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EMPIRICALLY CORRECT ELECTRODYNAMICS

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The electrodynamics that predicts all known relevant observations is based upon the force $\mathbf{F} = (qq'\mathrm{R}/\mathrm{R}^3)[1 - 2\mathbf{v}\cdot\mathbf{v}'/c^2 + 3(\mathbf{v}\cdot\mathrm{R})(\mathbf{v}'\cdot\mathrm{R})/c^2\mathrm{R}^2 + (\mathbf{a} - \mathbf{a}')\cdot\mathrm{R}/c^2]$ on charge q at $\mathbf{r}$ with the absolute velocity $\mathbf{v}$ and acceleration $\mathbf{a}$ due to charge q' at $\mathbf{r}'$ with absolute velocity $\mathbf{v}'$ and acceleration $\mathbf{a}'$, where $\mathrm{R} = \mathbf{r} - \mathbf{r}'$. This force yields Ampere's original empirical law for the force between current elements, which predicts the many effects due to Ampere tension between colinear current elements. It yields Faraday induction as well as Müller's localized unipolar induction. The force on an accelerating charge due to a stationary charge yields Lenz's law for the induced back emf; and, when applied to gravitation, qq' being replaced by − Gmm', it yields the inertial force ma, confirming Mach's priniciple. For charge velocities approaching the velocity of light c it predicts the results of the Kaufmann-Bucherer experiments and the Bertozzi experiment, assuming neomechanics, or mass change with velocity. It is readily written as a field theory. Introducing time retardation, it yields waves and radiation. It predicts the observed zero self-torque on the Pappas-Vaughan Z-shaped antenna. Energy is conserved. The Weber electrodynamic theory is shown to fail.

Key words: electrodynamics, forces, empirical tests, fields, Weber.

1. INTRODUCTION

The force

$$c^2\mathbf{F} = (qq'\mathbf{R}/R^3)\left[c^2 - 2\mathbf{v}\cdot\mathbf{v}' + 3(\mathbf{v}\cdot\mathbf{R})(\mathbf{v}'\cdot\mathbf{R})/R^2 + (\mathbf{a} - \mathbf{a}')\cdot\mathbf{R}\right] \quad (1)$$

on charge q at $\mathbf{r}$ with absolute velocity $\mathbf{v}$ and acceleration $\mathbf{a}$ due to charge q' at $\mathbf{r}'$ with absolute velocity $\mathbf{v}'$ and acceleration $\mathbf{a}'$, where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$, was originally proposed by Wesley [1–4] as an approximation of the Weber [5,6] force

$$c^2\mathbf{F}_W = (qq'\mathbf{R}/R^3)\left[c^2 + V^2 - 3(\mathbf{V}\cdot\mathbf{R}/R)^2/2 + \mathbf{A}\cdot\mathbf{R}\right], \quad (2)$$

where $\mathbf{V} = \mathbf{v} - \mathbf{v}'$ and $\mathbf{A} = \mathbf{a} - \mathbf{a}'$ are the relative velocity and acceleration. The velocity squared terms, involving v^2, $(\mathbf{v}\cdot\mathbf{R}/R)^2$, v'^2, and $(\mathbf{v}'\cdot\mathbf{R}/R)^2$ were omitted as yielding negligible forces that have never been observed. Without these velocity squared terms the resulting force, Eq.(1), could be written as an electrodynamic field theory.

However, the Weber force fails for charge velocities approaching the velocity of light, as discussed in the following Section; while the proposed force, Eq.(1), does not fail for charge velocities approaching c. It is now seen that the proposed force, Eq.(1), is the empirically correct force; while the Weber force, Eq.(2), is merely an approximation of Eq.(1) valid for small velocities.

The electrodynamics based upon the proposed force satisfies all the known relevant empirical evidence. The extensive evidence has been collected together and presented elsewhere [1–4]. To conserve space it must be assumed that the reader is already familiar with this evidence. It has been shown [1–4] that the Maxwell theory, having only a limited range of validity, fails empirically in general; so it is not considered here. Although the failure of other proposed electrodynamic theories to fit all of the empirical evidence can be readily demonstrated; a review of these theories is primarily of historical interest and cannot be undertaken here.

2. FAILURE OF THE WEBER THEORY

Weber proceeded from Ampere's [7] original empirical law for the force on current element ids due to current element ids'

$$c^2d^2\mathbf{F}_A = (ii'\mathbf{R}/R^3)\left[-2d\mathbf{s}\cdot d\mathbf{s}' + 3(d\mathbf{s}\cdot\mathbf{R})(d\mathbf{s}'\cdot\mathbf{R})/R^2\right]. \quad (3)$$

By assuming steady currents are formed by charges flowing with a constant velocity he could make the replacements $i\mathbf{ds} = q\mathbf{v}$ and $i'\mathbf{ds}' = q'\mathbf{v}'$. In order to make the force dependent upon the relative velocity he introduced the velocity squared terms v^2, $(\mathbf{v}\cdot\mathbf{R}/R)^2$, v'^2, and $(\mathbf{v}'\cdot\mathbf{R}/R)^2$. These velocity squared terms drop out when considering the force betwen two current carrying conductors, where four forces between stationary ions and moving electrons are involved; so Ampere's law is recovered exactly using Eq.(2) for steady currents.

Including the Coulomb force, Weber postulated the force between steadily moving charges as

$$c^2\mathbf{F}_W = (qq'\mathbf{R}/R^3)\left[c^2 + V^2 - 3(\mathbf{V}\cdot\mathbf{R}/R)^2/2\right]. \quad (4)$$

Unfortunately, Weber had no empirical justification for introducing both the velocity squared terms as well as the Coulomb force; because his force, Eq.(4), predicted a force on a stationary charge q due to a charge q' moving with the constant velocity $\mathbf{v}'$ given by

$$c^2\mathbf{F}_W = (qq'\mathbf{R}/R^3)\left[v'^2 - 3(\mathbf{v}'\cdot\mathbf{R}/R)^2/2\right]; \quad (5)$$

and this force had never been observed. Attempts to observe this very minute force for small charge velocities have failed (eg., Edwards et al [8] and Curê [9]).

When the charge velocity approaches c, the velocity squared terms in Eqs.(2), (4), and (5) are no longer negligible. For the Kaufmann [10] - Bucherer [11] experiments, involving fast electrons, Bush [12] and others [13, 14] have shown that the Weber theory predicts the observed results if neomechanics, or mass change with velocity, is neglected. But the Weber theory fails if neomechanics is assumed. The Bertozzi [15] experiment involves the determination of the time of flight velocity of electrons after being accelerated through a known potential. Velocities approaching c were observed. The Weber theory fails drastically when neomechanics is neglected and fails slightly when mass change with velocity is assumed [16]. Thus for charge velocities approaching c the Weber theory cannot predict simultaneously both the Kaufmann-Bucherer experiments and the Bertozzi experiment when assuming or not assuming neomechanics, or mass change with velocity. *The Weber theory fails!*

The failure of the Weber theory for large charge velocities may also be noted from the force, Eq.(4), for charges receding or approaching each other at constant high velocities. The force goes to zero for $V = \sqrt{2}c$, and a change in sign occurs for greater relative velocities. This nonphysical behavior was originally noted by Helmholtz [17]. Since it is now known that charges can approach the velocity of light c; the limit relative velocity should be 2c (such as can be actually found in a super collider) and not $\sqrt{2}c$. It may be noted that the force proposed here, Eq.(1), goes to zero for charges with constant absolute velocities c receding or approaching each other; so the limit relative velocity is $V = 2c$, as is required physically.

3. THE WEBER POTENTIAL AND PROPOSED VARIATIONS

Weber noted that his proposed force, Eq.(4) could be derived from a potential

$$U = (qq'/R)\left[1 - (\mathbf{V}\cdot\mathbf{R}/cR)^2/2\right], \tag{6}$$

where $dU/dt = -\mathbf{V}\cdot\mathbf{F}_W$, if a relative acceleration term were included, the last term in the square brackets on the right of Eq.(2). Thus, Weber was finally led to propose his potential, Eq.(6), and the consequent force, Eq.(2). The acceleration term is empirically correct. The predicted force on a stationary charge q due to an accelerating charge q', $(qq'\mathbf{R}/R^3)(-\mathbf{a}'\cdot\mathbf{R}/c^2)$, accounts for Faraday induction.

Because the Weber force, Eq.(2), is derived from such a simple potential, Eq.(6), and the Weber force is so extremely successful in predicting effects produced by slowly moving charges; the Weber potential has been regarded with exaggerated respect. It is often regarded as representing the fundamental physical basis of Weber electrodynamics. It is sometimes even assumed that the Weber potential is necessary to conserve energy.

Variations of the Weber potential have been proposed from time to time. Phipps [18] proposed the potential

$$U_P = (qq'/R)\sqrt{1 - (\mathbf{V}\cdot\mathbf{R}/cR)^2}, \tag{7}$$

which reduces to the Weber potential, Eq.(6), for small relative velocities. This Phipps potential is limited to relative velocities $V \leq c$; while the original Weber potential is limited to relative velocities $V \leq \sqrt{2}c$; and physically relative velocities should be limited to $V \leq 2c$. Wesley [19] speculated that the Phipps potential might arise as a root-mean-square average of retarded and advanced actions.

To recover the physically appropriate limit velocities of $v \leq c$, $v' \leq c$, and $V \leq 2c$ Wesley [20] proposed an appropriate potential that reduces to the Weber potential for small velocities. Unfortunately, the force derived from this potential behaves in precisely the same fashion as the original Weber force for charge velocities approaching c; so this potential also fails for charge velocities approaching c.

Variations of the Weber potential have been proposed by Assis [21], Gerber [22], Schroedinger [23], Tisserand [24] and others for gravitation, where qq' is replaced by $- Gmm'$.

This preoccupation with the Weber potential is not justified: First, the potential itself is never observed nor measured. It is merely a theoretical device that provides no more empirical information than the derived force. Second, the Weber potential is wrong; as it yields a force that does not agree with all of the experimental results for charge velocities approaching c. Third, such a potential is not necessary to conserve energy. Any force between two bodies obeying Newton's third law conserves energy. The total external force on the system of two bodies is zero, $\mathbf{F}(\text{external}) = \mathbf{F} + \mathbf{F'} = 0$; since, according to Newton's third law, the force on the primed body $\mathbf{F'}$ equals the negative of the force on the unprimed body, $\mathbf{F'} = - \mathbf{F}$. The external force, being zero, no external work is done on the system or by the system. Its energy remains constant or is conserved.

4. THE TWO BODY PROBLEM ASSUMING NEOMECHANICS

It is of interest to consider the two body problem assuming neomechnics and absolute space-time, as required by the present theory.

It may be seen from Eq.(1) that the proposed force obeys Newton's third law. It acts along the line joining the two charges, $\mathbf{R}$. Interchanging primes and unprimes, where $\mathbf{R} = \mathbf{r} - \mathbf{r'} = - \mathbf{R'} = - (\mathbf{r'} - \mathbf{r})$, it is seen that

$$\mathbf{F}(q.\mathbf{r},\mathbf{v},\mathbf{a};q',\mathbf{r'},\mathbf{v'},\mathbf{a'}) = - \mathbf{F}(q',\mathbf{r'},\mathbf{v'},\mathbf{a'};q,\mathbf{r},\mathbf{v},\mathbf{a}); \quad (8)$$

and the force on charge q' due to charge q is equal in magnitude and oppositely directed to the force on charge q due to q'. Thus, energy is conserved for the two charges.

For a particle of mass m and charge q and a particle of mass m' and charge q' Newton's second law from Eq.(1)

using neomechanics becomes

$$d(m\gamma\mathbf{v})/dt = \mathbf{F} = \mathbf{R}Q, \qquad d(m'\gamma'\mathbf{v}')/dt = -\mathbf{R}Q, \tag{9}$$

where Q is defined by the force apart from the R dependence, $Q = \mathbf{R}\cdot\mathbf{F}/R^2$, and where

$$\gamma = 1\Big/\sqrt{1 - v^2/c^2} \qquad \text{and} \qquad \gamma' = 1\Big/\sqrt{1 - v'^2/c^2}\ . \tag{10}$$

Adding Eqs.(9) yields immediately an integral of the motion,

$$m\gamma\mathbf{v} + m'\gamma'\mathbf{v}' = M_o\gamma_o\mathbf{V}_o \tag{11}$$

where $M_o\gamma_o\mathbf{V}_o$ is the total linear momentum, a constant of integration. This result (11) indicates the conservation of linear momentum. Assuming that the constant total linear momentum implies a constant linear velocity $\mathbf{V}_o$, then the position of the center of mass $\mathbf{R}_o$ becomes

$$\mathbf{R}_o(t) = \mathbf{R}_o(0) + \mathbf{V}_o t, \tag{12}$$

where $\mathbf{R}_o(0)$ is a constant of the motion.

Considering the total angular momentum with respect to the arbitrary origin from which $\mathbf{r}$ and $\mathbf{r}'$ are measured,

$$\mathbf{L}_t = \mathbf{r}\times m\gamma\mathbf{v} + \mathbf{r}'\times m'\gamma'\mathbf{v}', \tag{13}$$

it may be seen that

$$d\mathbf{L}_t/dt = \mathbf{r}\times d(m\gamma\mathbf{v})/dt + \mathbf{r}'\times d(m'\gamma'\mathbf{v}')/dt. \tag{14}$$

From Eqs.(9), where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$,

$$\mathbf{r}\times d(m\gamma\mathbf{v})/dt = -\mathbf{r}\times\mathbf{r}'Q, \qquad \mathbf{r}'\times d(m'\gamma'\mathbf{v}')/dt = \mathbf{r}\times\mathbf{r}'Q. \tag{15}$$

Adding these two Eqs.(15), it is seen that $d\mathbf{L}_t/dt = 0$; so $\mathbf{L}_t$, the total angular momentum, Eq.(13), is a constant of the motion.

Introducing center of mass coordinates, the individual particle positions are given by

$$\mathbf{r} = \mathbf{R}_o + m'\gamma'\mathbf{R}/(m\gamma + m'\gamma'), \qquad \mathbf{r}' = \mathbf{R}_o - m\gamma\mathbf{R}/(m\gamma + m'\gamma'), \tag{16}$$

Substituting Eqs.(16) into Eq.(13) and using Eq.(11) yields

$$\mathbf{L}_t = \mathbf{R}_o\times M_o\gamma_o\mathbf{V}_o + \mu\mathbf{R}\times\mathbf{V}, \tag{17}$$

where μ is the reduced mass defined by

$$\mu = m\gamma m'\gamma'/(m\gamma + m'\gamma'). \tag{18}$$

Substituting Eq.(12) into the first term on the right of Eq.(17), it is seen to be a constant of the motion, the angular momentum of the center of mass system about the original origin, defined by

$$\mathbf{L}_o = \mathbf{R}_o(0) \times M_o\gamma_o\mathbf{V}_o. \tag{19}$$

The angular momentum $\mathbf{L}$ about the center of mass is then also a constant of the motion given by

$$\mathbf{L} = \mu\mathbf{R} \times \mathbf{V} = \mathbf{L}_t - \mathbf{L}_o. \tag{20}$$

The problem has now been reduced to the mathematical problem of a pseudo particle of reduced mass μ moving in a plane perpendicular to $\mathbf{L}$, Eq.(20). Two variables, the radial distance R and the angle ϕ, can then specify the position of this pseudo particle. In these coordinates Eq.(20) may be written as

$$\mu R^2 \dot{\phi} = L. \tag{21}$$

Three scalar constants of the motion remain to be found. Two of these may be regarded as the initial position, R(0) and $\phi(0)$, which leaves only one remaining integral of the motion of interest to be determined. This remaining integral involves the details of the particular problem involved.

Newton's second law, Eqs.(9), may be written in terms of R and ϕ using the integrals of the motion already obtained, Eqs.(11), (12), (19), and (21). The resulting differential equation may then be integrated in principle to obtain $R = R(t)$ and $\phi = \phi(t)$; although this is complicated by the fact that μ, γ, and γ' are functions of the absolute velocities $\mathbf{v}$ and $\mathbf{v}'$. The remaining constant of integration, thus obtained, together with the other 5 constants of the motion then means that the problem is solved. Since the total energy E is known to be conserved; it may always be expressed as a function of the known constants of the motion.

It is important to note that neomechanics does not permit in general the total energy E to be separated as a simple sum of kinetic plus potential energy, as is usually the case in Newtonian mechanics. In particular, taking the scalar product of Eq.(9) with $\mathbf{v}$ and with $\mathbf{v}'$ and adding

$$d(c^2 m\gamma + c^2 m'\gamma')/dt = \mathbf{V}\cdot\mathbf{R}Q, \tag{22}$$

where $Q = \mathbf{R}\cdot\mathbf{F}/R^2$ is the force apart from the $\mathbf{R}$ dependence. The left side of Eq.(22) would appear to be the time rate of change of the kinetic energy T; but the right side is not a perfect time derivative of the form dU/dt that would permit Eq.(22) to be immediately integrated to yield E = T + U. The concepts of kinetic and potential energy become mixed in neomechanics. For example, in nuclear physics the mass of the nuclues, that enters into its kinetic energy, is given by the potential energy between the nucleons (as shown, for example, by Wesley and Green [25]).

It should be clear that nature does not in general permit the total energy to be separated into kinetic and potential energies. Attempts to force such a separation can lead to error, such as the incorrect (for large velocities) Weber potential energy, Eq.(6).

5. SLOWLY VARYING EFFECTS

The significant relevant extensive evidence for the proposed force, Eq.(1), for slowly varying effects has been collected together and presented elsewhere [1–4]. It may be immediately seen from Eq.(1) that it yields Ampere's [7] original empirical law, Eq.(3), for the force between steady currents in neutrally charged conductors. In general the use of linear current elements in Ampere's law is not empirically correct; as it yields an infinite force when two colinear current elements are brought together, and no such infinite force is observed in nature. The empirically correct form of Ampere's law involves volume current densities J and J'; thus,

$$c^2 d^6 F_A/d^3r d^3r' = (R/R^3)\left[-2J\cdot J' + 3(J\cdot R)(J'\cdot R)/R^2\right], \tag{23}$$

which implies no infinite forces.

One of the most interesting aspects of Ampere's law is the large repulsive force between colinear current elements giving rise to the Ampere tension. Ampere [7] demonstrated this force qualitatively with the force on his Ampere bridge, a ∏ shaped wire with ends in mercury troughs connected across a battery. The force on Ampere's bridge could not be quantitatively confirmed until Wesley [26] was able to integrate Eq.(23) in closed form. The force on a bridge of width L in a rectangular circuit of width L and length M with wires of circular cross section of radius r, small compared with L and M, carrying a current I, is

$$c^2 F_A(\text{bridge}) = 2I^2\Big[\ ln\,2 - 3/4 + ln\,(L/r) + \sqrt{1 + L^2/M^2} - ln\big(1 + \sqrt{1 + L^2/M^2}\big)\Big]. \qquad (24)$$

Moyssides and Pappas [27] were able to confirm this prediction quantitatively in the laboratory.

The Ampere tension is of the right order of magnitude [28] to account for the rupture and fragmentation of wires carrying heavy current as observed by Graneau [29] and others [30].

The Ampere tension yields an estimate [31] of the force that drives the Hering [32] - Graneau [33] wedged shaped copper submarine in a trough of current carrying mercury.

The force necessary to drive the current carrying mercury in Hering's pump [32,34] may be accounted for by Ampere's force law involving both a pinch effect as well as Ampere tension [35].

As originally shown by Weber, the force on a stationary charge q due to an accelerating charge q',

$$\mathbf{F}(\text{induction}) = (qq'\mathbf{R}/R^3)\big[-\mathbf{a}'\cdot\mathbf{R}/c^2\big], \qquad (25)$$

the last term in the square bracket of Eq.(1) for the proposed force, yields Faraday's law of induction of an emf when integrated around a closed loop [36].

The proposed force also accounts for the localized unipolar induction observed by Müller [37] and Kennard [38] (Wesley [39]).

6. ELECTRODYNAMIC FIELDS

The proposed force, as given by Eq.(1), is only applicable to slowly varying effects, where time intervals of interest $\delta t > L/c$, where L is the dimension of the setup or laboratory. It is an action at a distance theory. To extend the theory to encompass rapidly varying effects, where the time for an effect to travel from a source to a detector can no longer be neglected, fields must be introduced. A field theory also offers powerful mathematical methods for solving problems.

Introducing continuously extended source and detector with charge densities ρ and ρ' and current densities $\mathbf{J}$ and $\mathbf{J}'$, Eq.(1) may be written as

$$c^2 d^6F/d^3r d^3r' = (R/R^3)\big[c^2\rho\rho' - 2J\cdot J' + 3(J\cdot R)(J'\cdot R)/R^2 - \rho R\cdot\partial J'/\partial t + \rho' R\cdot\partial J/\partial t\big]. \tag{26}$$

Integrating over the primed sources, Eq.(26) yields

$$d^3F/d^3r = -\rho\nabla\Phi + J\times(\nabla\times A)/c - \rho\,\partial A/\partial tc - J\,\nabla\cdot A/c \\ (\partial J/\partial t)\Phi/c^2 + (J\cdot\nabla)\nabla\Gamma/c + \rho\,\nabla\partial\Gamma/\partial tc - \big[(\partial J/\partial t)\cdot\nabla\big]G/c^2, \tag{27}$$

where the field variables are defined by

$$\Phi = \int d^3r'\rho'(r',t)/R, \qquad A = \int d^3r' J'(r',t)/cR, \\ \Gamma = \int d^3r' R\, J'(r',t)/cR, \qquad G = \int d^3r' R\rho'(r',t)/R. \tag{28}$$

The correctness of Eqs.(27) and (28) may be verified by substituting Eqs.(28) into (27), placing all terms under the integral sign, and noting that the integrand is given by Eq.(26).

These integral expressions (28) can also be transformed into appropriate differential equations with suitable boundary conditions. For example the first of Eqs.(28) implies a potential Φ satisfying Poisson's equation,

$$\nabla^2\Phi = -4\pi\rho . \tag{29}$$

Since action can be assumed to travel with the finite velocity of light c; the fields defined by Eqs.(28) may be generalized to retarded and advanced fields by replacing the time t by

$$t_{ret} = t - R/c \qquad \text{and} \qquad t_{adv} = t + R/c. \tag{30}$$

With these replacements (30) the fields, Eqs.(28), can then also include the possibility of electrodynamic waves and radiation. With either of these replacements (30) the differential equations that the field variables satisfy, such as Eq.(29), become wave equations. For example the scalar potential Φ is then a solution to the wave equation

$$\nabla^2\Phi - \partial^2\Phi/\partial t^2c^2 = -4\pi\rho . \tag{31}$$

When the retarded time is used the primed charge distribution acts as a source; and, when the advanced time is used, the primed charge distribution acts as a sink.

The limited Maxwell theory involves only the first three terms of Eq.(27) and only the Φ and **A** fields. The Maxwell theory fails when the remaining terms in Eq.(27) are needed along with the additional Γ and **G** fields.

A particular example of the success of the present field theory for rapidly varying fields and the failure of the limited Maxwell theory is provided by the observed zero self-torque on the Pappas-Vaughan [40] Z-shaped antenna [41].

7. OBSERVATIONS WITH FAST CHARGES

The Kaufmann [10] - Bucherer [11] experiments involve balancing the electric and magnetic ($\mathbf{B} = \nabla \times \mathbf{A}$) forces on a fast electron passing parallel to the plates in a condenser. To obtain the force on a charge in a condenser according to the proposed force, Eq.(1), the force due to a single infinite plate with a surface charge density σ may be first considered. Letting the z axis be perpendicular to the plate at $z = z'$, the force on a charge e on the z axis at z due to a surface element of the plate is given from Eq.(1) by

$$d^2\mathbf{F} = e\sigma\rho d\rho d\phi(\mathbf{R}/R^3)\left[1 + \mathbf{a}\cdot\mathbf{R}/c^2\right], \tag{32}$$

where ρ and ϕ are cylindrical coordinates in the plane perpendicular to the z axis and where

$$\mathbf{R} = -\rho\mathbf{j} + (z - z')\mathbf{k}, \tag{33}$$

where **j** and **k** are unit vectors in the ρ and z directions.

From symmetry it is clear that no force can act in the radial direction, and the radial component of the acceleration is a matter of indifference. The force in the z direction is then given by

$$F_z = e\sigma\int_0^{2\pi} d\phi\int_0^{\infty}\rho d\rho\left[(z-z')/R^3\right]\left[1 + a_z(z-z')/c^2\right]. \tag{34}$$

Performing the integration yields

$$F_z = 2\pi\sigma e\left[1 + a_z(z - z')/c^2\right]. \tag{35}$$

Adding a second plate with a charge density $-\sigma$ at $z = z''$, where $z' < z < z''$, the net force on the charge e in the condenser becomes

$$F_z = 4\pi\sigma e\left\{1 + a_z\left[z - (z'+z'')/2\right]\right\}. \qquad (36)$$

Since the plates can be placed infinitely far apart; it is clear that no specific origin is possible to yield a force depending on z. Thus, the value of z in Eq.(36) may be suitably chosen here as $z = (z' + z'')/2$, midway between the plates. In conclusion the force on a chage e in an infinite plate condenser according to the present theory is simply

$$F_z = 4\pi\sigma e = eE, \qquad (37)$$

where E is the constant electric field.

For the magnetic force produced by closed current loops carrying steady current all terms vanish in Eq.(27) except $\mathbf{J}\times(\nabla\times\mathbf{A})/c = \mathbf{J}\times\mathbf{B}/c = e\mathbf{v}\times\mathbf{B}/c$; thus,

$$\mathbf{F}(\text{magnetic}) = e\mathbf{v}\times\mathbf{B}/c \qquad (38)$$

Since $\mathbf{v}$ is chosen perpendicular to $\mathbf{B}$ and $\mathbf{E}$ in the Kaufmann-Bucherer experiments; the electric and magnetic forces balance in the condenser, yielding

$$v/c = E/B. \qquad (39)$$

In the magnetic field alone the electron moves in a circle whose radius r, according to neomechanics, or mass change with velocity, is given by

$$mv^2/r\sqrt{1 - v^2/c^2} = evB/c. \qquad (40)$$

Combining Eqs.(39) and (40) yields the velocity variable mass as

$$erB^2/c^2E = m/\sqrt{1 - v^2/c^2} = m(1 + E^2/2B^2 + 3E^4/8B^4 + \cdots). \qquad (41)$$

This is the traditional result. The 1/2 coefficient of the second term on the right has been empirically confirmed to about 5 percent accuracy.

The explanation of the Bertozzi [15] result follows from Eq.(37) and neomechanics in the traditional way. The electric energy supplied to the electron travelling a distance D in the constant electric field is eED = eV, where V is the usual potential difference. This electric energy supplied should equal the resultant neomechanical kinetic energy; thus,

$$mc^2/\sqrt{1 - v^2/c^2} - mc^2 = eV. \qquad (42)$$

Bertozzi measured the potential V and the time of flight velocity of the electron for velocities approaching the velocity of light c. The expected value of v^2/c^2 was observed to about a 2 percent accuracy for five values from $v^2/c^2 = 0.75$ to 1.00.

It is, thus, seen that the proposed electrodynamics based on the force, Eq.(1), agrees with experimental observations involving charges approaching the velocity of light c, assuming neomechanics, or mass change with velocity.

8. THE THEORY APPLIED TO GRAVITATION

Since Coulomb's law and Newton's universal law of gravitation have the same geometrical character; it is reasonable to speculate that the proposed force, Eq.(1), is also valid for gravitation when qq' is replaced by $-$ Gmm', where G is the universal gravitational constant and m and m' are the gravitating masses.

It is of particular interest to examine the force on an accelerating mass m due to the distant stationary masses m' in the rest of the universe. From the 5th term on the right of Eq.(27) this force according to the present theory applied to gravitation is

$$\mathbf{F} = - m\mathbf{a}\Phi/c^2, \tag{43}$$

where

$$\Phi = G\int d^3r' \rho'(\mathbf{r}')/R, \tag{44}$$

where here $\rho'(\mathbf{r}')$ is the mass density of the universe. The minus sign in Eq.(43) indicates a force opposite to the acceleration. This result (43) confirms Mach's principle, if

$$\Phi/c^2 = 1. \tag{45}$$

This Eq.(45) represents a cosmological condition for proposed models of the universe [42].

Since the inertial reaction, according to neomechanics is $d(\gamma m\mathbf{v})/dt$ instead of ma; the acceleration in the proposed force, Eq.(1) can be replaced by

$$\mathbf{a} \rightarrow d(\gamma\mathbf{v})/dt = d(\mathbf{v}/\sqrt{1 - v^2/c^2})/dt. \tag{46}$$

9. DISCUSSION

Since the experiments usually cited to establish neomechanics involve simultaneously questions about the electrodynamics as well as the mechanics; the conclusions based on these experiments have been questioned as ambiguous. The electrodynamics proposed here fits all known observations if neomechanics, or mass change with velocity, is assumed. This success, thus, seems to provide strong evidence in favor of neomechanics as well as the proposed electrodynamics. In addition, there is evidence for neomeechanics that does not depend upon electrodynamics. Neomechanics can be derived from the Voigt-Doppler effect for light by considering the momentum and energy of photons [43]. Using mass-energy equivalence, that is firmly established empirically in nuclear and particle physics, the change in kinetic energy $\mathbf{v}\cdot d(m\mathbf{v})$ of a particle may be equated to a change in its mass-energy [44]; thus,

$$d(mc^2) = \mathbf{v}\cdot d(m\mathbf{v}) = v^2 dm + md(v^2/2). \tag{47}$$

This Eq.(47) may be immediately integrated to yield

$$m = m_o/\sqrt{1 - v^2/c^2}\ , \tag{48}$$

where m_o is a constant of integration, the mass when $v = o$.

Empirically it would appear that the absolute velocity of the particle is needed in the γ factor for neomechanics, as assumed here. The radioactive half-life of cosmic-ray muons, being proportional to the γ factor and thus to the absolute velocity of the muons, produces an anisotropy in the sea-level flux of muons. Observations of this anisotropy [45] has been used to determine the absolute velocity of the solar system in agreement with other observations.

The present theory is empirically oriented. It is correct only in terms of the experimental evidence that is available today. The theory may not prove to be correct when future experimental evidence becomes available. The evidence available for slowly moving charges and slowly varying effects is extensive and is probably adequate. In this range the present theory is undoubtedly correct (in contrast to the Maxwell theory).

The evidence available for rapidly moving charges is very meager indeed and inadequate. Instead of relying upon presumed electrodynamic theory to assign velocities to charges, their actual velocities need to be measured as time of flight velocities, as in Bertozzi's [15] experiment.

In addition, the neomechanics, assumed here, may not prove to be precisely correct when adequate high velocity experiments are performed, where the time-of-flight velocity of charges are actually measured. Some other function of the velocity might be found for the kinetic energy instead of $mc^2(\gamma - 1)$.

Although the present theory is correct empirically for high velocities; it may not be quite correct in principle. In particular, for the case of comoving charges, where $\mathbf{v} = \mathbf{v}'$, the force, Eq.(1), becomes

$$\mathbf{F} = (qq'\mathbf{R}/R^3)\left[1 - (2 - \cos^2\theta)v^2/c^2\right], \qquad (49)$$

where θ is the angle between $\mathbf{v}$ and $\mathbf{R}$. The Coulomb force would thus appear to be a function of the absolute velocity of the laboratory and its orientation with respect to the separation vector $\mathbf{R}$, which does not seem reasonable. But this effect is very minute and has never been observed.

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