# 1. AN ALTERNATIVE ELECTRODYNAMICS TO THE THEORY OF SPECIAL RELATIVITY


## Abstract

An electrostatic force is propagated at the velocity of light ***c*** and the velocity of transmission of the force, relative to an electron moving with velocity ***v***, is the vector *(**c** – **v**)*. The electron can be accelerated to the speed of light *c* and no faster. The accelerating force ***F*** on an electron of charge *–e* and mass *m* moving at time *t* with velocity ***v*** at an angle $\theta$ to ***F***, in an electrostatic field of intensity ***E*** and magnitude *E*, is proposed as given by the vector equation:

$$\mathbf{F} = \frac{eE}{c}(\mathbf{c} - \mathbf{v}) = \frac{-e\mathbf{E}}{c}\sqrt{c^2 + v^2 - 2cv\{\cos(\theta - \alpha)\}} = m\frac{d\mathbf{v}}{dt}$$

where $\alpha$ is the small angle of aberration such that $\sin\alpha = (v/c)\sin\theta$, and $(\theta - \alpha)$ is the angle between ***v*** and ***c***. For $\theta = 0$ or $\pi$ radians, there is rectilinear motion with emission of radiation but stable circular revolution if $\theta = \pi/2$ radians.



*Keywords:* Force, mass, radiation, relativity, velocity.


## 1.1 Introduction

There are now three systems of electrodynamics. There is classical electrodynamics applicable to electrically charged particles moving at a speed much slower than that of light. Relativistic electrodynamics is for particles moving at a speed comparable to that of light. Quantum electrodynamics is for atomic particles moving at very high speeds. There should be one consistent system of electrodynamics applicable at all speeds up to that of light.

Classical electrodynamics is based on the second law of motion, originated by Galileo in 1638, according to Lenard [1], but enunciated by the great physicist, Newton [2]. The theory of special relativity was formulated in 1905 mainly by the celebrated physicist, Einstein [3, 4] and the quantum theory was initiated by the renowned physicist Planck [5]. Relativistic electrodynamics reduces to classical electrodynamics at low speeds but the relativity and quantum theories are incompatible at high speeds. Both the relativity and quantum theories, therefore, cannot be correct. One of the theories or both theories may be wrong. Indeed, special relativity is under attack by physicists: Beckmann [6] and Renshaw [7]. This paper introduces *radiational electrodynamics*, as a new electrodynamics, applicable to electrically charged particles moving at speeds up to that of light *c*, with mass of a particle as constant.

According to Newton's second law of motion, a particle can be accelerated by a force to a speed greater than that of light with its mass remaining constant. But no particle, not even the electron, the lightest particle known in nature, can be accelerated beyond the speed of light. The theory of special relativity explains this limitation by positing that the mass of a particle increases with its speed, becoming infinitely large when the speed reaches that of light. That since an infinite mass cannot be accelerated any faster by any finite force, the speed of light is the ultimate limit to which a body can be accelerated. The famous Einstein's mass-speed formula of special relativity is:

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma m_o \tag{1.1}$$

where $m$ is the mass of a particle moving with speed $v$, $m_o$ is the rest mass or classical mass, $c$ is the speed of light in a vacuum and $\gamma$ is a ratio depending on $v$. Equation (1.1), where $m$ is a physical mass, which is supposed to have weight due to gravitational attraction, becoming infinitely large at the speed of light, is the bone of contention in this paper.

The proponents of special relativity just ignore the difficulty with equation (1.1) expressing *mass expansion*, which results in infinitely large masses at the speed of light $c$. They avoid the difficulty altogether by arguing that the speed never really reaches $c$, that particles moving at speed $c$ have zero rest mass or are exempted from equation (1.1) or that the increase in mass has no weight as it is not affected by the force of gravity. It is not said which physical property, volume or density of a body, increases with speed, while its electric charge remains constant.

Special relativity makes electric charge a quantity independent of speed. It is shown by the author [8] that the mass of a body is proportional to the sum of squares of the constituent electric charges. So, mass should also remain constant with the magnitude of the electric charges.

Moreover, the mass-speed formula is challenged by virtue of a *positional principle* to the effect that *"any material property that is independent of its position in space is also independent of its velocity in space"*. Doing away with infinite masses of particles moving at the speed of light, would bring great relief to physicists all over the world.

The difficulty with infinite mass, at the speed of light *(v = c)* in equation (1.1), is the Achilles' heel of the theory of special relativity. Resolving this difficulty is the main aim of this paper. It is shown that for an electron of mass *m* and charge *–e* revolving with constant speed *v* in a circle of radius *r*, under the attraction of a radial electrostatic field of magnitude *E*, the quantity *"m"* in equation (1.1) is actually the ratio $\{(eE)/(v^2/r)\}$ of force *(eE)* on a stationary electron to the centripetal acceleration $(v^2/r)$ in circular motion. The acceleration reduces to zero at the speed *c*, where the radius *r* becomes infinitely large for motion in a circle of infinite radius or motion in a straight line.

Also challenged are decrease of *length* with speed or *length contraction* and increase of *time* with speed or *time dilation*. Without *mass expansion* the other aspects of special relativity, *length contraction* and *time dilation*, disappear. The difficulty associated with *length contraction*, of moving bodies becoming smaller or even disappearing, is seldom discussed in special relativity. The problem with *time dilation*, of moving bodies aging less or even becoming ageless, is dismissed by special relativity as "clock paradox". However, velocity, a vector quantity, central in special relativity, remains unchanged, as absolute distance covered *divided by* absolute time taken, not contracted distance *divided by* dilated time.

Usually, physicists employ vector quantities, having magnitudes and directions, indicated in ***boldface*** type. Velocity, for example, is a vector quantity denoted by $\boldsymbol{c}$, $\boldsymbol{u}$, $\boldsymbol{v}$, $\boldsymbol{w}$ or $\boldsymbol{z}$ and speed, its magnitude, is a scalar quantity shown in ordinary type as *c, u, v*, *w* or *z*. A useful way of denoting a vector is as a product, $\boldsymbol{c} = c\hat{\boldsymbol{u}}$, where $\hat{\boldsymbol{u}}$, a unit vector in the direction of $\boldsymbol{c}$, varies with direction only. An electrostatic field of intensity $\boldsymbol{E}$ and magnitude *E* may be written as $\boldsymbol{E} = E\hat{\boldsymbol{u}} = E\boldsymbol{c}/c$, where $\mathbf{c}$ is the velocity of light with which an electrical effect is propagated in space.

The velocity of light $\boldsymbol{c}$, in space, relative to its source, is an absolute constant independent of velocity of the source. The magnitude of velocity of light, in a vacuum, relative to its source, is also an absolute constant *c*, equal *to* $2.998\times10^8$ *m/sec*, as obtained with electromagnetic waves.

### 1.1.1 Maxwell's equations of electromagnetic waves

In 1873, James Clerk Maxwell [9], in his ground-breaking treaties, showed that electromagnetic waves were propagated in a vacuum at constant speed, equal to that of light c, given by:

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 2.998 \times 10^8 \text{ } \textit{metres per second} \qquad (1.2)$$

where $\mu_o$ is the permeability and $\varepsilon_o$ the permittivity of a vacuum. Here, $c$ is the absolute speed of light, the magnitude of velocity of light relative to the source. The absolute speed of light $c$, given by equation (1.2), is a significant principle in physics. Another issue on the speed of light is the result of Michelson-Morley experiment.

### 1.1.2 Michelson-Morley experiment

The Americans, physicist Albert Michelson and chemist Edward Morley in 1887 [10], conducted an experiment to detect the *ether*, the luminiferous medium in which light is supposed to be propagated, like sound waves in the air. This, the most delicate and accurate experiment ever performed by physicists, demonstrated that the *ether* did not exist and that empty space contained *nothing*.

According to a cardinal principle of the theory of special relativity, the speed of light $c$, relative to an observer, is an absolute constant independent of speed of the source or the observer. The result of Michelson-Morley experiment was misinterpreted, in 1905, to lend support to the supposed invariance of the speed of light according to special relativity. It was claimed that the experiment proved the constancy of the speed of light from a source, relative to an observer. In fact, the constancy of the speed of light, relative to an observer, was not proven by this experiment or any other observation. The correct situation is given by the Galilean-Newtonian relativity of classical mechanics.

### 1.1.3 Galilean-Newtonian relativity

A basic principle of physics is the Galilean-Newtonian relativity. According to this principle, the relative velocity of light $\boldsymbol{z}$ emitted by a moving source, as measured by an observer moving with velocity $\boldsymbol{v}$ relative to a frame of reference, is given, in magnitude and direction, by the vector equation:

$$\mathbf{z} = \mathbf{c} + (\mathbf{u} - \mathbf{v}) \qquad (1.3)$$

where $\boldsymbol{c}$ is the velocity of light relative to its source and $\boldsymbol{u}$ is the velocity of the source relative to the observer's frame of reference. The velocity of light $\boldsymbol{c}$, being a constant, relative to its source, is an experimental fact. In equation (1.3), the relative velocity $z$ can be less or greater than $\boldsymbol{c}$ depending on the magnitudes and directions of the velocities $\boldsymbol{u}$ and $\boldsymbol{v}$. The theory of special relativity makes the relative velocity $z$ a constant equal to the velocity of light $\boldsymbol{c}$, irrespective of the magnitudes of $\boldsymbol{u}$ and $\boldsymbol{v}$. The velocity $z$ would be equal to the velocity of light $\boldsymbol{c}$ only if the magnitude of $\boldsymbol{c}$ were infinite. The magnitude of velocity of light, relative to the source, although fantastically high, is a finite universal constant $c$ equal to *2.998 × $10^8$ metres per second.*

The Galilean-Newtonian relativity, as expressed in equation (1.3), is one of the most significant principles in physics, but now relegated to the background in favour of Einstein's theory of special of relativity. Equation (1.3) was employed by the author [11] to deduce an expression for the speed of light $w$ in a medium moving with speed $v$ in the direction of the light ray emitted by a stationary source. The speed $w$ of transmitted light incident normally on the plane surface of a medium of refractive index $\mu$, which is moving with speed $v$ in a vacuum, is simply obtained as as given by the equation:

$$w = \frac{c}{\mu} + v\left(1 - \frac{1}{\mu}\right) \tag{1.4}$$

Equation (1.4) was used, without recourse to the theory of special relativity, to explain the result of an experiment performed by Fizeau in 1851 and repeated by Michelson and Morley in 1886 [12], to measure the speed of light in moving water. According to special relativity, the speed of light, relative to a medium moving in a vacuum, is $c$ and the speed of light in a moving medium is in accordance with Einstein's *velocity addition rule*. Another issue, connected with relative velocity of light, is Doppler Effect.

### 1.1.4 Doppler Effect

Doppler Effect, described by the Austrian physicist Christian Doppler in 1842, pertains to change in frequency of a light wave (or sound wave) due to motion of the source and/or the observer. Further information on Doppler is given by Stoll [13]. The Effect clearly demonstrates the relativity of velocity of light on the source of light moving with velocity $\boldsymbol{u}$ and/or the observer moving with velocity $\boldsymbol{v}$. For the observer moving in the same direction away from the source (***c***, ***u*** and ***v*** are along the same line), equation (1.3) gives $z$ as the magnitude of the relative velocity and the frequency $f_m$ perceived by the moving observer, the Doppler frequency, is:

$$f_m = \frac{fz}{c} = \frac{f\{c + (u - v)\}}{c} \tag{1.5}$$

where $f$ is the frequency perceived by the observer moving with the same velocity as the source, i.e. $(\boldsymbol{u} = \boldsymbol{v})$. The wavelength remains unchanged as $\lambda = c/f$. For the observer moving towards the source, $v$ in equation (1.5), should be replaced by $-v$.

Equation (1.5) shows that if the speed $z$ were absolutely equal to $c$, there would have been no change in frequency and no Doppler Effect. This Effect is an every-day occurrence and equation (1.5) applies to sound waves as well. The next issue is Larmor formula for radiation power of electrons accelerated by an electrostatic field.

### 1.1.5 Larmor formula of classical electrodynamics

Larmor formula of classical electrodynamics, described by Griffith [14], gives the radiation power $R_p$ of an accelerated electron as proportional to the square of its acceleration. For an electron revolving with speed $v$ in a circle of radius $r$ with centripetal acceleration of magnitude $v^2/r$, Larmor classical formula gives $R_p = (e^2/6\pi\varepsilon_o r^2)v^4/c^3$, where $\varepsilon_o$ is the permittivity of vacuum. Special relativity adopted this formula [14] and gives radiation power $R = \gamma^4 R_p$, where $\gamma$ is defined in equation (1.1). The factor $\gamma^4$ means that the radiation power increases explosively as the speed $v$ approaches that of light $c$.

According to Larmor formula, the hydrogen atom, consisting of an electron revolving round a positively charged nucleus, would radiate energy as it accelerates and spirals inward to collide with the nucleus, leading to the collapse of the atom. But atoms are the most stable particles known in nature. Use of this erroneous formula was most unfortunate as it led physics astray early in the 20th century. It required the brilliant hypotheses of Niels Bohr's [15] quantum mechanics to stabilize the Rutherford's [16] nuclear model of the hydrogen atom.

### 1.1.6 Rutherford's nuclear model of the hydrogen atom

If Larmor formula is accepted then Rutherford's nuclear model of the hydrogen atom cannot stand and Bohr's quantum mechanics had to be contrived to stabilize it. It would have been much easier to discard Larmor formula since the nuclear model of the hydrogen atom is inherently stable without the need for the quantum theory. This is so because circular motion of an electron does not involve any change of potential or kinetic energy and, therefore, no radiation occurs. Radiation takes place only when the electron is dislodged from the stable circular orbit, resulting in a change of potential or kinetic energy. The excited electron revolves in an unclosed elliptic orbit of decreasing eccentricity, before reverting back, after many cycles of revolution, into the stable circular orbit. It is like an oscillating loop settling down into a circular ring and rolling along.

On the basis of stability of circular motion of an electron, a new model of the hydrogen atom was developed [17]. The formula derived by Balmer in 1885, generalised by Rydberg in 1889, and described by Bitter [18], for discrete frequencies of radiation from the hydrogen atom, is deduced without recourse to Bohr's quantum mechanics. The frequency of emitted radiation is related to the frequency of circular revolution of the electron. This is something which quantum mechanics failed to do. The next issue is Bertozzi's experiment with regards to rectilinear motion of electrons,

### 1.1.7 Bertozzi's experiment

A most remarkable demonstration of the existence of a universal limiting speed, equal to the speed of light $c$, was in an experiment by William Bertozzi [19] of the Massachusetts Institute of Technology. The experiment showed that electrons accelerated through energies of 15 MeV or over, attain, for all practical purposes, the speed of light $c$. Bertozzi measured the heat energy $J$ developed when a stream of accelerated electrons hit an aluminium target at the end of their flight path, in a linear accelerator. He found the heat energy released to be nearly equal to the potential energy $P$ lost, to give $P = J = K$. Bertozzi identified $J$ as solely due to the kinetic energy lost by the electrons, on the assumption that the force, on a moving electron, is $-e\boldsymbol{E}$, independent of its speed and always equal to the accelerating force $\boldsymbol{F}$.

Bertozzi might have made a mistake in equating the heat energy $J$ with the kinetic energy $K$ of the electrons. The energy equation should have been $P = J = K + R$. Here, $R$ was the energy radiated. Radiation, propagated at the speed of light, also caused heating effect upon impinging at the same point or on the same target as the accelerated electrons. For rectilinear motion, the accelerating force ***F***, a vector in the **x**-direction, is given by:

$$\mathbf{F} = \frac{dK}{d\mathbf{x}} = \frac{dP}{d\mathbf{x}} - \frac{dR}{d\mathbf{x}} \tag{1.6}$$

In equation (1.6), ***F*** = *dK/d**x*** is the accelerating force, *dP/d**x*** the electrostatic (impressed) force and *–dR/d**x*** is the radiation reaction force as a result of an electron moving along an electrostatic field. The radiation reaction force is a result of aberration of electric field.

### 1.1.8 Aberration of electric field

Figure.1.1 depicts an electron, moving at a point *P* with velocity ***v***, in an electrostatic field ***E*** due to a stationary source charge +*Q* at an origin *O*. For motion at an angle $\theta$ to the accelerating force ***F***, the electron is subjected to aberration of electric field. This phenomenon is similar to aberration of light discovered by the English astronomer James Bradley in 1728 [20]. In aberration of electric field, as in aberration of light, the direction of the electrostatic field, indicated by the velocity vector ***c*** (see Fig.1.1), appears shifted by an aberration angle $\alpha$, from the instantaneous line ***PO***, such that:

$$\sin\alpha = \frac{v}{c}\sin\theta \tag{1.7}$$

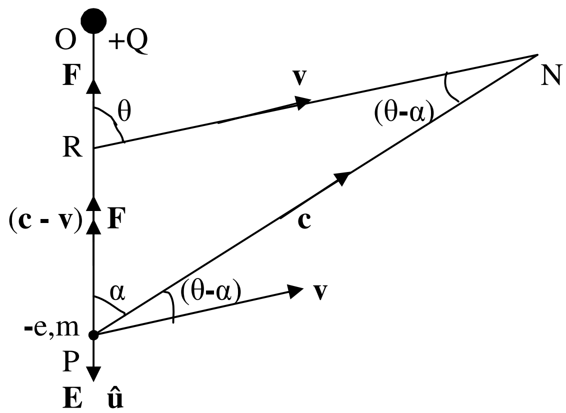


Figure 1.1. Vector diagram depicts angle of aberration $\alpha$ as a result of an electron of charge *–e* and mass *m* moving, at a point *P*, with velocity ***v***, at an angle $\theta$ to the accelerating force ***F***. The unit vector $\hat{\boldsymbol{u}}$ is in the direction of the electrostatic field of intensity ***E*** due to a stationary source charge +*Q* at the origin *O*.

where the speeds $v$ and $c$ are the magnitudes of the velocities $\boldsymbol{v}$ and $\boldsymbol{c}$ respectively. Equation (1.7) was first derived by James Bradley.

The result of aberration of electric field is that the accelerating force on a moving electron depends on the velocity of the electron. If the accelerating force reduces to zero at the speed of light $c$, that speed becomes the ultimate limit. This aspect, which is missing in classical and relativistic electrodynamics, is used in the formulation of *radiational electrodynamics*.

## 1.2 Equations of motion in *radiational electrodynamics*

The force exerted on an electron, moving with velocity $\boldsymbol{v}$. by an electrostatic field is transmitted at the velocity of light $\boldsymbol{c}$ relative to the source charge and with velocity $(\boldsymbol{c} - \boldsymbol{v})$ relative to the electron. The electron can be accelerated to the velocity of light $\boldsymbol{c}$ and no faster. In Figure 1.1 the electron can be accelerated in the direction of the force with $\theta = 0$ or it can be decelerated against the force with $\theta = \pi$ radians or it can revolve in a circle with $\theta = \pi/2$ radians.

The accelerating force $\boldsymbol{F}$ (see Figure 1.1), on an electron of charge $-e$ and mass $m$ moving at time $t$ with velocity $\boldsymbol{v}$ and acceleration $(d\boldsymbol{v}/dt)$, in an electrostatic field of magnitude $E$ and intensity $\boldsymbol{E} = E\hat{\boldsymbol{u}}$, in the direction of unit vector $\hat{\boldsymbol{u}}$, is proposed as given by the vector equation and Newton's second law of motion, thus:

$$\mathbf{F} = \frac{eE}{c}(\mathbf{c} - \mathbf{v}) = m\frac{d\mathbf{v}}{dt} \tag{1.8}$$

where $\boldsymbol{c}$ is the velocity of light at aberration angle $\alpha$ to the accelerating force $\boldsymbol{F}$ and $(\boldsymbol{c} - \boldsymbol{v})$ is the relative velocity of transmission of the force with respect to the moving electron. The simple idea behind a limiting velocity $\boldsymbol{c}$ is that the electrostatic force or "electrical punches" propagated at velocity of light $\boldsymbol{c}$, cannot "catch up" and "impact" on an electron also moving with velocity $\boldsymbol{v} = \boldsymbol{c}$. Equation (1.8) may be regarded as an extension or amendment of Coulomb's law of electrostatic force between two electric charges, taking into consideration the relative velocity between the charges.

Equation (1.7) links the angle $\theta$ with the aberration angle $\alpha$ (Fig.1.1). Equation (1.8) is the basic expression of *radiational electrodynamics*.

Expanding equation (1.8), by taking the *modulus* of the vector ***(c − v)***, with respect to the angles $\theta$ and $\alpha$, gives:

$$\mathbf{F} = \frac{-eE}{c}\sqrt{c^2 + v^2 - 2cv\{\cos(\theta - \alpha)\}}\,\hat{\mathbf{u}} = m\frac{d\mathbf{v}}{dt} \tag{1.9}$$

### 1.2.1 Equations of rectilinear motion

For an accelerated electron where $\theta = 0$, equations (1.7) and (1.9) give the accelerating force ***F***, in rectilinear motion, as:

$$\mathbf{F} = -eE\left(1 - \frac{v}{c}\right)\hat{\mathbf{u}} = -m\frac{dv}{dt}\hat{\mathbf{u}} \tag{1.10}$$

The solution of equation (1.10) for an electron accelerated by a uniform field of magnitude $E$, from zero initial speed, is:

$$\frac{v}{c} = 1 - \exp\left(-\frac{at}{c}\right) \tag{1.11}$$

where $a = eE/m = eE/m_o$, is the acceleration constant. Figure 1.2.C1 is a graph of $v/c$ against $at/c$ according to equation (1.11).

For a decelerated electron where $\theta = \pi$ radians, equations (1.7) and (1.9) give the decelerating force ***F*** as:

$$\mathbf{F} = -eE\left(1 + \frac{v}{c}\right)\hat{\mathbf{u}} = m\frac{dv}{dt}\hat{\mathbf{u}} \tag{1.12}$$

Solving (1.12) for an electron decelerated from speed $c$, gives:

$$\frac{v}{c} = 2\exp\left(-\frac{at}{c}\right) - 1 \tag{1.13}$$

Figure 1.2.C2 is a plot of $v/c$ against $at/c$ according to equation (1.13).

Figure 1.2 shows a graph of $v/c$ against $at/c$ for an electron accelerated from zero initial speed, or an electron decelerated from speed of light $c$, by a uniform field: the solid lines, (A1) & (A2) according to classical electrodynamics, the dashed curve (B1) and line (B2) according to relativistic electrodynamics and the dotted curves (C1) and (C2) according to equations (1.11) and (1.13).

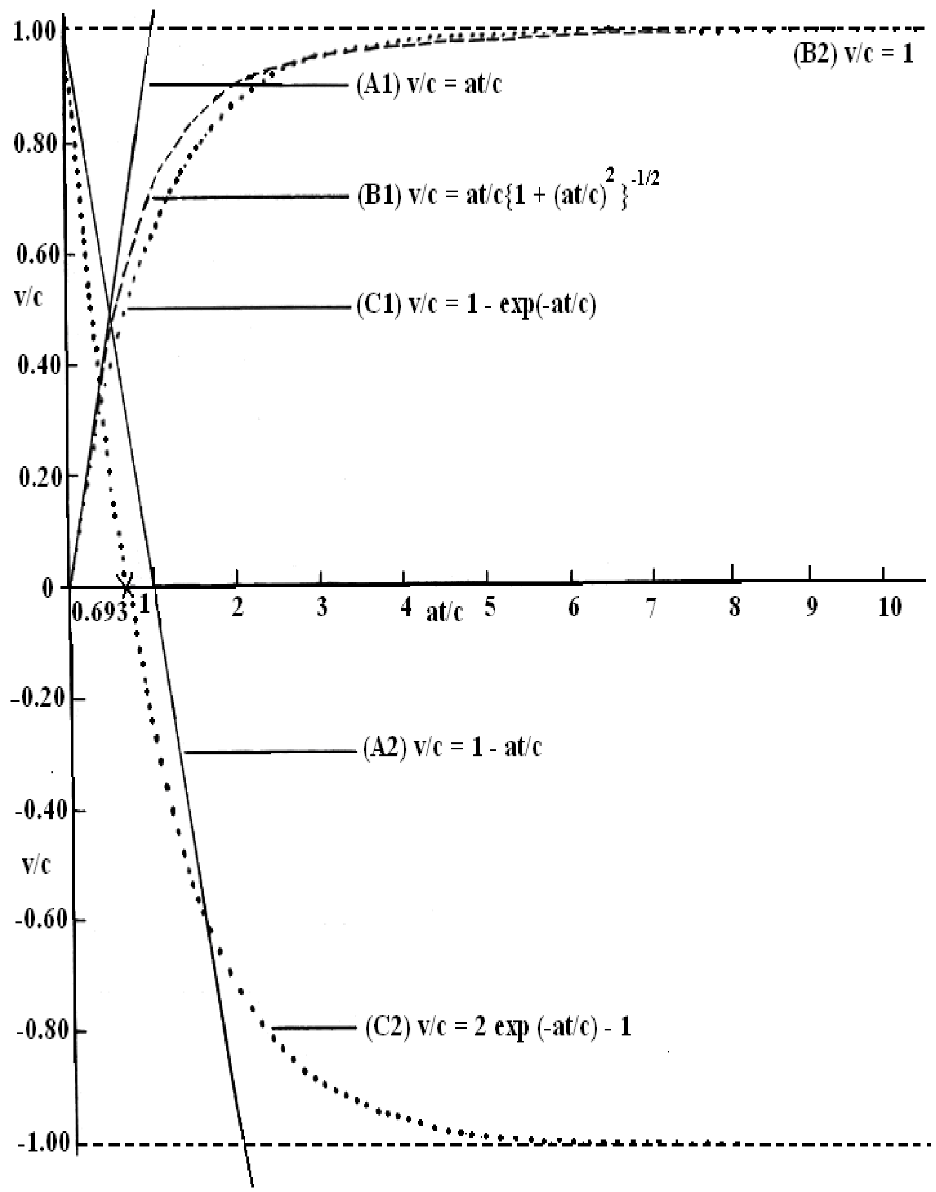


Figure 1.2. *v/c (speed in units of c)* against *at/c (time in units of c/a)* for an electron of charge $-e$ and mass $m = m_o$ accelerated from zero initial speed or decelerated from the speed of light $c$, by a uniform electrostatic field of magnitude $E$, where $a = eE/m$; the lines (A1) and (A2) according to classical electrodynamics, the dashed curve (B1) and line (B2) according to relativistic electrodynamics and the dotted curves (C1) and (C2) according to equations 1.11 and 1.13 of *radiational electrodynamics* presented here..

### 1.2.2 Equations of circular motion

For $\theta = \pi/2$ radians, motion is in a circle of radius $r$ with constant speed $v$ and acceleration $(-v^2/r)\hat{\mathbf{u}}$. Equations (1.7) and (1.9), with mass $m = m_o$ and noting that $cos(\pi/2 - \alpha) = sin\,\alpha = v/c$, give:

$$\mathbf{F} = -eE\sqrt{1-\frac{v^2}{c^2}}\,\hat{\mathbf{u}} = -m_o\frac{v^2}{r}\hat{\mathbf{u}} \qquad (1.14)$$

$$eE = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}\frac{v^2}{r} = \varsigma\frac{v^2}{r}$$

$$\varsigma = \frac{eEr}{v^2} = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}} \qquad (1.15)$$

Equation (1.1) for "*m*" and equation (1.15) for ζ are identical but obtained from two different points of view. In equation (1.1), the quantity "*m*" increases with speed *v*, becoming infinitely large at speed *c*. In equation (1.15), mass *m* remains constant at the rest mass $m_o$, and $\zeta = \{(eE)/(v^2/r)\}$ is the ratio of magnitude $F_o$, equal to the electrostatic force $(eE)$ on a stationary electron, to the centripetal acceleration $(v^2/r)$ in circular motion. This quantity ζ (not to be mistaken for physical mass $m = m_o$) may become infinitely large at the speed of light *c*, without any difficulty. At the speed of light, that is $(v = c)$, the electron moves in a circle of infinite radius, a straight line, to make "*m*" or ζ also infinite. The quantity ζ in equation (1.15) may be referred to as "*submass*".

In classical electrodynamics, the radius *r* of circular revolution for an electron of charge –e and mass *m*, in an electrostatic field of magnitude *E* due to a positively charged nucleus, is:

$$r = \frac{mv^2}{eE} = \frac{m_o v^2}{eE} = r_o \qquad (1.16)$$

where $m = m_o$, the classical mass or rest mass, is a constant and $r_o$ is the classical radius of revolution.

In relativistic electrodynamics, where mass *m* varies with speed in accordance with equation (1.1), the radius of revolution becomes:

$$r = \frac{mv^2}{eE} = \frac{m_o v^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \gamma r_o \tag{1.17}$$

In *radiational electrodynamics*, where $m = m_o$ is a constant, the radius of revolution, obtained from equation (1.14), is:

$$r = \frac{mv^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_o v^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \gamma r_o \tag{1.18}$$

Relativistic electrodynamics and *radiational electrodynamics* give the same expression for radius of revolution as $r = \gamma r_o$.

## 1.3 Radiation reaction force and radiation power

The difference between the accelerating force $\boldsymbol{F}$ on a moving electron (equation 1.8) and the electrostatic force $-e\boldsymbol{E}$ on a stationary electron, is the radiation reaction force $\boldsymbol{R_f} = \boldsymbol{F} - (-e\boldsymbol{E})$, that is always present when a charged particle is accelerated by an electrostatic field. This is analogous to a frictional force, which always opposes motion. Radiation reaction force $\boldsymbol{R_f}$ is missing in classical and relativistic electrodynamics and it makes all the difference. The radiation force, $-\boldsymbol{R_f}$, gives the direction of emitted radiation from an accelerated charged particle. For rectilinear motion, with $\theta = 0$ (Fig.1.1), equation (1.8) gives $\boldsymbol{R_f}$, in the direction of unit vector $\hat{\boldsymbol{u}}$, as:

$$\mathbf{R}_f = -\frac{eE}{c}(c-v)\hat{\mathbf{u}} + eE\hat{\mathbf{u}} = \frac{eEv}{c}\hat{\mathbf{u}} = -\frac{eE}{c}\mathbf{v} \tag{1.19}$$

In rectilinear motion, with $\theta = \pi$ radians, $\boldsymbol{R_f} = -(eEv/c)\hat{\boldsymbol{u}} = -(eE\boldsymbol{v}/c)$.

Radiation power $R_p = -\boldsymbol{v}.\boldsymbol{R_f}$, the scalar product of $\boldsymbol{R_f}$ and velocity $\mathbf{v}$. The scalar product is obtained, with reference to Figure 1.1, as:

$$R_p = -\mathbf{v}\cdot\mathbf{R}_f = -\mathbf{v}\cdot\left\{\frac{eE}{c}(\mathbf{c}-\mathbf{v}) + e\mathbf{E}\right\}$$

$$R_p = eEv\left\{\cos\theta - \cos(\theta-\alpha) + \frac{v}{c}\right\} \tag{1.20}$$

For rectilinear motion with $\theta = 0$ or $\pi$ radians, equations (1.7) and (1.20) give the radiation power $R_p$ as:

$$R_p = -\mathbf{v}.\mathbf{R}_f = eE\frac{v^2}{c} \quad (1.21)$$

Positive radiation power, as given by equation (1.21), means that energy is radiated in accelerated and decelerated motions. Note the difference between equation (1.21) and Larmor classical formula.

In circular motion, where $\boldsymbol{v}$ is orthogonal to $\boldsymbol{E}$ and $\boldsymbol{R}_f$, the radiation power $R_p$ (scalar product of $\boldsymbol{v}$ and $\boldsymbol{R}_f$) is zero, as can be ascertained from equations (1.7) and (1.17) with $\theta = \pi/2$ radians and $cos(\theta - \alpha) = sin\alpha = v/c$. Equation (1.20) is significant in *radiational electrodynamics* [13]. It makes circular motion of an electron, round a centre of revolution, as in Rutherford's nuclear model of the hydrogen atom, without radiation and stable, without recourse to Bohr's quantum theory. This result is used by the author [17, 21] to develop two new models of the hydrogen atom, for the gas state and the liquid or solid state, which are inherently stable, outside Bohr's quantum electrodynamics.

Equations (1.19), (1.20) and (1.21) are the radiation formulas of *radiational electrodynamics*. These equations are in contrast to those of classical electrodynamics [14] where the radiation force is proportional to the rate of change of acceleration and the radiation power is proportional to the square of acceleration.

## 1.4 Mass-energy equivalence formula

The author [8] showed that the electrostatic energy of a particle of mass $m$, equal to the energy content of the mass, is $W = m/2\mu_o\varepsilon_o = ½mc^2$, where $c = (\mu_o\varepsilon_o)^{-1/2}$, is the speed of light in a vacuum and $\mu_o$ *is* the permeability and $\varepsilon_o$ the permittivity of a vacuum [9]. The kinetic energy of a particle of mass $m$ moving with speed $v$, is $K = ½mv^2$, so that the total energy content $E$, is:

$$E = W + K = \frac{m}{2}\left(c^2 + v^2\right) \quad (1.22)$$

This is in contrast to Einstein's most famous formula of special relativity, the mass-energy equivalence formula, that gives the total energy content of a body of mass $m$ and rest mass $m_o$ moving with relative speed $v$, as:

$$E = mc^2 = \frac{m_o c^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad (1.23)$$

## 1.5 Conclusion

In special relativity, Einstein's influence is so overwhelming that difficulties of the theory as in mass expansion, and contradictions as in Doppler Effect, are ignored or avoided altogether. Challenge of Einstein is considered, by the establishment physicists, as sacrilegious. Physicists might have been dazzled by Einstein's "brilliance" and the public amazed by adulation of a "genius" who toppled Galileo Galilei, dethroned Isaac Newton and overturned natural sense. However, now disproving some aspects of special relativity and putting general relativity to test, should not, in any way, detract from Einstein's stature and ingenuity as the man of the $20^{th}$ Century.

Einstein filled a gap that existed in knowledge during his time. He brilliantly answered the question why an electron cannot be accelerated beyond the speed of light by positing that mass increases with speed, becoming infinitely large at the speed of light. This position is apparently plausible as an infinite mass cannot be accelerated to any faster by a finite force. Now, with the amendment of Coulomb's law for electrostatic force, giving rise to what may be called *force-velocity formula of electrodynamics*, we have the ultimate speed without infinite mass. There is no longer reason for sticking to Einstein's theory of special relativity.

In *radiational electrodynamics*, there is no increase of *mass* with speed or *mass expansion*. The mass $m$ of a moving electron remains constant as the rest mass $m_o$ and it is the accelerating force that becomes zero at the speed of light $c$. Relativistic and *radiational electrodynamics* give the same expression (equations 1.17 and 1.18) for the radius of revolution of an electron round a positively charged nucleus. This explains the cause of misconception or delusion connected with increase of mass with speed. In this regard, the relativistic mass-energy and mass-velocity formula expressed in equation (1.23), the bone of contention here, is shown to be wrong.

The relativistic mass *"m"* in equation (1.23), being equated with the physical mass $m$ of an electron, is a very expensive case of mistaken identity. This is a good example of Beckmann's *correspondence theory* [6] whereby the correct result is produced mathematically but it does not correspond with physical reality. For example, equation (1.23) leads to the speed of light as the ultimate limit but for the wrong reason, i.e. mass *m* becoming infinitely large at the speed of light $v = c$. Two other contentious issues are *length contraction* and *time dilation*.

This paper regards *mass*, l*ength* and *time* as absolute quantities, independent of motion or position of the observer. *Mass expansion*, *length contraction* and *time dilation* are completely rejected. The contentious issue remaining is Larmor formula.

Larmor formula, an erroneous formula for radiation power of accelerated electrons, influenced physics early in the $20^{th}$ century. It required Bohr's quantum theory, devised to prevent radiation and stabilize the Rutherford's nuclear model of the hydrogen atom.

Relativistic electrodynamics fails for electrons decelerated from the speed of light *c*. In *radiational electrodynamics*, an electron is readily accelerated to the speed of light *c*, through a potential energy of 15 MeV or higher. An electron accelerated to the speed of light *c*, is easily stopped by a decelerating field and then accelerated backwards to reach an ultimate speed $-c$ (curve C2, in contrast to lines A2 and B2, in Fig.1.2).

An experiment may be performed to test *radiational electrodynamics* by having a narrow pulse of electrons, accelerated to the speed of light (or almost to the speed of light) *c*, made to enter a decelerating field. The electrons being stopped at all and turned back in their track, invalidates special relativity. This is the litmus test of validity of the new electrodynamics.

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