction with Doppler effect, to determine the aberration caused by the motion of the solar system around the Galaxy.

For a source and observer moving with the same speed in the same direction, the effect of light aberration is exactly balanced by the effect of light travel time. The space motion of the solar system, for example, does not alter the true position of a planet as seen from Earth. However, this situation is not exactly equivalent to its counterpart in a frame of reference at rest. That is because, in a moving frame of reference, during the light travel time t, the displacement of observer moving with the common velocity of the system v_o, is $d = v_o t$.

This displacement subtends at the source distance an angle that increases the perspective angle of moving observer, at the leading side, and decreases it at the trailing side of a moving source, by an amount equal to the angle of aberration, but in the opposite direction.

Thus, the aberration effect, in this case, transfers the image of the source from its position at emit time, to the true position of the source at receive time, but it does not change the actual result of the perspective angle of a moving observer, to that of the viewing angle of an observer at rest. For instance, because of the effect of light travel time, a terrestrial observer sees more of the lit side of a planet, when the planet is trailing the sun, and less of the same side, when the planet is between the sun and the solar apex. Therefore, according to Emission theory, it is possible to employ the effects of the galactic aberration and light travel time, together with the synodical period of planet and its position with respect to the sun, to explain the 'phase anomaly' of the inner planets as observed from the earth [Corliss, 1979].

If the axial rotation of a solar object is considered, the difference in velocity between light emitted or reflected from approaching edge, and that from receding edge, introduces differences in the light travel time. As the earth travels in its orbit, the two rotating edges exchange position as the leading edge relative to the solar apex. This, in principle, leads to oscillations in the apparent diameter of the solar object, between minimum when the receding edge is the leading edge, and maximum when the approaching edge is the leading edge with respect to the solar apex.

6. Refraction of Light from Moving Source

According to the Thomson theorem, in a medium of refractive index n, light travels with the vector sum of its refracted velocity relative to the medium, and the velocity of the medium with respect to the master frame. Therefore, given the relative velocity between incident light and refractive medium, it is essential to identify the manner in which this velocity is refracted.

Using a telescope filled with water, Airy concludes that refraction does not change the free-space values of Bradley effect. From the negative result of Airy's experiment, Fresnel deduces his well-known coefficient [Michelson, 1927]. Theoretically, Fresnel coefficient can be obtained from the conservation of momentum and energy [Fox, 1965]. It can also be deduced from the concept of free path between the particles of refractive medium. In the laboratory, the coefficient is verified by the Fizeau experiment. This experiment deals primarily with the special case in which refractive medium is in motion, and the source and the observer is at rest in the master frame. Because of the symmetrical nature of relative motion, however, it is possible to extend the scope of the results obtained by Fizeau to include the case in which the source is in motion, and the observer and the medium are at rest with respect to the primary frame of reference. Consider a medium of index n, moving directly in the direction of incidence with velocity v_m relative to the reference frame in which the source and the observer are at rest. From the Fizeau experiment: $c/n' = (c/n) - v_m(1-n^{-2})$, where c/n' is the total velocity of incident light inside the moving medium. This total velocity, according to the above theorem, is the resultant of the refracted relative velocity of $(c + v_m)$ of the incident light, and the velocity of the refractive medium. Hence, the refracted relative velocity of

$$(c+v_m) = \frac{c}{n} + \frac{v_m}{n^2}. \tag{6.1}$$

When the medium is receding along the direction of incidence, we have

$$(c-v_m) = \frac{c}{n} - \frac{v_m}{n^2}. \tag{6.2}$$

From the symmetry of relative motion:

$$\text{refracted } (c+v_s) = \frac{c}{n} + \frac{v_s}{n^2}, \tag{6.3}$$

and

$$\text{refracted } (c - v_s) = \frac{c}{n} - \frac{v_s}{n^2}, \tag{6.4}$$

where v_s is the velocity of the source with respect to the frame of reference in which the observer and medium at rest. To generalise, the refracted velocity w of incident light from moving source is $w = (c/n) + (c' - c/n^2)$, where c' is the relative velocity of the incident light. Since, in this case, $c' = c\sqrt{1 - (v_s^2/c^2)\sin^2 i} + v_s \cos i$, where i is the angle between the line of sight and the velocity vector of the source, we obtain:

$$w = \frac{c}{n} + c\left[\sqrt{1 - \frac{v_s^2}{c^2}\sin^2 i} - 1\right] + \frac{v_s \cos i}{n^2}, \tag{6.5}$$

where w is the velocity of the incident light inside the refractive medium. The case in which the medium absorbs and re-emits the incident light has been fully investigated by J.G. Fox [Fox, 1965]. It is actually a case of source and medium moving with the same speed in the same direction. Thus, the velocity of light through the medium is (c/n), in the inertial frame of the medium, and the vector sum of this velocity and the velocity of the medium, in the laboratory frame of reference. Outside the medium, the velocity of emerging light is the resultant of its Maxwellian velocity c, and the velocity of its new source in the laboratory. This resultant velocity of the emerging light is the basis for the xenon experiment, from which W. Kantor deduces that the Einstein postulate of constancy is incorrect [Kantor, 1962]. Another important case is the case in which the observer is moving inside a refractive medium, with velocity v_o with respect to the medium. Here, the values of both Doppler effect and Bradley effect due to this motion, are greater by the refractive index n, than their free-space values, as measured by the observer. Furthermore, when a source is moving through a refractive medium, the free-space value of its Doppler effect, as measured in any frame of reference, is always multiplied by the index of refraction n', where $n' = c/w$.

7. Effect of Gravitation

Referring to the basic element of radiation, W. Ritz uses the phrase "infinitesimally small fictitious particle" to redefine the Newtonian corpuscle, within the context of electromagnetic theory. Taken in isolation, the Newtonian corpuscle by itself, is no more than a convenient mathematical device. If, however, the fundamental parameters of emission are considered, this concept, in conjunction with variability, is very effective in saving phenomena and generating predictions. The radiation parameters (frequency, wavelength, and speed) imply the notion of an ordered and well-defined group. The concept of the corpuscular group, in the Emission theory, is very close, in many respects, to the photon concept, to be dubbed the 'corpuscular photon'. Nevertheless, there are significant differences between the two concepts. The photon is a bundle of waves. It has no rest mass, and its energy and momentum vary only with frequency. In contrast, the corpuscular group is a bundle of particles. It has mass, and its energy and momentum are proportional to speed and frequency. It has also a finite size that varies with pulse duration. How infinitesimally small is the Newtonian corpuscle? Consider the basic formula in the photon model: $E = hf$, where $h = 6.63 \times 10^{-34}$ J.s.

From this equation, the energy E when $f = 1$ Hz, can be computed. If the result is equated to $\frac{1}{2}mc^2$, where m is the mass of the corpuscle, we obtain: $m = 1.473 \times 10^{-47}$ g. Clearly, the phrase 'infinitesimally small' used by Ritz is well justified.

In interaction with gravitation, the corpuscular group gains energy by travelling along the direction of a gravitational field, and loses energy by travelling in the opposite direction. Because the corpuscular group, by definition, travels as a single unit, gravitation, in this case, produces changes in velocity and wavelength, but it has no effect on frequency. Since this effect on light, is exactly equivalent to the effect of a refractive medium, gravitational fields, in this regard, can be treated as virtual refractive media. Therefore, it is possible to use the path length and the average strength of a gravitational field, to compute its average effect on traversing light. With respect to the observer, a gravitational field acts on light from external sources, in two possible ways. For an observer at the centre of gravity, the field always acts on light as a medium with refractive index less than unity. For an observer off the centre, the gravitational field acts as a medium with index lower than unity, at the far side of the centre, and as a medium with refractive index higher than unity, at the near side, *i.e.*

$$n' = \frac{c}{c + gt}, \tag{7.1}$$

for the far side, and

$$n' = \frac{c}{c - gt}, \tag{7.2}$$

for the near side, where n' is the average factor of deflection by the field, g is the average acceleration in the field along the light path, and t is the average travel time of light from a stationary source, through the field. Thus, given the angle of incidence, it is possible to obtain the angle of gravitational deflection, from Snell's law, by treating the above factor as a refractive index. For a gravitational field in motion, the effect of gravitation is directly proportional to the velocity of the field, on light travelling in the same direction and inversely proportional to the velocity of the field, on light traversing the field, in the opposite direction. In a stationary field, the net effect of gravitation is nil, on velocity of light traversing equal paths at both sides of a gravitational centre. When the observer is moving inside a gravitational field, with velocity v_o with respect to the field, the gravity-free values of both Doppler effect and Bradley effect due to this motion, as measured by the observer, are always multiplied by the factor of deflection n'. Moreover, when a source is moving through a gravitational field, the gravity-free value of its Doppler effect is always multiplied by the factor n', as measured in any frame of reference.

8. Characteristics of Corpuscular Radiation

Corpuscular radiation consists of Newtonian corpuscles that grouped into distinct entities on the basis of velocity and frequency. The structure of the corpuscular group is based entirely upon direction, speed, temporal, and spatial frequencies. Here, temporal frequency is the number of corpuscles per unit time, and spatial frequency is the number of corpuscles per unit distance. Hence, corpuscular groups passing simultaneously through the same volume, can interact with each other to produce over-tone temporal and spatial frequencies, in conformity with the principles of interference and superposition. In addition, the probability of deviations in speed and direction between the members of a corpuscular group approaches unity, as the path length approaches infinity. As a result, the probability of transformation into sub-groups of lower frequencies is directly proportional to the distance covered by the group of higher frequency.

Radiation composed of groups of corpuscles in motion, is actually a corpuscular wind whose pressure and radiant flux are in inverse proportion to the square of distance, according to the inverse-square law. Geometrically, the derivation of the inverse-square law is based on an ideal point source of radiation that emits continually and isotropically in all directions. Real sources of light, however, are made up of a very large, but finite number of basic emitters that radiate independently and discontinuously, in a random fashion, in all directions. Therefore, significant fluctuations in flux density with time and distance are possible over all surfaces that have the source as their common centre.

It has to be considered self-evident that the absolute direction of a moving particle, is an ideal limit that can be indefinitely approached, through extrapolation, but it can never be precisely determined or obtained. In any case, if the straight line passing through the projection of a corpuscular group at the source surface, is taken as the assumed path, the separation between this assumed path and the new extrapolated path of the group, at a subsequent surface, can be found from the relation: $s = r \tan d\Theta$, where r is the distance from the source, and $d\Theta$ is the angle between the assumed path and the extrapolated path of the group.

Thus, corpuscular groups passing simultaneously through a surface area across the direction of their propagation, can be classified into five major sets, depending on the deviation in the direction of the group path from the normal to the surface of incidence. These sets of groups are:

1. Groups with paths parallel to the normal,
2. Groups with paths deviate to the left of the surface,
3. Groups with paths deviate to the right of the surface,
4. Groups with paths deviate upwards,
5. Groups with paths deviate downwards.

This classification is always maintained, even in the cases in which the source of incident light is assumed to be at infinite distance from the surface of projection. The last four sets of groups with path deviation, allow light to bend around obstacles in its path, to spread into, and eventually to extinguish shadows cast by them, provided that their surface areas are relatively small compared to that of the source. Furthermore, rotating frames of reference, *e.g.*, the earth, introduce systematic variations in the flux of incident light, and deviations in its direction, that are in inverse proportion to the velocity of the corpuscular group.

9. Effect of Acceleration

Accelerations acting on a basic emitter, during the time of emission, if they are not part of an emission mechanism, can produce permanent and systematic differences in velocity between the members of a corpuscular group. Given the vector sum of these accelerations, the shift in wavelength, caused by differences in corpuscular velocities, can be computed. Consider the simple case in which a basic source of light is accelerating from rest along the line of sight, directly towards the observer, with a constant acceleration, a. Since during the period T, the velocity of light is incremented by a factor equal to aT, we obtain:

$$l' = cT - aT\left[\frac{d}{c+aT}\right], \tag{9.1}$$

and accordingly,

$$\Delta l = -aT\left[\frac{d}{c+aT}\right], \tag{9.2}$$

where d is the distance between the source and the observer, and (–) indicates that the initial wavelength cT, after the removal of the transient Doppler shift caused by the acceleration of the source, is greater than the final wavelength l'. If the basic emitter is accelerating away from the observer, then

$$\Delta l = aT\left[\frac{d}{c-aT}\right], \tag{9.3}$$

where $cT < l'$.

In the general case, if a source is moving with velocity v_s relative to the observer, undergoes acceleration a, during the time of emission, then

$$v_s' = \sqrt{v_s^{\,2} + (aT)^2 - 2v_s aT \cos ß}\ , \tag{9.4}$$

where v_s' is the velocity of the source at the end of the period T, and $ß$ is the angle between the vectors v_s and aT. The initial velocity of light along the line of sight is $c_1' = c\sqrt{1-\left(v_s^2/c^2\right)\sin^2 i} + v_s \cos i$, where i is the angle between the line of sight and the velocity vector of the source. The velocity of light after period T, is $c_2' = c\sqrt{1-\left(v_s'^2/c^2\right)\sin^2 i'} + v'_s \cos i'$, where i' is the angle between the line of sight and the vector v_s'. Therefore, the difference in velocity is $\Delta c' = c_1' - c_2'$. This difference in velocity shifts the wavelength with distance to

$$l' = c_1'T + \frac{d}{c_2'\Delta c'}, \tag{9.5}$$

from which

$$\Delta l = (\Delta c')\frac{d}{c_2'}, \tag{9.6}$$

where Δl is the difference in wavelength at distance d from the source.

Since the above effect is caused by differences in corpuscular velocities, it might be appropriate to refer to as the 'Δ-effect'. The Δ-effect, therefore, is the effect of lasting differences in velocities of corpuscles within a group, as a result of an accelerating source during the time of emission.

The following points can be made about the Δ-effect:

1. The Δ-effect depends on the magnitude and the direction of the acceleration that a source undergoes during the time of emission.
2. The Δ-effect produces either blue shifts or red shifts, depending on the direction of the acceleration vector with respect to the line of sight.
3. The red shift of the Δ-effect is directly proportional to the time elapsed since emission, and hence it is directly proportional to distance, and inversely proportional to the common velocity of the corpuscular group.

4. The blue shift of the Δ-effect is directly proportional to distance until it reaches its peak point at $l' = \frac{1}{8}at^2$ After this point, the blue shift is inversely proportional to distance until it vanishes at $\Delta l = 0$, and then it turns into red shift which is in direct proportion to distance.
5. The Δ-effect changes both the wavelength and frequency. In comparison, Doppler effect, according to the Emission theory, changes velocity and frequency, but leaves the wavelength unchanged, while refraction changes both the velocity and the wavelength, but it has no effect on frequency.

10. Delta Effect on Light from Distant Sources

The dependency of delta effect on distance can lead to observable changes in both the spectrum and the flux of light from a distant source. To determine this effect in an astrophysical setting, the following types of acceleration have to be considered:

1. Accelerations related to radiation mechanisms: Accelerations, such those an electron experiences during transitions between different levels of energy inside the atom, their end result, according to quantum mechanics, is always an emission with constant speed *c* [Heavens, *et al.*, 1991].
2. Accelerations by recoiling: These are generated, during emission, as a result of the action and reaction between an emitted corpuscle and basic emitter. Because the vector of this type of acceleration is always pointing to the opposite direction of propagation, it produces only delta red shifts.
3. Random accelerations: Interaction between basic sources of light introduces random accelerations whose delta effect has equal probability of producing blue and red shifts of various magnitudes.
4. Gravitational accelerations: This type of acceleration is related to the random motions of basic sources in a gravitational field. Since most of the light from astronomical sources, comes from stars, gravitation must be an important factor with regard to delta effect. A gravitational field can be divided into two equal regions, by the vertical plane to the line of sight, that passes through its centre of gravity. In the near region, the field vector always points away from the observer. Therefore, moving materials in this region, experience accelerations that can only generate delta red shift. In the far region, the field vector points towards the observer, and consequently gravitational accelerations in this region, produce only delta blue shift. With respect to the gravitational field of a star, the emitting materials are divided equally, at all times, between the near region and the far region. Nonetheless, most of the light received by the observer comes from stellar materials that occupy the near region, and consequently their emission is delta red-shifted.
5. Rotational accelerations: Accelerations produced by the axial rotation of a star, form a sine function whose vector points towards the observer, at the far side, and away from the observer, at the near side of the star. Accordingly, axial rotations always generate delta red shifts at the near side, and delta blue shifts at the far side.
6. Orbital accelerations: With respect to the observer, a star is in the far region of its orbit, during the time between velocity of maximum recession and velocity of maximum approach, and the near region, between maximum approach and maximum recession. Therefore, the delta effect generated by orbital accelerations, produces blue shifts, in the far region, and red shifts in the near region.

In any case, the resultant delta shift is determined by the vector sum of accelerations acting globally on basic sources of light. Intense flux and sharp compression in pulse duration usually accompany the delta blue shift. Because of this, the delta blue-shifted radiation resembles, in most cases, the synchrotron radiation.

In contrast, the delta red shift leads to linear expansion in the size of the corpuscular group, and because of that, it is very similar, in many respects, to the Doppler red shift. However, within the framework of the Emission theory, both the synchrotron radiation and the Doppler red-shifted radiation, have a component of their energy that varies with velocity, but remains constant in delta-shifted radiation. Moreover, the values of delta effect vary, by a small amount, with radiation frequency. Let $z = \left(l' - l/l\right) = \Delta l/l$ (10.1), where *l and l*' are the emitted wavelength and observed wavelength, respectively. For a source accelerating from rest, away along the line of sight,

$$\Delta l = \left(aT\right)\frac{d}{c - aT}, \tag{10.2}$$

where *d* is distance of the source, *a* is the acceleration, and *T* is the period of the radiation. Since, after the removal of the transient Doppler shift caused by the acceleration of the source, $l = cT$, we obtain

$$z = \frac{ad}{c^2 - acT} \tag{10.3}$$

For a source accelerating directly towards the observer,

$$z = -\left[\frac{ad}{c^2 + acT}\right] \tag{10.4}$$

In general, if the velocity of light changes from c'_1 to c'_2, due to the acceleration of the source, during the time of emission, then

$$z = \frac{\Delta c'}{cT}\left[\frac{d}{c'_2}\right] \tag{10.5}$$

Therefore, Δz is directly proportional to period, and consequently, it is inversely proportional to frequency.

The reverse is true, in the case of delta blue shift, *i.e.* it decreases with period, and increases with frequency. If these minute variations with frequency are ignored, then the observed nebular red shift can be interpreted as being due to the delta effect. According to the empirical law found by Hubble, the lines in the spectra of distant nebulae are displaced to the red by an amount Δl, where $\Delta l/l = 1.7\left(10^{-9}\right)d$, *d* being the distance of the nebula in parsecs [Heavens, *et al.*, 1991].

It is possible, therefore, to calculate the minimum acceleration required for producing delta displacement of the observed magnitude. From Hubble's formula, at $d = 3 \times 10^{16}$ m, $z = 1.7 \times 10^{-9}$. By substituting the same values for *d* and *z* in the formula $a = \left(zc^2/d + zcT\right)$, of a source accelerating away from the observer, and omitting *zcT* which is small compared to *d*, the minimum acceleration that produces delta displacement equal to that of Hubble's, at any distance, is approximately 5.1×10^{-9} ms^{-2}. It should be noted that in dealing with the nebular redshift problem, the Emission theory is far more effective and superior to the conventional theories in this field.

11. The Consequences of Variable Group Velocity

Global and continuous accelerations, e.g. orbital accelerations, acting on a source of radiation over a period of time, have the potential of producing differences in the velocities of the corpuscular groups emitted during that period. Differences in group velocity can lead to significant changes in the radiant flux and the apparent brightness of a distant source, that are independent of the inverse-square law for radiation. Consider the simple case, in which a source of light accelerates from rest, along the line of sight, directly towards the observer, with a uniform acceleration a, over a period of time t_0. If r is the distance between the leading pulse emitted at the beginning of the period t_0, and the last pulse emitted at the end of this period, then $r = ct_0 - \frac{1}{2}at_0^2$. Since the difference in velocity between the two pulses is at_0, we obtain $r' = r - at_0 t$, where r' is the distance between the two pulses after t, the time elapsed since the emission of the last pulse.

Given a and t_0, therefore, it is possible to compute the time of maximum apparent brightness t_{max}, *i.e.*

$$t_{\max} = \frac{r}{at_0} = \frac{c}{a} - \frac{1}{2}t_0 . \tag{11.1}$$

Thus the distance of the maximum from the position of the source, where the initial pulse emitted, is

$$d_i = c\left(t_{\max} + t_0\right), \tag{11.2}$$

and from that where the final pulse emitted, is

$$d_f = t_{\max}\left(c + at_0\right). \tag{11.3}$$

According to the inverse-square law, the radiant flux s of a non-accelerating source, is $s = L/4\pi d^2$, where L is the luminosity of the source, and d is its distance from the observer. Therefore, the maximum radiant flux s_{max}, from the above accelerating source, is equal to the sum of ($L/4\pi d^2$), over the interval [d_i, d_f]. It can be shown that the extent to which the flux at maximum, is compressed, cannot exceed R_{max}, where $R_{\max} = \frac{1}{8}at_0^2$.

It should be pointed out, that global accelerations instrumental in producing differences in group velocities, produce also differences in corpuscular velocities within the groups. In the latter case, however, they constitute only a fraction of the vector sum of the accelerations that can generate delta effect. Because of that, all sorts of combination between changes in radiant flux and delta shifts are possible. Depending on the intrinsic luminosity L, and the time interval t_0 over which the acceleration a operates, the maximum radiant flux s_{max} of distant sources, can be enormous.

For instance, a source with only one solar luminosity and proper orbital configurations at various distances from the observer is capable of generating kinematic novae and supernovae of the same apparent magnitudes as that of their dynamic counterparts. After the peak point of apparent brightness, the radiant flux of the source, varies with time in a similar manner to that of a source accelerating away from the observer. Just as the radiant flux of accelerating sources can be greater than expected from the inverse-square law, it can also be diluted below the expected level, by differences in group velocity. Consider the case of a source accelerating from rest, along the line of sight, away from the observer, with a constant acceleration a, for a period of time t_0. At the end of that period, the distance between the fastest and the slowest pulses, is

$$r = ct_0 + \frac{1}{2}at_0^{\ 2}. \tag{11.4}$$

After a period of time *t*, since emission, the volume containing the radiation, expands linearly to

$$r' = r + at_0t = t_0\left(c + \frac{1}{2}at_0 + at\right). \tag{11.5}$$

If *s* is the radiant flux expected from the inverse-square law, then due to the differences in group velocity, *s* is diluted by a factor (r/r') to *s'*. That is,

$$s' = s\left(\frac{r}{r'}\right) = s\left[\frac{c + \frac{1}{2}at_0}{c + \frac{1}{2}at_0 + at}\right]. \tag{11.6}$$

Hence, the dilution of the radiant flux from accelerating-away sources, over the level expected from the inverse-square law, is directly proportional to light travel time, and accordingly, it is directly proportional to distance.

One important class of global accelerations that can generate the two effects above, is orbital acceleration. With respect to the observer, the portion of the orbit, between the point of maximum recession and the point of maximum approach, generates ascending group velocities. The other portion of the orbit produces group velocities in descending order. As mentioned earlier, ascending group velocities lead to greater radiant flux with distance, up to the point of maximum apparent brightness, beyond which the radiant flux decreases indefinitely with distance. Furthermore, ascending group velocities reduce the apparent orbital period at the far side of the orbit, until it reaches a minimum value during the time of maximum radiant flux, after which it increases linearly and indefinitely with distance. That is on one hand. Descending group velocities, on the other hand, lead, indefinitely with distance, to linear decrease in the radiant flux, in addition to that caused by the inverse-square law and linear increase in the apparent orbital period, at the near side of the orbit.

12. Conclusion

As far as first-order deductions from basic principles, are concerned, the Emission theory can be judged as both very simple and very effective. Yet, admittedly, the final verdict must be experimental. As pointed out at the beginning of this discussion, the issue of variability and constancy cannot be resolved by the use of indirect experimental means. The pi-mesons, for example, in the upper atmosphere, reach the earth surface, before their decay, either because of the time slowdown within their inertial frame of reference [Frisch, *et al.*, 1963], or because their speed is superluminal. Any attempt to exclude either one of these two possible interpretations, leads inevitably, to outright circularity. That is because in order to measure the velocity of a particle indirectly, its kinetic energy and momentum have to be obtained. To obtain the velocity from those measured quantities, the equations of energy and momentum of the theory to be tested have to be used. For this reason, measuring the transit time of light from moving sources, over pre-specified distances, is in this case, the most decisive test possible.

The Thomson theorem, as demonstrated in this discussion, constitutes a fundamental part of the Emission theory. The consequences of this theorem are extremely open to experimental testing. Therefore, if only one of these consequences is disproved by experiment, the theory will have no chance of being adjusted to meet the challenge. Thomson's theorem predicts that each time a beam of light reflected from a moving mirror, its velocity incremented by a factor of two times the velocity of the approaching mirror, and decremented by the same factor each time reflected from a receding mirror. The velocity of the experimental beam, therefore, can be increased or decreased to any desirable level through the use of multiple reflection from moving mirrors. This consequence of the Thomson theorem is easily verifiable by measuring the Doppler shift, the Michelson fringe shift, or by measuring the flight time of the experimental beam over a predefined path.

References

Corliss, William R. (1979). *A Handbook of Astronomical Anomalies*. Glen Arm, MD: Sourcebook Project.

Fox, J.G. (January, 1965). "Evidence Against Emission Theories," *Am. J. Phys*. 33:1-17.

Frisch, David H, and James H. Smith. (1963). "Measurement of the Relativistic Time Dilation Using π-Mesons.," *Am. J. Phys*. 31:342.

Heavens, O. S., and R. W. Ditchburn. (1991). Insight into Optics. New York: John Wiley & Sons.

Kantor, W. (September, 1962). "Direct First-Order Experiment on the Propagation of Light from a Moving Source," *J. Opt. Soc. Am*. Vol. 52, No. 8, p. 978.

Michelson, Albert A. (1962, c1927). *Studies in Optics*. Chicago: Chicago University Press.

Michelson, Albert A., and Edward W. Morley. (November, 1887). "On the Relative Motion of the Earth and Luminiferous Ether," *Am. J. Sci*., 3d Ser. 34:333-345.

Stewart, O.M. (1911). "The Second Postulate of Relativity and the Electromagnetic Emission Theory of Light," *Phys. Rev*. 32:418-428.

Tolman, Richard C. (August, 1912). "Some Emission Theories of Light," *Phys. Rev*. 35:136-143.