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# An Alternative Electrodynamics to the Theory of Special Relativity

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## Abstract

The velocity of transmission of electric force, relative to a charged particle moving with velocity $\boldsymbol{v}$, is proposed as $(\boldsymbol{c} - \boldsymbol{v})$. The accelerating force $\boldsymbol{F}$ on an electron of charge $-e$ and mass $m$ moving at time $t$ with velocity $\boldsymbol{v}$ in an electric field of intensity $\boldsymbol{E}$, is given as vector:

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

where $m$ is a constant, $c$ is the magnitude of velocity of light, $E$ is the magnitude of electric field, $\theta$ is the angle between the vectors $\boldsymbol{F}$ and $\boldsymbol{v}$, $(\theta - \alpha)$ is the angle between the vectors $\boldsymbol{c}$ and $\boldsymbol{v}$ and $\alpha$ is angle of aberration such that:

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

The difference $\boldsymbol{F} - e\boldsymbol{E} = \boldsymbol{R}_f$ is the radiation reaction force. Radiation power is the scalar product $\boldsymbol{v}.\boldsymbol{R}_f$. For $\theta = 0$ or $\theta = \pi$ radians, there is rectilinear motion with emission of radiation. If $\theta = \pi/2$ radians, there is motion without radiation in a circle of radius $r$ with centripetal acceleration $v^2/r$ and the magnitude of force $\boldsymbol{F}$ as:

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

where $m = m_o$ is the rest mass. In the alternative electrodynamics, $F$ decreases with speed $v$, becoming 0 at $v = c$, in contrast to special relativity where

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

It is as if the accelerating force $F = -eE$ is independent of speed and mass $m$ is misconceived as increasing with speed in accordance with the relativistic mass-velocity formula.

*Keywords:* Acceleration, electric charge, energy, force, mass, radiation, velocity

## 1 Introduction

There are now three systems of electrodynamics. There is classical electrodynamics applicable to electrically charged particles moving at a speed which is 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 to every particle at all speeds up to that of light.

Classical electrodynamics is based on the second law of motion, originated by Galileo Galilei in 1638 [1], but enunciated by Isaac Newton [2]. The theory of special relativity was formulated in 1905 mainly by Albert Einstein [3, 4] and the quantum theory was initiated by Max 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 an alternative electrodynamics, applicable to an electrically charged particle moving at speeds up to that of light *c*, with mass of a particle remaining 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 approaches 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 relativistic mass-velocity formula is:

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma m_o \qquad (1)$$

where $m$ is the mass of a particle moving with speed $v$, $m_o$ is the rest mass, $c$ is the speed of light in a vacuum and $\gamma$ is a ratio depending on $v$. Equation (1), where $m$ is a physical quantity, becoming infinitely large at the speed of light, is the bone of contention in this paper. The difficulty with infinite mass, at the speed of light, $v = c$, in equation (1), is the Achilles' heel of the theory of special relativity. Resolving this difficulty, by allowing a moving particle to reach the speed if light, is the main aim of this paper.

The proponents of special relativity just ignore the problem with equation (1). They say that it is the momentum, not the mass, which increases with speed. They avoid the difficulty altogether by arguing that the speed never really reaches that of light *c*, or that particles moving at the speed of light (photons) have zero rest mass. But electrons are easily accelerated and have been accelerated to practically the speed of light as demonstrated by William Bertozzi [8] using a linear accelerator of 30 MeV energy. Electron accelerators, betatrons and electron synchrotrons of over 100 BeV, have been built and operated with electrons moving at the speed of light for all practical purposes.

### 1.1 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 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 *K* lost by the electrons, on the assumption that the force on a moving electron is $-e\mathbf{E}$, independent of its speed and always equal to the accelerating force.

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:

$$P = J = K + R \tag{2}$$

where $R$ 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. This radiation is a result of aberration of electric field.

### 1.2 Aberration of electric field

Figure.1 depicts an electron of charge $-e$ and mass $m$, moving at a point $P$ with velocity $\boldsymbol{v}$, in an electrostatic field $\boldsymbol{E}$ due to a stationary source charge $+Q$ at an origin $O$. For motion at an angle $\theta$ to the accelerating force $\boldsymbol{F}$, the electron is subjected to aberration of electric field. This is a phenomenon similar to aberration of light discovered by the English astronomer James Bradley in 1728 [9]. In aberration of electric field, as in aberration of light, the direction of the electrostatic field, indicated by the velocity vector $\boldsymbol{c}$ (see Fig.1), appears shifted by an aberration angle $\alpha$, from the instantaneous line $\boldsymbol{PO}$, such that:

$$\sin\alpha = \frac{v}{c}\sin\theta \tag{3}$$

where the speeds $v$ and $c$ are the magnitudes of the velocities $\boldsymbol{v}$ and $\boldsymbol{c}$ respectively. Equation (3) was first derived by James Bradley. Aberration of electric field, which is missing in classical and relativistic electrodynamics, is used in the formulation of the alternative electrodynamics.

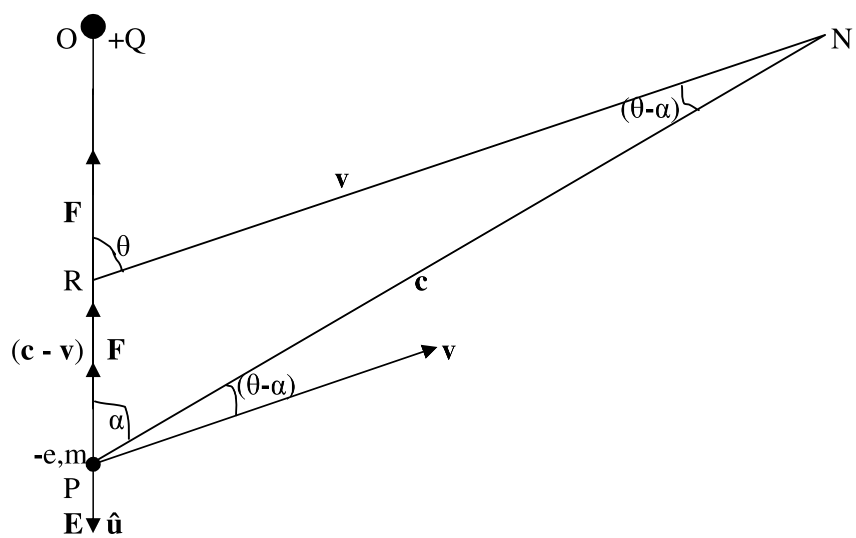


Figure 1 Vector diagram depicts angle of aberration $\alpha$ as a result of an electron of charge $-e$ and mass $m$ moving, at a point $P$, with velocity $\boldsymbol{v}$, at an angle $\theta$ to the accelerating force $\boldsymbol{F}$. The unit vector $\hat{\boldsymbol{u}}$ is in the direction of the electrostatic field of intensity $\boldsymbol{E}$ due to a stationary source charge $+Q$ at the origin $O$.

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, in accordance with Newton's first law of motion. Also, the difference between the accelerating force and the electrostatic force (on a stationary electron) gives the radiation reaction force, from which the radiation power is derived, in contrast to Larmor formula of classical electrodynamics.

### 1.3 Larmor formula

Larmor formula of classical electrodynamics, described by Griffith [10], 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 [10] and gives radiation power $R = \gamma^4 R_p$, where $\gamma$ is defined in equation (1). The relativistic 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 entities known in nature. Use of Larmor formula was unfortunate as it led physics astray early in the 20th century. It required the brilliant hypotheses of Niels Bohr's [11] quantum mechanics to stabilize the Rutherford's [12] nuclear model of the hydrogen atom.

In the alternative electrodynamics, there is no need for Bohr's quantum theory to stabilize the Rutherford's nuclear model of the hydrogen atom. In this paper it is shown that circular motion of an electron round a nucleus is stable and without emission of radiation. Radiation takes place only if there is motion of a charged particle along an electric field.

## 2 Equations of motion in the alternative electrodynamics

The force exerted on an electron, moving with velocity $\boldsymbol{v}$, by an electrostatic field, is propagated at the velocity of light $\boldsymbol{c}$ relative to the source charge and transmitted 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 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, perpendicular to the accelerating field, where $\theta = \pi/2$ radians.

The accelerating force $\boldsymbol{F}$ (see Figure 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:

$$\mathbf{F} = \frac{eE}{c}(\mathbf{c} - \mathbf{v}) = m\frac{d\mathbf{v}}{dt} \tag{4}$$

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 speed $c$ 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 $\boldsymbol{v} = \boldsymbol{c}$. With no force on the electron, it continues to move with constant speed $c$, in accordance with Newton's first law of motion. Equation (4) may be regarded as an extension, amendment or modification of Coulomb's law of electric force between two electric charges, taking into consideration their relative velocity.

Equation (3) links the angle $\theta$ with the aberration angle $\alpha$ (Fig.1). Equation (4) is the basic expression of the alternative electrodynamics. Expanding this equation, by taking the *modulus* of the vector $(\boldsymbol{c} - \boldsymbol{v})$, with respect to the angles $\theta$ and $\alpha$, gives:

$$\mathbf{F} = \frac{-eE}{c}\sqrt{c^2 + v^2 - 2cv\{\cos(\theta - \alpha)\}}\hat{\mathbf{u}} = m\frac{d\mathbf{v}}{dt} \tag{5}$$

## 2.1 Equations of rectilinear motion

For an accelerated electron where $\theta = 0$, equations (3) and (5) give the force $\boldsymbol{F}$ as:

$$\mathbf{F} = -eE\left(1 - \frac{v}{c}\right)\hat{\mathbf{u}} = -m\frac{dv}{dt}\hat{\mathbf{u}} \tag{6}$$

This is a first order differential equation. The solution of equation (6) for an electron accelerated by a uniform electric field of constant magnitude *E*, from zero initial speed, is:

$$\frac{v}{c} = 1 - \exp\left(-\frac{at}{c}\right) \tag{7}$$

where $a = eE/m$ is a constant. Figure 2.C1 is a graph of $v/c$ against $at/c$ for equation (7).

For a decelerated electron where $\theta = \pi$ radians, equations (3) and (5) give the decelerating force $\boldsymbol{F}$ as:

$$\mathbf{F} = -eE\left(1 + \frac{v}{c}\right)\hat{\mathbf{u}} = m\frac{dv}{dt}\hat{\mathbf{u}} \tag{8}$$

Solving equation (8) for an electron decelerated from speed *c*, by a uniform field, gives:

$$\frac{v}{c} = 2\exp\left(-\frac{at}{c}\right) - 1 \tag{9}$$

Figure 2.C2 is a plot of $v/c$ against $at/c$ according to equation (9).

Figure 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 electric 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 (7) and (9) of the alternative electrodynamics.

## 2.2 Equations of circular motion

For $\theta = \pi/2$ radians, motion is in a circle of radius *r* with constant speed *v* and centripetal acceleration $(-v^2/r)\hat{\boldsymbol{u}}$. Equations (3) and (5), with mass $m = m_o$ and noting that $\cos(\pi/2 - \alpha) = \sin\alpha = v/c$, give the accelerating force $\boldsymbol{F}$ as:

$$\mathbf{F} = -eE\sqrt{1 - \frac{v^2}{c^2}}\hat{\mathbf{u}} = -m_o\frac{v^2}{r}\hat{\mathbf{u}} \tag{10}$$

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

$$\varsigma = \frac{eEr}{v^2} = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{11}$$

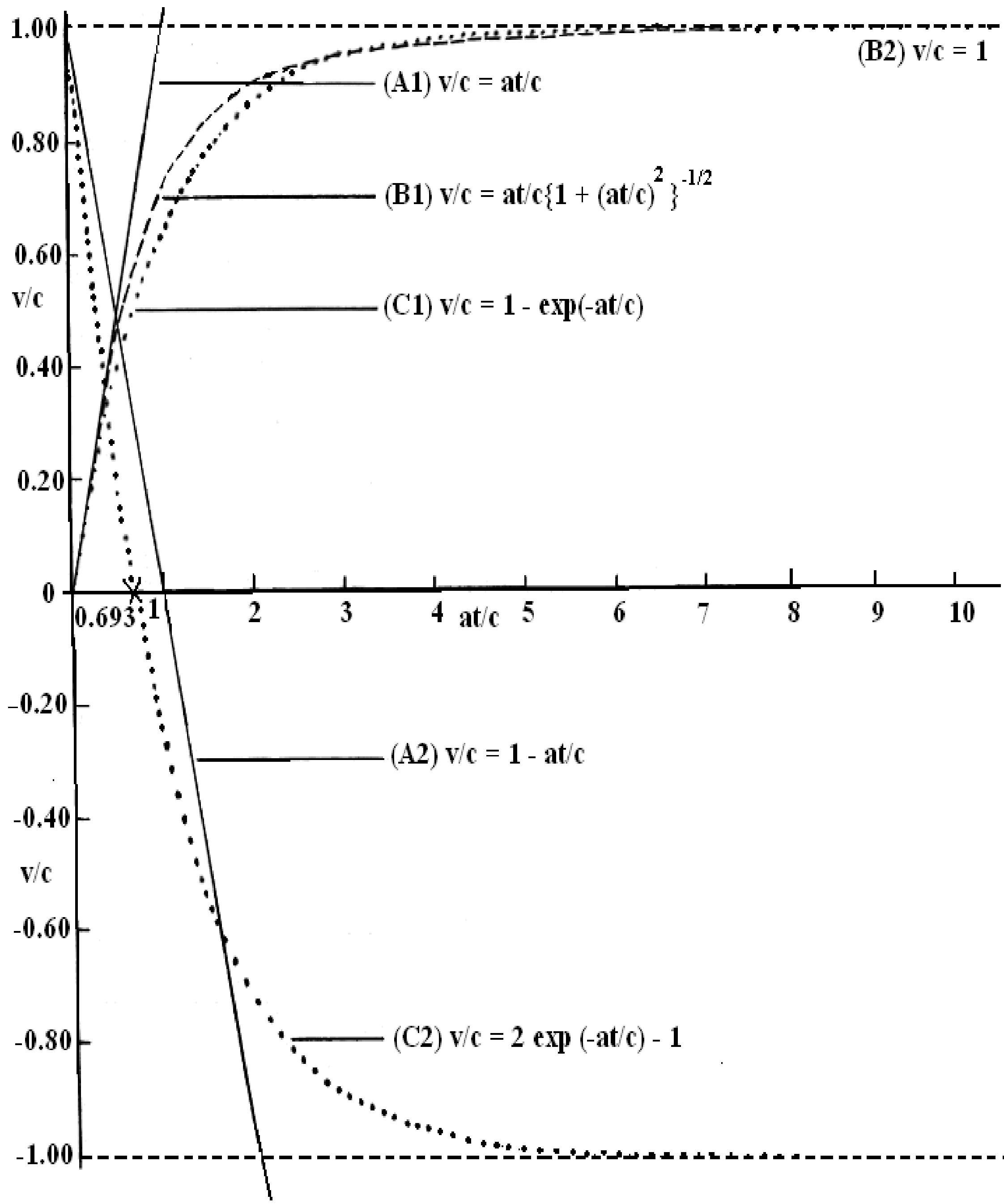


Figure 2. *v/c (speed in units of c)* against *at/c (time in units of c/a)* for an electron of charge $-e$ and mass $m = m_o$ accelerated from zero initial speed or decelerated from the speed of light $c$, by a uniform electrostatic field of magnitude $E$, where $a = eE/m$; the lines (A1) and (A2) according to classical electrodynamics, the dashed curve (B1) and line (B2) according to relativistic electrodynamics and the dotted curves (C1) and (C2) according to equations 7 and 9 of the alternative electrodynamics presented here..

Equation (1) for '*m'* and equation (11) for $\zeta$ are identical but obtained from two different points of view. In equation (1), the quantity '*m'* increases with speed *v*, becoming infinitely large at speed *c*. In equation (11), mass *m* remains constant at the rest mass $m_o$, and the quantity $\zeta = \{(eE)/(v^2/r)\}$ is the ratio of magnitude of the electrostatic force *(eE)* on a stationary electron, to the centripetal acceleration $(v^2/r)$ in circular motion. This quantity $\zeta$ 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 $\zeta$ also infinite without any problem or difficulty.

In classical electrodynamics, 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:

$$r = \frac{mv^2}{eE} = \frac{m_o v^2}{eE} = r_o \qquad (12)$$

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

In relativistic electrodynamics, where mass *m* is supposed to vary with speed *v* in accordance with equation (1), the radius of revolution becomes:

$$r = \frac{mv^2}{eE} = \frac{m_o v^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \gamma r_o \qquad (13)$$

In the alternative electrodynamics, where $m = m_o$ is a constant, the radius of revolution, obtained from equation (10), is:

$$r = \frac{mv^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_o v^2}{eE\sqrt{1-\frac{v^2}{c^2}}} = \gamma r_o \qquad (14)$$

Relativistic electrodynamics and the alternative electrodynamics give the same expression for radius of revolution in circular motion as $r = \gamma r_o$ but for different reasons.

## 3. Radiation reaction force and radiation power

The difference between the accelerating force $\boldsymbol{F}$ on a moving electron 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 electric field. This is analogous to a frictional force, which always opposes motion. A simple and useful expression for 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), equation (4) gives $\boldsymbol{R}_f$, in the direction of unit vector $\hat{\boldsymbol{u}}$, as:

$$\mathbf{R}_f = -\frac{eE}{c}(c-v)\hat{\mathbf{u}} + eE\hat{\mathbf{u}} = \frac{eEv}{c}\hat{\mathbf{u}} = -\frac{eE}{c}\mathbf{v} \qquad (15)$$

In rectilinear motion, with $\theta = \pi$ radians, $\boldsymbol{R}_f = -(eEv/c)\hat{\boldsymbol{u}} = -(eE\boldsymbol{v}/c)$, same as equation (15).

Radiation power is $R_p = -\mathbf{v}.\mathbf{R}_f$, the scalar product of $\mathbf{R}_f$ and velocity $\mathbf{v}$. The scalar product is obtained, with reference to Figure 1, as:

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

$$R_p = eEv\left\{\cos\theta - \cos(\theta-\alpha)+\frac{v}{c}\right\} \tag{16}$$

For rectilinear motion with $\theta = 0$ or $\pi$ radians, equations (3) and (16) give radiation power as:

$$R_p = -\mathbf{v}.\mathbf{R}_f = eE\frac{v^2}{c} \tag{17}$$

Positive radiation power, as given by equation (17), means that energy is radiated in accelerated and decelerated motions.

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 (3) and (16) with $\theta = \pi/2$ radians and $cos(\theta-\alpha) = sin\alpha = v/c$. Equation (16) is significant in the alternative electrodynamics. 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, outside Bohr's quantum theory.

Equations (15), (16) and (17) are the radiation formulas of the alternative electrodynamics. These equations are in contrast to those of classical electrodynamics where the radiation force is proportional to the rate of change of acceleration and the radiation power is proportional to the square of acceleration. There is no formula for radiation force in relativistic electrodynamics.

## 4. Conclusion

In special relativity, Einstein's influence is so overwhelming that difficulties of the theory, as in mass expansion, 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, should not, in any way, detract from Einstein's stature and ingenuity as the man of the 20th 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 any faster by a finite force. Now, with the amendment of Coulomb's law for electrostatic force, giving rise to what might be called *force-velocity formula of electrodynamics*, we have the ultimate speed without infinite mass.

In the alternative 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 the alternative electrodynamics give the same expression (equations 13 and 14) for the radius of revolution of an electron in circular motion 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-speed formula expressed in equation (1), the bone of contention here, is open to question. It is a good example of Beckmann's *correspondence theory* [6], whereby the correct result is produced mathematically but it does correspond with physical reality.

Larmor formula, an erroneous equation for radiation power of accelerated electrons, influenced physics early in the 20th century. It required the brilliant contrivance of Bohr's quantum theory 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 the alternative electrodynamics, an electron is readily accelerated to the speed of light $c$, through a potential energy of 30 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.2).

An experiment may be performed to test the alternative electrodynamics by having a narrow pulse of electrons, accelerated 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 alternative electrodynamics. It should dispel the controversial opinion of mass of particle increasing with its speed, becoming infinitely large at the speed of light, according to the theory of special relativity, and bring great relief to physicists all over the world..

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