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Coulomb's Law in Electrostatic, Gravitational and Inertial Forces and Emission of Radiation

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ABSTRACT

Electric fields, from charges in bodies, in accordance with Coulomb's law, occupying a vacuum, constitute an elastic medium called aether. Electrostatic, gravitational, and inertial forces are explained by considering the aether as an electric-field medium, supporting transmission of radiation at the speed of light. A partice of charge *Q* is supposed to be an impregnable hollow sphere, with radial force pulling the surface outwards, to maintain a stable structure of radius a and mass m, as the smallest quantities. Lines of force from stationary adjacent charges, are curled, in positive potential energy, for repulsion or negative for attraction. A charge *Q*, moving at constant velocity, carries its straight lines of radial fields, with increase forwards, to account for the kinetic energy. Force of gravity is by virtue of bodies displacing volumes of the aether, one in the shadow of another, to make for a pushings force of attraction, in accordance with Newton's law. Due to finite speed of light, acceleration of charge *Q* moving at time t with velocity **v**, is not simultaneously passed to all the fields, resulting in curling of lateral field lines and creation of reactive field **E** and inertial force *Q***E** = -*m*(*d***v**/*dt*), as inertia. Coulomb's law is modified, with a velocity term, in view of aberration of electric field, for radiation from accelerated charges. Curving of space-time continuum is replaced with curling of electric field lines of force. Materials for teaching electromagnetic fields and radiation, in space, are well provided.

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Introduction

Over the ages, gravity had been an enigma, more so after the great physicist, Sir Isaac Newton, had enunciated the universal inverse square law of gravity in1687 [1, 2]. The cause of force of gravity has defied rational explanations in classical mechanics and relativistic mechanics [3-5]. Such a pervasive and persistent force may have a simple explanation which has escaped the attention of modern physicists, who are cruising, at breakneck speed, in space-time continuum. Gravitation succumbed to complicated mathematical expressions. Hence, there emerged the formulation of the theory of general relativity or Einstein's theory of gravity [6-10]. The theory of general relativity, which ascribes gravitation to distortion, curving or warping of four-dimensional space-time continuum, in the presence of matter, is a brilliant, revolutionary, and very appealing proposition [11, 12]. It is the reigning doctrine of physics today. General relativity, extending into several extra dimensions, has stretched the imagination, by the modern physicists, too far, but so far, without any experimental verification of space having more than one dimension with three orthogonal components. The search for an explanation of gravitation has continued with gravitational quantum physics and other new-fangled indulgencies [13].

This paper assumes an electric charge, like an electron, to be an impregnable spherical shell of radius a. It considers the electric fields, from a stationary charged particle, to be in radial straight lines, acting from the centre, pulling the surface of the charge equally outwards. The pulling forces act equally, directed away from the centre, to be in equilibrium, and maintain a stable structure. This idea of field lines of force is in line with the remarkable perception of physical lines of force treated by Maxwell [14, 15]. Visualisation of lines of force should assist in explaining the cause of electrostatic force of repulsion or attraction between charges, in accordance with Coulomb's law [16]. It may give a physical explanation of the cause of gravitational force of attraction between bodies composed of charges and the cause of inertia of a body under acceleration. It may even lead to a realistic unification of electrostatics and gravitation. Indeed, every phenomenon in nature has a physical explanation and a mathematical expression, subject to experimental verifiction. Virtually all electrical phenomena can be explained in terms of force and motion with regard to electric charges, as embodied in Coulomb's law.

The speed of light *c = 299 792 458 meters per second* features prominently in this paper. The great Scottish mathematician and physicist, James C. Maxwell, gave the speed of electromagnetic wave, same as the speed of light c in free space, in a vacuum, as [17, 18]:

$$c = \sqrt{\frac{1}{\mu_o \varepsilon_o}} \tag{1}$$

where μ_o is the permeability and ε_o permittivity of space.

The missing link, in physics today, is aberration of electric field [19]. This is a phenomenon similar to aberration of light discovered in 1728 by English astronomer, James Bradley, one of the most significant discoveries in science. Aberration of light clearly demonstrated the relativity of speed of light. Taking aberration of electric field into consideration, gives the speed of light as a limit, to which an electric charge may be accelerated by an electric field, without recourse to theory of special relativity [20]. Radiation is obtained, from accelerated charged particles, outside quantum mechanics [21]. A mass-energy equivalence law is obtained as $E = ½ mc^2$ in contrast to the relativistic equation $E = mc^2$.

The issue of lumineferous aether as an electric field medium pervading the universal space, in accordance with Coulomb's law, is tackled [22-25].

Coulomb's Law, Electric Field and Electric Potential

Figure 1 illustrates Coulomb's law, perhaps the most important principle in physics. It gives the force F between two stationary electric charges of magnitudes Q and K, separated by distance r, as:

$$\mathbf{F} = \frac{KQ}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{KQ}{4\pi\varepsilon_o r^2}\frac{\mathbf{c}}{c} \qquad (2)$$

$$\mathbf{E}_r = \frac{K}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = \frac{K}{4\pi\varepsilon_o r^2}\frac{\mathbf{c}}{c} \qquad (3)$$

where ε_o is electric permittivity, $\hat{\mathbf{u}} = \mathbf{c}/c$ is a unit vector in the direction of force of repulsion, $\mathbf{c}$ is the velocity of light, a vector of magnitude c, at which an electrical force is transmitted, and $\mathbf{E}_r$ is the electrostatic field intensity, due to charge K, at the location of charge Q, as shown in Figure 1.

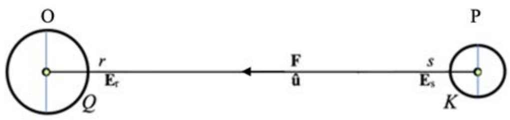

Figure 1: Force **F** between two stationary electric charges Q and K separated by distance r = s.

Force of repulsion is a positive and force of attraction is negative. Charge K in Figure 1 may move, at time t, with velocity $\mathbf{v}$ and acceleration $d\mathbf{v}/dt$, relative to Q. Charge Q may move relative to an observer.

In Figure 1, the force $K\mathbf{E}_s$, on charge K, due to charge Q, at the location of charge K, is:

$$K\mathbf{E}_s = \frac{KQ}{4\pi\varepsilon_o s^2}\hat{\mathbf{u}} = \frac{KQ}{4\pi\varepsilon_o s^2}\frac{\mathbf{c}}{c} \qquad (4)$$

If charge K moves at velocity $\mathbf{v}$, in an external field $\mathbf{E}_s$, due to charge Q, relative velocity between K and electrical force transmitted at velocity of light $\mathbf{c}$, is vector $(\mathbf{c} - \mathbf{v})$. Electric force experienced by K, is:

$$K\mathbf{E}_s = \frac{KQ}{4\pi\varepsilon_o cs^2}(\mathbf{c} - \mathbf{v}) \qquad (5)$$

For charge K moving with velocity $\mathbf{v}$, relative to an observer (charge Q), the dynamic electric field is:

$$\mathbf{E}_v = \frac{K}{4\pi\varepsilon_o cr^2}(\mathbf{c} + \mathbf{v}) \qquad (6)$$

Taking scalar product of both sides of equation (2), with element of displacement ($d\mathbf{r}$), at distance $\mathbf{r}$ from charge K, in the direction of the force $\mathbf{F}$, gives line integral:

$$W = \int_L \mathbf{F}.(d\mathbf{r}) = \int_L \frac{KQ}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}}.(d\mathbf{r}) = \int_r^\infty \frac{KQ}{4\pi\varepsilon_o r^2}(dr) = \frac{KQ}{4\pi\varepsilon_o r} = \varphi Q$$

W is the work done in bringing the charge Q from infinity to a point distance r from K. Potential energy φQ may be positive or negative. Work done on a unit charge, is the potential φ, as:

$$\varphi = \frac{K}{4\pi\varepsilon_o r} \qquad (7)$$

This potential j, at a point distance r from K, depends only on the beginning and end of path taken.

$$\frac{\partial\varphi}{\partial r}\hat{\mathbf{u}} = -\frac{K}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} = -\mathbf{E}_r$$

$$\mathbf{E}_r = -\frac{\partial\varphi}{\partial r}\hat{\mathbf{u}} = -\nabla\varphi \qquad (8)$$

The symbol ∇, standing for *gradient* or *grad* of a scalar quantity φ, is a useful notation, which operates on a saclar quantity φ to produce a vector quantity $\nabla\varphi$.

Taking scalar product of both sides of equation (3), with element of surface area (d**S**), in the direction of electric field $\mathbf{E}_r$, gives surface integral:

$$\int_S \mathbf{E}_r.(d\mathbf{S}) = \int_S \frac{K}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}}.(d\mathbf{S})$$

For a point charge at the centre of a spherical surface, an enclosing area at constant radius r, is $4\pi r^2$, in the direction of radial vector $\hat{\mathbf{u}}$. This gives:

$$\int_S \mathbf{E}_r.(d\mathbf{S}) = \frac{K}{\varepsilon_o} \qquad (9)$$

The divergence theorem, converting surface integral to volume integral, gives equation (9), as;

$$\int_S \mathbf{E}_r.(d\mathbf{S}) = \int_V \nabla.\mathbf{E}_r(dV) = \frac{K}{\varepsilon_o} \qquad (10)$$

The symbol $\nabla.$, standing for *divergence* or *div* of vector quantity **E**, operates on a vector quantity to produce a scalar. Where K is a uniform distribution of charges, with density r, equation (10) becomes:

$$\int_S \mathbf{E}_r.(d\mathbf{S}) = \int_V \nabla.\mathbf{E}_r(dV) = \frac{Q}{\varepsilon_o} = \frac{1}{\varepsilon_o}\int_V \rho(dV) \qquad (11)$$

$$\nabla.\mathbf{E}_r = \frac{\rho}{\varepsilon_o} \qquad (12)$$

Equation (11) is Gauss's law in the integral form and equation (12) in the differential form.

Electric Current and Magnetic Field
Equation (10), gives electric current *I*, due to motion of charge *K*, at time *t*, as:

$$I = \frac{\partial K}{\partial t} = \varepsilon_o \int_S \frac{\partial}{\partial t}\mathbf{E}_r.(d\mathbf{S}) = \int_S \mathbf{J}.(d\mathbf{S})$$

$$\mathbf{J} = \varepsilon_o \frac{\partial \mathbf{E}_r}{\partial t} \qquad (13)$$

The current intensity **J** may be from conduction current, due to flow of electric charges in a conductor, or Maxwell's displacement current from induction electric field due to change of magnetic field.

Taking vector (cross) product on both sides of equation (6), with velocity, as vector **v**, in a straight line, with dynamic electric field $\mathbf{E}_v$ of moving charge *K*, gives magnetic field **H**, due to motion, as:

$$\mathbf{H} = \varepsilon_o \mathbf{v}\times\mathbf{E}_v = \varepsilon_o \mathbf{v}\times\frac{E_r}{c}(\mathbf{c}+\mathbf{v}) = \varepsilon_o \mathbf{v}\times\mathbf{E}_r = -\varepsilon_o \mathbf{v}\times\nabla\varphi = \varepsilon_o \nabla\times\varphi\mathbf{v} \qquad (14)$$

Equation (14) defines magnetic field **H**. Magnetic flux intensity, $\mathbf{B} = \mu_o\mathbf{H}$, is:

$$\mathbf{B} = \mu_o\mathbf{H} = \mu_o\varepsilon_o\nabla\times\varphi\mathbf{v} = \nabla\times\mathbf{A} \qquad (15)$$

where **A** is the magnetic vector potential and ∇x**v** = 0, as **v** is a vector in a straight line. The symbol ∇xv=0, standing for *curl* of vector quantity **A**, operates on a vector quantity to produce another vector.

A particle of charge *K*, with electric field $\mathbf{E}_r$, moving at velocity **v**, generates a magnetic field **H**, in a surface area **S**, such that:

$$\int_S \mathbf{H}\times(d\mathbf{S}) = \varepsilon_o\int_S(\mathbf{v}\times\mathbf{E}_r)\times(d\mathbf{S}) = \varepsilon_o\int_S\{\mathbf{v}.(d\mathbf{S})\}\mathbf{E}_r - \varepsilon_o\int_S\{\mathbf{E}_r.(d\mathbf{S})\}\mathbf{v}$$

$$\int_S \mathbf{H}\times(d\mathbf{S}) = -\varepsilon_o\int_S\{\mathbf{E}_r.(d\mathbf{S})\}\mathbf{v} = -K\mathbf{v} \qquad (16)$$

$$\int_S\{\mathbf{v}.(d\mathbf{S})\}\mathbf{E}_r = 0$$

where ∇.**v** = 0, as **v** is a vector in a straight line, not diverging

For a conducting wire of length **L**, carrying a current *I*, current element is a vector *I*(d**L**) = (*dK*/*dt*)(*d***L**) = (*dK*)**v**, which makes:

$$K\mathbf{v} = \int_L I(d\mathbf{L}) \qquad (17)$$

For a current *I*, equation (16) becomes:

$$\int_S \mathbf{H}\times(d\mathbf{S}) = -K\mathbf{v} = -\int_L I(d\mathbf{L}) \qquad (18)$$

For a current of intensity **J**, in (d**L**) direction, *curl theorem*, converts equation (18) to:

$$\int_S \mathbf{H}\times(d\mathbf{S}) = -\int_V \mathbf{J}.(d\mathbf{A})(d\mathbf{L}) = -\int_V \mathbf{J}(dV)$$

$$\int_S \mathbf{H}\times(d\mathbf{S}) = -\int_S \nabla\times\mathbf{H}(dV) = -\int_V \mathbf{J}.(d\mathbf{A})(d\mathbf{L}) = -\int_V \mathbf{J}(dV)$$

$$\nabla\times\mathbf{H} = \mathbf{J} \qquad (19)$$

Equation (19) is Ampere's law in the differential form. The current intensity **J** may be conduction current due to flow of electric charges in a conductor, in accordance with Ohm's law, or induction current due to a changing magnetic field, in accordance with Faraday's law.

For a moving electric charge, equations (5) and (17), give:

$$\mathbf{H} = \frac{K}{4\pi cr^2}\mathbf{v}\times(\mathbf{c}+\mathbf{v}) = \frac{K}{4\pi cr^2}\mathbf{v}\times\mathbf{c} = \frac{K\mathbf{v}}{4\pi r^2}\times\hat{\mathbf{u}} = \frac{\int_L I(d\mathbf{L})}{4\pi r^2}\times\hat{\mathbf{u}}$$

$$(d\mathbf{H}) = \frac{I(d\mathbf{L})}{4\pi r^2}\times\hat{\mathbf{u}} = \hat{\mathbf{e}}\frac{I(dL)}{4\pi r^2}\sin\theta \qquad (20)$$

where *I*(d**L**) is an electric current I in an infinitesimal length of conductor (d**L**) and ê is a unit vector perpendicular to the current's direction. Equation (20) is Biot-Savart law. An important law in electromagnetism, which occupies the same position as Coulomb's law in electrostatics.

Induction Electric Field
Figure 2 shows a paticle of charge *K*, and its radial electric field *E*, moving at time t, with velocity v as vector directed out of the page. The moving charge generates magnetic flux intensity **B** = *mo***H**, at a distance **r**, around the charge, as given by equation (15).

$$\mathbf{B} = \mu_o\mathbf{H} = \mu_o\varepsilon_o\nabla\times\varphi\mathbf{v} = \nabla\times\mathbf{A}$$

This magnetic field moves, in a plane perpendicular **v**, away from the charge, as a wave, with radial velocity *d***r**/*dt*, at time *t*, in the radial **û**-direction, creating induction electric field **E**a, thus:

$$\mathbf{E}_a = \hat{\mathbf{u}}\frac{\partial r}{\partial t}\times\mathbf{B} = \frac{\partial \mathbf{r}}{\partial t}\times\mathbf{B}$$

$$\nabla\times\mathbf{E}_a = \hat{\mathbf{u}}\times\frac{\partial \mathbf{E}_a}{\partial r} = \hat{\mathbf{u}}\times\frac{\partial}{\partial r}\left(\frac{\partial \mathbf{r}}{\partial t}\times\mathbf{B}\right) = -\frac{\partial}{\partial r}\frac{\partial r}{\partial t}\mathbf{B} = -\frac{\partial \mathbf{B}}{\partial t} \qquad (21)$$

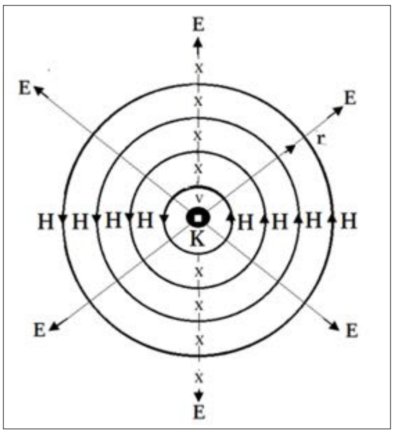

Figure 2: Particle of charge *K* and electric field E, moving with velocity **v**, and acceleration *d***v**/*dt* directed out of the page, and generating magnetic field H round the charge and reactive field **E**a into the page

Equation (21) is Farady's law of electromagnetic induction.
The induction electric field **E**a also acts on the charge *K* of mass *m* to produce inertial force *K***E**a, equal and opposite to the accellertaing force, in accordance with Newton's second law of motion, thus:

$$K\mathbf{E}_a = -m(d\mathbf{v}/dt) \qquad (22)$$

Figure 3 shows an electric current *I*, in the ***Z***-direction of cylindrical coordinates, changing with time *t*, generating magnetic field **H** and induction electric field **E**a.

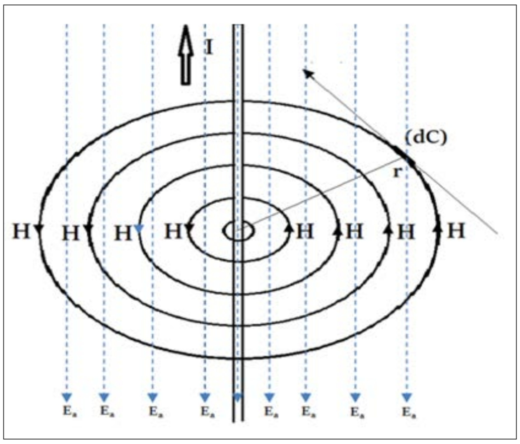

Figure 3: Oscillating electric current *I*, generating magnetic field **H** round the current and induction electric field **E**a in opposite direction of increasing current flow

In Figure 3, an electric curret *I*, develops a magnetic field **H**, in a cylindrical surface **S** enclosing a volume *V* containing the conductor. The relationship between suface area **S** and current I in a length **Z** of conductor, perpendicular to the magnetic field, are in the following integrals:

$$\int_S \mathbf{H}\times(d\mathbf{S}) = -\int_L I(d\mathbf{Z}) = -\int_V \mathbf{J}(dV) \qquad (23)$$

Element of surface area (d**S**) = (dC)′(d**Z**), with (d**C**) along the magnetic field **H**, gives:

$$\int_S \mathbf{H}\times(d\mathbf{S}) = \int_S \mathbf{H}\times\{(d\mathbf{C})\times(d\mathbf{Z})\} = -\int_S \mathbf{H}.(d\mathbf{C})(d\mathbf{Z}) = -\int_L I(d\mathbf{Z})$$

$$\oint_L \mathbf{H}.(d\mathbf{C}) = I \qquad (24)$$

The integral in equation (24) is to be taken round the current-carrying conductor. Equation (24) is the popular expression of Ampere's law. It is a very impotant law applicable under all conditions.

If the current *I*, in Figure 3 changes in time *t*, the magnetic field **H** changes similarly and an induction electric field $\mathbf{E}_a$ is generated, in accordance with the following surface and volume integrals.

$$\int_L \{\mathbf{E}_a.(d\mathbf{Z})\} = \frac{\partial}{\partial t}\int_V \mathbf{B}(dV) = \frac{\partial}{\partial t}\int_S \mathbf{B}.(d\mathbf{X}) \qquad (25)$$

$$\nabla\times\mathbf{E}_a = -\frac{\partial\mathbf{B}}{\partial t} \qquad (26)$$

Equation (26), like equation (21), is Faraday's law of electromagnetic induction in the differential form.
With $\mathbf{E}_a$ perpendicular to (d**C**), equation (25) may be written as:

$$\int_S \mathbf{E}_a\times(d\mathbf{S}) = \int_S \{\mathbf{E}_a.(d\mathbf{Z})\}(d\mathbf{C}) = \frac{\partial}{\partial t}\int_V \mathbf{B}(dV) = \frac{\partial}{\partial t}\int_V \mathbf{B}\{(d\mathbf{X}).(d\mathbf{C})\}$$

$$= \frac{\partial}{\partial t}\int_V \mathbf{B}.(d\mathbf{X})(d\mathbf{C})$$

$$\int_L \{\mathbf{E}_a.(d\mathbf{Z})\} = \frac{\partial}{\partial t}\int_V \mathbf{B}(dV) = \frac{\partial}{\partial t}\int_S \mathbf{B}.(d\mathbf{X}) \qquad (27)$$

where (d**C**) is n infinitesimal length along the magnetic field **H** and (*d***X**) an element of surface area in the direction of the magnetic flux intensity **B**. Equation (27), giving the voltage generated equal to rate of change of magnetic flux, is the famous and most useful Faraday's law of electromagnetic induction.

Aberration of Electric field and Emission of Radiation

Aberration of electric field is like aberration of light, discovered by English astronomer, James Bradley, in 1728. Since an electrical force is transmitted at the velocity of light **c**, a charged particle, moving in an electric field, is subject to aberration of electric field. Figure 4 depicts aberration of electric field for a particle of charge *K* at a point P moving, in time *t*, with velocity v at instantaneous angle *q* to OP, in the electric field of intensity **E** = *E***û**, due to source charge *Q* at O.

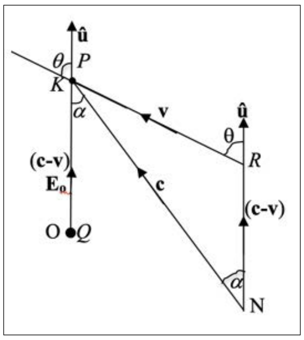

Figure 4: Aberration of electric field for a particle of charge *K* at P moving with velocity **v** at Angle *θ* to accelerating force **F** due to charge *Q* at O

In Figure 4, angle between relative velocity (**c** – **v**) and velocity **c** at which an electrical force is transmitted, is the aberration angle *a*. Triangle NPR, in Figure 4, gives the sine rule:

$$\sin\alpha = \frac{v}{c}\sin\theta \qquad (28)$$

Equation (28) is Bradley's equation, a universal formular applicable at atomic and astronomical levels. It clearly demonstrated the relativity of speed of light, with respect to a moving observer.

In Fig. 4, accelerating force **F** on charge *K* of constant mass *m* = rest mass m_o, at time *t*, with velocity **v** and acceleration *d***v**/*dt*, in accordance with Newton's second law of motion, should be:

$$\mathbf{F} = \frac{KE}{c}(\mathbf{c}-\mathbf{v}) = \frac{KE}{c}\sqrt{c^2+v^2-2vc\cos(\theta-\alpha)}\,\hat{\mathbf{u}} = m_o\frac{d\mathbf{v}}{dt} \qquad (29)$$

where (*θ* – *α*) is the angle between the vectors **c** and **v**. The particle of charge *K* may move with deceleration at *θ* = 0 or with acceleration at *q* = π radians. An interesting case is where K is a negative and the particle moves in a circle round O with *q* =

p/2 radians. The velocity of light **c**, being a limit, is implicit in equation (29), not because mass of a moving particle increases with its speed but as a result of accelerating force cecreasing with speed, reducing to zero at the speed of light *c*.

Equation (29) shows that accelerating force on a moving charged particle, is less than the force *K***E** on a stationary one, due to some kind of "frictional force". The difference is radiation reaction force **R** and radiation power R_p = -**v**.**R**, obtained in terms of angles *q* and a in Figure 4, thus:

$$\mathbf{R} = \frac{KE}{c}(\mathbf{c}-\mathbf{v}) - K\mathbf{E} \qquad (30)$$

$$R_p = -\mathbf{v}.\left\{\frac{KE}{c}(\mathbf{c}-\mathbf{v}) - K\mathbf{E}\right\} = KEv\left\{\cos\theta - \cos(\theta-\alpha) + (v/c)\right\} \qquad (31)$$

Radiation power R_p is Kev^2/c in rectilinear motion ($\theta = 0$ or $\theta = \pi$ *radians*) and *0* in circular motion with ($\theta = \pi/2$) radians.

Electric Field Lines of Force

A charged particle remains stationary with its straight radial field lines of force, in accordance with Coulomb's law (equation 2), pulling the surface charge outwards, as shown in Figure 5.

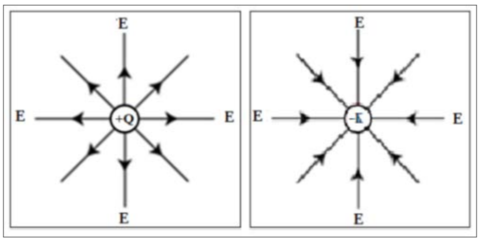

Figure 5: Straight lines of electrostatic fields of two stationary isolated charges +Q and -K.

The radial field lines of force are pulling the surface charge outwards to maintain a stable structure

In Figure 5, it is as if the lines of force are equally pulling the surface of each charge (positive or negative) outwards, acting from the centre. In effect, the fields of an electric charge exert a pulling force on the same charge producing the field. With no resultant force on the charge, it stays in equilibrium, under tension, but remains stationary or moves with constant velocity v, taking its straight electrostatic field lines along with it.

Electric Field of a Moving Charged Particle

Considering aberration of electric field, the dynamic electric field **E**v of a charged particle moving with velocity **v**, at angle θ to its electrostatic field **E**o, with respect to an observer, is illustrated in Figure 6:

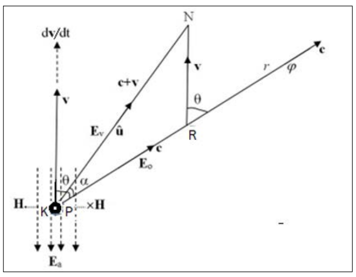

Figure 6: A particle of charge *K* at P moving with velocity **v** at angle θ to electrostatic field **E**o, giving dynamic field **E**v, in **û**-direction, displaced by aberration angle a from **E**o

In Figure 6, a particle of charge *K*, at a point P, moving, at time *t*, with velocity **v**, with respect to an observer, has electrostatic field **E**o, potential φ at distance *r* and sets up a magnetic field **H** round the charge. The electrostatic field **E**o, appears displaced from OR to ON, by aberration angle a, such that:

$$\sin\alpha = \frac{v}{c}\sin(\theta-\alpha) \qquad (32)$$

The electrostatic field **E**o of magnitude *Eo*, becomes a dynamic electric field *Ev*, in the (**c** +**v**), **û**-direction, along ON, as expressed in equations (33) and (34), below:

In Figure 5, an electrostatic field **E**o of magnitude *Eo*, at angle *q* to velocity **v**, is shifted by aberration angle *a*, to become a dynamic electric field **E**v, in the (**c** +**v**), along ON, of direction **û**, as expressed in equations (33) and (34), below:

$$\mathbf{E}_v = \frac{K}{4\pi\varepsilon_o c r^2}(\mathbf{c}+\mathbf{v}) \qquad (33)$$

$$\mathbf{E}_v = \frac{E_o}{c}(\mathbf{c}+\mathbf{v}) = \frac{E_o}{c}\sqrt{c^2+v^2+2cv\cos(\theta)}\,\hat{\mathbf{u}} \qquad (34)$$

If the charge suffers acceleration *d***v**/*dt* at time *t*, a reactive field **E**a is brought about.

The polar representation, in terms of angle θ, of dynamic electric field **E**v of a particle of charge *K*, at a centre, moving with constant velocity **v**, relative to an observer, is shown in Figure 7 below:

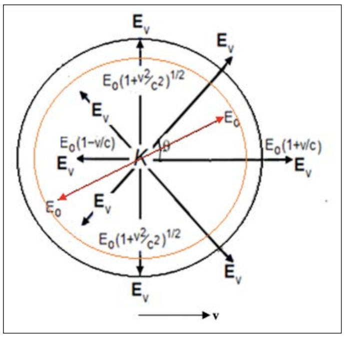

Figure 7: Change in radial fields of charge *K*, from electrostatic field **E**o to dynamic electric field **E**v of particle of charge *K* moving, at time *t*, with constant velocity **v** relative to an observer

The electric field is increased in the forward direction, doubling at the speed of light. The field is decreased backwards, reducing to zero at the speed of light. The fields are straight radial lines, but distorted, relative to an observer. Kinetic energy of the moving charge is contained in the dynamic electric field **E**v. Relative to the charge, however, the field remains undistorted, as in Figure 5.

Mass-energy Equivalence

The electrostatic energy or intrinsic energy E_n of an electric charge of magnitude *Q*, in the form of a spherical shell of radius *a*, is contained in the electrostatic field **E**o. En is given by well-known classical formula as volume integral:

$$E_n = \frac{\varepsilon_o}{2}\int_V E_o^2(dV) = \frac{\varepsilon_o}{2}\int_a^\infty\left(\frac{Q}{4\pi\varepsilon_o r^2}\right)^2\left(4\pi\varepsilon_o r^2\right)(dr) \qquad (35)$$

$$E_n = \frac{Q^2}{8\pi\varepsilon_o a} \qquad (36)$$

The integral in equation (35) is taken from infinity to distance a from centre of the charge. Inside the charge, electric field is zero and the potential is constant.
From equations (35), total energy ET of the dynamic field **E**v is given by the volume integral:

$$E_T = \frac{1}{2}\varepsilon_o \int_V E_v^2 (dV) = \frac{1}{2}\varepsilon_o \int_V E_o^2 \left(1 + \frac{v^2}{c^2} + \frac{2v}{c}\cos\theta\right)(dV)$$

$$E_T = \frac{1}{2}\varepsilon_o \int_V E_v^2 (dV) = \frac{1}{2}\varepsilon_o \int_V E_o^2 \left(1 + \frac{v^2}{c^2} + \frac{2v}{c}\cos\theta\right)(dV)$$

$$\frac{1}{2}\varepsilon_o \int_V E_o^2 \frac{2v}{c}\cos\theta (dV) = \frac{1}{2}\varepsilon_o \int_\pi^0 E_o^2 \frac{2v}{c}\cos\theta\left(2\pi r^2\right)\cos\theta\sin\theta(d\theta) = 0$$

$$E_T = \frac{1}{2}\varepsilon_o \int_V E_o^2 \left(1 + \frac{v^2}{c^2}\right)(dV) \qquad (37)$$

Equation (37) consists of intrinsic energy E_n (equation 35) of particle and the kinetic energy K, as:

$$K = \frac{1}{2}\varepsilon_o \int_V E_o^2 \frac{v^2}{c^2}(dV) = E_n \frac{v^2}{c^2} = \frac{1}{2}mv^2$$

Equation (36) and the kinetic energy K, give:

$$E_n = \frac{1}{2}\varepsilon_o \int_V E_o^2 (dV) = \frac{1}{2}mc^2 \qquad (38)$$

Equation (36) with a mass-energy equivalence law in equation (38), gives:

$$E_n = \frac{1}{2}mc^2 = \frac{m}{2\mu_o\varepsilon_o} = \frac{Q^2}{8\pi\varepsilon_o a} \qquad (39)$$

Equation (39) gives the mass m of an electric charge of magnitude Q, a hollow sphere of radius a, as:

$$m = \frac{\mu_o Q^2}{4\pi a} \qquad (40)$$

Equation (40) expressing mass m of a partice in terms of its charge Q and showing that m is proportional to charge Q^2 , independent of speed of a charged particle, is a landmark expression.

Physical Explanation of Cause of Electrostatic Force

Figure 8 below, depicts two stationary like-charges $+Q$ and $+K$, in positive potential energy, under force of repulsion. In Figure 9 the two unlike charges, $+Q$ and $-K$, are in negative potential energy, under attraction. The field lines in Figures 8 and 9 are no longer straight but curled to make for force of repulsion in Figure 8 and force of attraction in Figure 9. In Figure 8, with positive potential energy, the field lines of force subtract between the charges and add behind them, and it is as if the charges are being pulled away from one another with a pulling force of repulsion **F**.

In Figure 9, with negative potential energy, the field lines of force add between the charges and subtract behind them, and it is as if the charges are being pulled towards one another with a pulling force of attraction **F**.

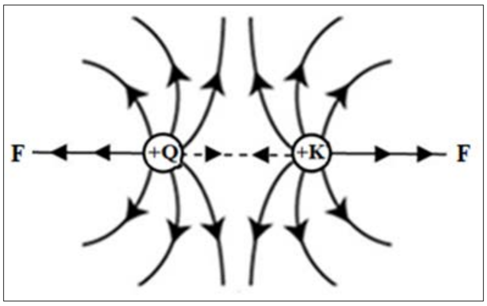

Figure 8: Field lines of force of stationary like charges $+Q$ and $+K$, with positive potential energy, under pulling force of repulsion $F = K$**E**

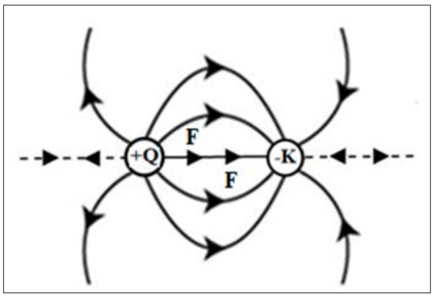

Figure 9: Field lines of force of stationary unlike charges $+Q$ and $-K$, in negative potential energy, under pulling force of attraction **F** = -K**E**.

Electrostatic and Gravitational Forces Between Two Charges

Figure 10 shows two electric charges Q and K as spherical shells of radii a and b and masses m_1 and m_2 respectively, separated by a distance r in space. The small force **f** between the charges, is a combination of electrostatic forces of repulsion or attraction given by Coulomb's law and gravitational force of attraction given by Newton's law, thus:

$$\mathbf{f} = \pm\frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - G\frac{m_1 m_2}{r^2}\hat{\mathbf{u}} \qquad (41)$$

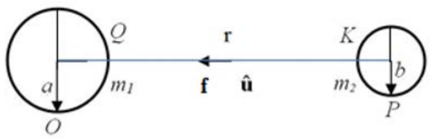

Figure 10: Force **f** between electric charges Q of mass m_1 at O and K of mass m_2 at P, as impregnable spherical shells separated by distance r

where $\hat{\mathbf{u}}$ is a unit vector in the direction of force of repulsion and G is the gravitational constant. In equation (41) the force of repulsion is positive between like charges or attractive (negative) between unlike charges. The force of gravity is always (negative) attractive. Substituting for the masses m_1 and m_2 from equation (40), where m_1 is proportional to Q^2 and m_2 is proportional to K^2 , into equation (41), gives the force of repulsion as:

$$\mathbf{f} = \frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - G\frac{m_1 m_2}{r^2}\hat{\mathbf{u}} = \frac{QK}{4\pi\varepsilon_o r^2}\hat{\mathbf{u}} - \chi\frac{Q^2 K^2}{r^2}\hat{\mathbf{u}} \qquad (42)$$

An interpretation of equations (42) is that the force of repulsion, between like charges, is reduced by $\chi Q^2K^2/r^2$ and the force of attraction, between unlike charges, is increased by the same amount. Net increase in force of attraction, gravitational force of attraction, between two charges *Q* and *K*, is:

$$\mathbf{f}_G = -\chi \frac{Q^2K^2}{r^2}\hat{\mathbf{u}} \qquad (43)$$

where *c* is a constant. For a charge *Q* of radius *a* and surface charge intensity σ as a constant, the mass m in equation (40) is obtained, in terms of volume V of the charge in the electric fields of the aether,

$$m = 3\mu_o V\sigma^2 \qquad (44)$$

This impenetrable spherical volume is a distortion of of the aether, akin to Einstein's general relativity's curving of space-time continuum, causing a gravitational field of attraction. Substituting for m_1 and m_2, in terms of the respective volumes V_1 and V_2, gives Newton's universal law of gravity, as:

$$\mathbf{f}_G = -G\frac{m_1m_2}{r^2}\hat{\mathbf{u}} = -\chi\frac{Q^2K^2}{r^2}\hat{\mathbf{u}} = -\xi\frac{V_1V_2}{r^2}\hat{\mathbf{u}} \qquad (45)$$

where *x* is a constant. Impenetrable volumes, occupying spaces in the electric fields of the aether, one in the shadow of another, naturally attract each other with a pushing force inversely proportional to the square of distance separating them.

Force of Gravity Between Two Neutral Bodies

A neutral body consists of equal numbers or equal amounts of positive and negative electric charges. A neutral body does not have a resultant electric field to exert any force of repulsion or attraction on other bodies or other charges, but the gravitational forces of attraction, proportional to the sum of square of the charges, remain and add up. The gravitational force of attraction **F**G between one body of mass M_1 consisting of $N_1/2$ positive charges and $N_1/2$ negative charges, each of magnitude *Q*, occupying volume V_1, and another body of mass M_2 containing $N_2/2$ positive charges and $N_2/2$ negative charges, each of magnitude *K*, occupying volume V_2, is obtained from equations (43) and (45), as the sums:

$$\mathbf{F}_G = -G\frac{M_1M_2}{Z^2}\hat{\mathbf{u}} = \sum \mathbf{f}_G = -\frac{\chi}{Z^2}\sum_{n=1}^{N_1}Q_n^2\sum_{n=1}^{N_2}K_n^2\hat{\mathbf{u}} = -\frac{\chi}{Z^2}N_1N_2Q^2K^2\hat{\mathbf{u}} \qquad (46)$$

$$\mathbf{F}_G = -G\frac{M_1M_2}{Z^2}\hat{\mathbf{u}} = \sum \mathbf{f}_G = -\frac{\chi}{Z^2}\sum_{n=1}^{N_1}Q_n^2\sum_{n=1}^{N_2}K_n^2\hat{\mathbf{u}} = -\frac{\xi}{Z^2}N_1N_2V_1V_2\hat{\mathbf{u}} \qquad (47)$$

where *Z* is the distance between the centers of mass of the masses. Both numbers N_1 and N_2, may, of course, be infinitely large. It should be noted that the gravitational force of attraction **F**G, between two neutral bodies, is independent of relative velocity between the bodies. The gravitational force of attraction depends only on the separation of the bodies, in accordance with Newton's universal law.

Physical Cause of Inertia

It was pointed out that the radial electric fields, of an electric charge, exert a pulling force on the same charge. In Figure 11 the charge moves with acceleration *d***v**/*dt*. As a result of finite speed of light, if a charge *K* suffers acceleration, the sudden change of velocity is not instantaneously and simultaneously communicated to all the fields. Consequently, the lateral field lines of force become curled backwards. The field lines of force appear to be increased in the backward direction and reduced in the forward direction, to make for a reactive field **E**a, and inertial force *K***E**a, opposed to motion.

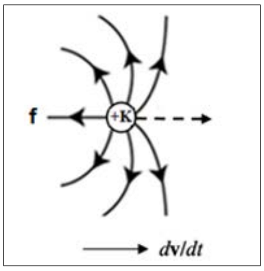

Figure 11: Electric field lines of force of a particle of charge *K* and mass *m* moving with acceleration (*d***v**/*dt*) and inertial force **f** = -*m*(*d***v**/*dt*)

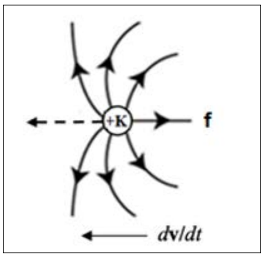

Figure 12: Electric field lines of force of a particle of charge *K* and mass *m* moving with deceleration -(*d***v**/*dt*) and inertial force **f** = -*m*(*d***v**/*dt*)

The reactive electric field **E**a, in Figures 11 and 12, acts on the same charge *K*, of mass *m*, producing the field, to give the inertial force **f**, such that:

$$\mathbf{f} = K\mathbf{E}_a = -m\frac{dv}{dt} \qquad (48)$$

The curled electric field lines of force, in Figures 11 and 12 and equation (48), give a physical explanation for the cause of inertia on an accelerated charged particle.

Each of the reactive electric fields (**E**a) acts only on and at the location of the charge producing it. The (**E**a)s are not externally manifested, as being equally positive and negative in a neutral body, they cancel out exactly outside. For a body of mass M composed of *N/2* positive charges and *N/2* negative charges, under acceleration *d***v**/*dt*, the inertial forces on the respective charges add up to give total **I**, as:

$$\mathbf{I} = N\mathbf{f} = NQ\mathbf{E}_a = -Nm\frac{d\mathbf{v}}{dt} = -M\frac{d\mathbf{v}}{dt} \qquad (49)$$

Equation (49) explains inertia **I** of a body, the tendency of the body to resist acceleration, according to Newton's first law of motion, as a self-induced force residing in the body.

The reactive field **E**a in equation (48), due to an accelerated charged particle, is the result of change in its magnetic field **H**, as given by equation (21). This reactive field **E**a is the same as the induction electric field given by Faraday's law (equation 26):

$$\nabla \times \mathbf{E}_a = -\mu_o\frac{\partial \mathbf{H}}{\partial t} \qquad (50)$$

This Reactive or induction electric field **E**a also plays a vital role in the generation of radio radiation with Poynting vector **E**ax**H**.

Results and discussion

- The lumineferous aether is proposed to be an electric field medium filling the universal space, in accordance with Coulom's law, and supporting propagation of electromagnetic radiation at the speed of light.
- Aberration of electric field is invoked to describe motion and radiation for a charged particle moving in an external electric (Figures 4) and show change in radial electric field of a charged moving with constant velocity relative to an observer (Figures 6 and 7).
- Equation (29) is the flagship expression of this paper, with a velocity term and Newton's second law of motion, to give the speed of light as the ultimate to which a charged particle may be accelerated by an electric field, with emission of radiation and mass of a moving particle remaining constant at the rest mass.
- Equation (33), illustrated in Figures 6 and 7, shows that the dynamic electric field Ev, with respect to an observer, for a moving charged particle, is larger than the electrostatic field Eo, for a stationary particle. Kinetic energy of the moving particle is contained in the energy of Ev.
- An electron or positron, each with charge of magnitude e, is supposed to be an impregnable hollow sphere, the basic constituent of matter with radius a as the smallest length in nature, the surface charge or electric field as the largest and intrinsic charge e as the smallest unit.
- It is proposed that electric fields of a charged particle exert a pulling radial force on the charge and that curling of the radial field lines of force gives rise to positive potential energy for force of repulsion (Figure 8) and negative potential energy for force of attraction (Figure 9) between adjacent charges.
- Gravitation is proposed to be the result of charged particles occupying volumes in the electric fields of the aether, one in the shadow of the others, to give a pushing force of attraction in accordance with Newton's law, as in equations (45) and (47).
- Curling of electric field lines of force, as discussed here, is reminiscent of curving, bending or warping of four-dimentioal space-time continuum in the general theory of relativity.
- Motion of a body in a gravitational field is without radiation, such that change in kinetic energy is equal to the change in potential energy.
- In view of aberration of electric field, motion of a charged particle in an electric field is with radiation, as the difference between change in kinetic energy and change in potential energy.
- Inertia is electrical in nature and a property residing in a body, resulting from curling of radial electric field lines of force of a charged particle (Figures 11 and 12), creating a reaction, if it suffers acceleration, a sudden change of velocity.
- Equations (38) and (40), for energy, mass and charge of a particle, are landmark expressions. If charge is independent of speed of charged particle, so should mass also be independent of speed.
- Identifying reactive electric field due to acceleration of a charged particle (Figure 2) with Faraday's induction electric field due to change in magnetic field (Figure 3), giving rise to electromagnetic radiation (equation 50), is a new insight in electrodynamics and radiation.
- The speed of light c, being a constant everywhere in the Universe, is realised by considering permeability mo and premittivity eo, as properties of the innumerable electric fields of the aether, emanating from charges and occupying a vacuum, permeating the universal space, in accordance with Coulomb's law, and allowing propagation of electromagnetic radiation at speed = 299 792 458 meters per second.

Conclusion

A charged particle, such as an electron, is supposed to be the smallest impregnable hollow sphere with straight lines of radial electric field pulling the surface charge equally outwards, to maintain a stable structure, such that electrostatic force of repulsion or attraction and inertial force due to acceleration, are the results of curling of the radial field lines of force, while gravity is a weak force by virtue of particles occupying volumes, in an electric field medium (aether), one in the shadow of another, naturally attracting each other with a pushing force.

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