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A Modified Coulomb's Law and Newton's Second Law of Motion are Sufficient in Electrodynamics

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Abstract: The paper inserts a velocity factor in Coulomb's law of electrostatics and equates it with Newton's second law of motion, to obtain speed of light *c*, in a vacuum, as limit to which a charged particle gets accelerated, by an electric field, at constant mass. Radiation is obtainable from accelerated charged particles, outside quantum mechanics. Electrons attaining speed of light *c*, without infinitely large masses, should bring real relief to physicists.
Keywords: Aberration of Electric Field, Acceleration, Electric Charge, Electric Field, Energy, Force, Mass, Radiation, Relativity, Speed, Velocity.

1. Introduction

Newton's second law of motion was enunciated in 1687 by the great English physicist, Sir Isaac Newton. Newton's laws of motion form the foundation of classical mechanics. Coulomb's law enunciated in 1786 by French physicist, Charles Augustin de Coulomb, is an important principle in physics. The theories of special and general relativity, enunciated by the celebrated physicist, Albert Einstein, and quantum theory originated by Max Planck, are the reigning doctrines of physics. However, these theories are not mutually compatible. So, one or ~~all the~~both theories may be wrong. This paper, invoking aberration of electric field, a missing link in physics, intends to introduce a radiative electrodynamics, where a charged particle is accelerated by an electric field, at constant mass as the rest mass m_o, with emission radiation. Radiation is the difference between change in potential energy and change in kinetic energy. Radiation reaction force, a kind of frictional force proportional to velocity in an electric field, prevents accelerated charged particles from going beyond the speed of light *c*.

A great physicist of the 19th Century, Professor James C. Maxwell, derived an expression for speed of light, in a vacuum, as:

$$c = \sqrt{1/\mu_o\varepsilon_o} \;=\; 299\,792\,458\ m/s \qquad (1)$$

where μ_o is permeability and ε_o permittivity of an electric field in a vacuum, making *c* the speed of light in free space. This speed, the same, relative to the source, everywhere in the Universe, is the most measured and most accurately known quantity in physics.

2. Coulomb's Law and Aberration of Electric Field

Figure 1 shows Coulomb's law for force **f** and field $\mathbf{E}_o$ between stationary charges *Q* & *K* apart. Figure 2 depicts aberration of electric field for a particle of charge *K* moving at P with velocity **v** at angle θ to electrostatic field $\mathbf{E}_o$ in the direction of unit vector **û,** due to charge *Q* at O. The field appears at light velocity **c** displaced by aberration angle α, such that vector (**c** – **v**) is along OP, and:

$$\sin\alpha = (v/c)\sin\theta \qquad (2)$$

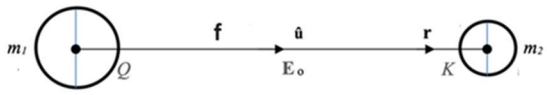

Fig. 1: Electrostatic field $\mathbf{E}_o$ and force **f** due to stationary charges *Q* relative to charge *K*, distance *r* apart

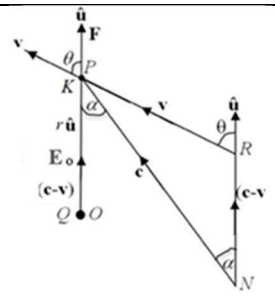

Fig. 2: Aberration of electric field $\mathbf{E}_o$ due to charge *K* moving with velocity **v** at P.

In view of aberration of electric field, with respect to Figure 2, accelerating force **f** on charge *K* of mass m_2, moving at time *t* with velocity **v** and acceleration *d***v**/*dt*, relative to *Q*, is in equation 3:

$$\mathbf{f} = (KE_o/c)(\mathbf{c}-\mathbf{v}) = (KE_o/c)\sqrt{c^2+v^2-2cv\cos(\theta-\alpha)}\,\hat{\mathbf{u}} = m_2(d\mathbf{v}/dt) \qquad (3)$$

where $(\theta - \alpha)$ is angle of vectors **c** and **v**. Equations *2* & *3* with $\theta = \pi/2$ rads, in circular motion of radius *r*, and $cos(\theta - \alpha) = v/c$, gives:

$$\mathbf{f} = (KE_o/c)(\mathbf{c}-\mathbf{v}) = (KE_o/c)\sqrt{c^2+v^2-2cv\cos(\theta-\alpha)}\,\hat{\mathbf{u}} = (KE_o/c)\sqrt{c^2-v^2}\,\hat{\mathbf{u}} = m_2(d\mathbf{v}/dt) = -m_2(v^2/r)\hat{\mathbf{u}} \qquad (4)$$

In equation 4, accelerating force **f** decreases with velocity **v**, reducing to *0* at velocity of light, **v** = **c**, makes **c** a limit, at constant mass m_2.

An interesting case in equation (4) is where charge *K* is negative, such as an electron of charge -*e* and rest mass $m_2 = m_o$, thus:

$$\mathbf{f} = -(eE_o/c)(\mathbf{c}-\mathbf{v}) = -(eE_o/c)\sqrt{c^2+v^2-2cv\cos(\theta-\alpha)}\,\hat{\mathbf{u}} = -(eE_o/c)\sqrt{c^2-v^2}\,\hat{\mathbf{u}} = m_o(d\mathbf{v}/dt) = -m_o(v^2/r)\hat{\mathbf{u}} \qquad (5)$$

Special relativity takes **f** as -*e*$\mathbf{E}_o$, independent of speed *v*, and transposed equation (5), to introduce relativistic mass m_v as in equation 6:

$$eE_o = m_o/\sqrt{1-(v/c)^2}\,(v^2/r) = \gamma m_o(v^2/r) = m_v(v^2/r) \qquad (6)$$

where γ is Lorentz factor. Relativistic mass-velocity formula $m_v = \gamma m_o$ is correct in circular motion only but not because of mass increases.

In equation (4), accelerating force on a moving charge, is less than force on a stationary one, the difference is radiation reaction force $\mathbf{R}_f$ ~~.in equation (7).~~ Radiation power is ~~the~~ scalar product -**v**.$\mathbf{R}_f$ ~~. as expressed in equations (7) and (8):~~**R**$_f$, in equations (8), in terms of angles θ and α of Figure 1, thus:

$$\mathbf{R}_f = (KE_o/c)(\mathbf{c}-\mathbf{v}) - K\mathbf{E}_o \qquad (7)$$

$$-\mathbf{v}.\mathbf{R}_f = -\mathbf{v}.\{(KE_o/c)(\mathbf{c}-\mathbf{v}) - K\mathbf{E}_o\} = KE_o v\{\cos\theta - \cos(\theta-\alpha) + v/c\} \qquad (8)$$

In equation (8), radiation power is $KE_o v^2/c$ in rectilinear motion with $\theta = 0$ or π radians and *zero* power in circular motion with $\theta = \pi/2$.

In Figure 2, with charge *Q*, of mass m_1, moving at velocity **v**, relative to an observer, the dynamic electric field $\mathbf{E}_v$, is put as:

$$\mathbf{E}_v = (E_o/c)(\mathbf{c}+\mathbf{v}) \qquad (9)$$

Kinetic energy of the moving particle is contained in the increase of electric field by $\mathbf{E}_o$v/c from $\mathbf{E}_o$ to $\mathbf{E}_v$, not in mass increase with speed.

3. Results

- Equation (3) gives linear motion with $\theta = 0$ (in acceleration), as $\mathbf{f} = (KE_o/c)(c-v)\hat{\mathbf{u}} = m_2(dv/dt)\hat{\mathbf{u}}$ and with $\theta = \pi$ (deceleration), as $\mathbf{f} = (KE_o/c)(c+v)\hat{\mathbf{u}} = -m_2(dv/dt)\hat{\mathbf{u}}$. Knowing $\mathbf{E}_o$, the equations are solved to obtain speed *v* in terms of time *t*.
- In equation 4, accelerating force **f** reduces to *0* at velocity **v** = **c**, making light velocity **c** a limit with constant moving mass m_2.
- Lorentz factor γ in equation 6, has no link with mass but due to motion of a charged particle perpendicular to an electric field.
- Relativistic mass-velocity formula $m_v = \gamma m_o$, in equation (6), is correct for circular motion only, as in cyclic particle accelerators.

4. Conclusion: A modified Coulomb's law with Newton's Second Law of Motion, makes relativistic & quantum mechanics unneeded.

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