Foundations of Physics Letters, Vol. 3, No. 6, 1990

WEBER ELECTRODYNAMICS: PART III. MECHANICS, GRAVITATION

J. P. Wesley

Weiherdammstrasse 24
7712 Blumberg
Federal Republic of Germany

Received June 20, 1990

Weber electrodynamics predicts the Kaufmann-Bucherer experiments and the fine structure energy level splitting of the H-atom (neglecting spin) without mass change with velocity (i.e., mass $\neq m_0/\sqrt{1 - v^2/c^2}$). The Weber potential for the gravitational case yields Newtonian mechanics, confirming Mach's principle. It provides a cosmological condition yielding an estimated radius of the universe of 8×10^9 light years. Despite these successes, the independent evidence for Kaufmann mechanics, where mass changes with velocity (i.e., mass $= m_0/\sqrt{1 - v^2/c^2}$) is convincing. Perhaps a slight alteration may make the Weber theory compatible with Kaufmann mechanics.

Key words: electrodynamics, Weber theory, Kaufmann experiment, Mach's principle confirmed, radius of universe, Kaufmann mechanics evidence for.

1. INTRODUCTION

This is part III of a review paper presented in three parts. Part I (*Found. Phys. Lett.* 3, 443 (1990)) presents the general Weber theory extended to fields and the supporting evidence for slowly varying effects. Part II (*Found. Phys. Lett.* 3, 471 (1990)) presents Weber theory for unipolar induction experiments and the determination of the zero torque on the Pappas-Vaughan Z-antenna, results not explained by Maxwell theory. The present part III shows that

0894-9875/90/1200-0581$06.00/0

the Weber theory predicts the Kaufmann-Bucherer experiments and the fine structure energy level splitting of the H-atom (neglecting spin)) without mass change with velocity. When applied to gravitation the Weber theory yields Newtonian mechanics, confirming Mach's principle. It provides a cosmological condition yielding an estimated radius of the universe of 8×10^9 light years. The independent evidence for Kaufmann mechanics, where the mass changes with velocity, is convincing. (The designation "relativistic mechanics" is avoided here; as it is not historically accurate; and it implies an endorsement of "special relativity".)

The Weber theory [1] is based upon a potential for a charge q at $\mathbf{r}$ and a charge q' at $\mathbf{r}'$; thus,

$$U = (qq'/R)\left[1 - (dR/dt)^2/2c^2\right], \tag{1}$$

where $R = |\mathbf{r} - \mathbf{r}'|$ is the separation distance. The Weber force $\mathbf{F}_W$ is obtained from Eq.(1) by differentiation; thus,

$$dU/dt = - \mathbf{V}\cdot\mathbf{F}_W, \tag{2}$$

where $\mathbf{V}$ is the relative velocity $\mathbf{V} = \mathbf{v} - \mathbf{v}'$, and

$$\mathbf{F}_W = (qq'\mathbf{R}/R^3)\left[1 + V^2/c^2 - 3(\mathbf{R}\cdot\mathbf{V})^2/2c^2R^2 + \mathbf{R}\cdot d\mathbf{V}/dtc^2\right]. \tag{3}$$

2. THE WEBER VELOCITY SQUARED FORCE

The Weber velocity squared force involves the force between a stationary charge q at $\mathbf{r}$ and a negative charge - q' moving with a steady velocity $\mathbf{v}'$ at $\mathbf{r}'$ in a conductor where the net charge is zero; thus, from Eq.(3)

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

One of the early objections to the Weber theory was the fact that this velocity squared force, Eq.(4), had never been observed. One cannot arbitrarily remove this force; because it is required for the conservation of energy. The force is needed to derive the Weber force from a velocity potential. To remove this problem Fechner [2] hypothesized that currents consisted of positive charges flowing in one direction with an equal flow of negative charges in the opposite direction. Today it is known that this hypothesis is false; as it is only the negative electrons that flow in a wire.

To discredit the Weber theory the proponents [3] of the Maxwell theory like to claim that the Weber theory requires the Fechner hypothesis. The Fechner hypothesis is, however, not needed if it is assumed that the velocity squared forces actually exist but that they are usually too small to be observed.

2.1. Experiments to observe the velocity squared force

The velocity squared force, Eq.(4), is extremely minute. The force produced on a static charge by a conduction current involves the drift velocity of the conduction electrons, which is only of the order of millimeters per second. It is this velocity squared divded by c^2 that is involved, an extremely small number, $v^2/c^2 \sim 10^{-22}$.

Sansbury [4] claims to have observed the Weber velocity squared force on a static charge produced by a current carrying wire. The force on a static charge q a distance r from an infinitely long straight wire carrying a current I may be obtained from Eq.(4) by letting $q'v' = Idy$ and integrating; thus, the force directed perpendicular to the wire is given by

$$F_W = -(qIv'r/c^2)\int_0^{\infty} dy(2/R^3 - 3y^2/R^5) = -qIv'/c^2r. \qquad (5)$$

This corresponds to an effective electric charge per unit length λ on the wire given by

$$\lambda = -Iv'/c^2. \qquad (6)$$

The velocity v' of the conduction electrons may be approximated from the density of valence electrons in the wire of known cross section carrying a known current I. Thus, for a current of 1000 amps = 3×10^{12} esu/sec in a copper wire of 1 cm^2 cross-sectional area and a valence 1 with a density 8.94 the velocity is $v' = 0.074$ cm/sec. The force on a charge q = 1 esu at a distance 1 cm from this wire is

$$F_W = -2.5 \times 10^{-10} \text{ dynes}. \qquad (7)$$

It is difficult to believe that Sansbury could have detected, even qualitatively, a force of such a small order of magnitude with his suspended fiber torsion balance. He claims the force was independent of the direction of the current I, as would be expected from the Weber theory; but he found the charge per unit length, Eq.(6), to be positive instead of negative.

Edwards et al. [5] also claim to to have observed the Weber velocity squared force by placing a metal cylinder around a current carrying wire and measuring the potential difference induced on the condenser, thus formed, by the charge per unit length λ given by Eq.(6). The capacitance of a cylindrical condenser is given by

$$C = L/ln(b/a), \tag{8}$$

where L is the length, a is the radius of the wire and b is the radius of the outer cylinder. The potential expected is then from Eq.(8) and (7)

$$V = Q/C = \lambda\, ln(b/a). \tag{9}$$

If the ratio b/a is chosen as 1.1, for the above example, where $\lambda = -2.5\times10^{-10}$ esu/cm, the expected voltage is

$$V = -7\times10^{-9}\ \text{volt}. \tag{10}$$

Edwards et al. claim to have observed a potential of the expected very small order of magnitude which was independent of the direction of the current in the wire and involved an effective negative charge on the wire as expected from the Weber theory. Unfortunately, their paper is so badly written that it is quite impossible to discover exactly what their experiment might have been; and a proper evaluation is not possible.

Curé [6] has observed the horizontal drift of a charged drop levitated between the plates of a condenser (a la Millikan) when a horizontally oriented permanent magnet is brought near the drop chamber. The voltage necessary to levitate the drop of known weight gives the charge on the drop; and the horizontal drift rate and the radius of the drop, using Stokes drag law, yields the horizontal force acting.

From the Weber velocity squared force, Eq.(4), a permanent magnet is expected to produce such a force, observed by Curé, on a stationary charge. The force on q on the axis of a circular current loop of radius a carrying a current I is obtained by letting $q'v' = Iad\varphi$ in Eq.(4) and integrating; thus,

$$F_W = -q(2\pi I/c)\left[az/(a^2+z^2)^{3/2}\right](v'/c). \tag{11}$$

Curé's flat permanent magnet of radius $a = 2.54$ cm with a field at the center of $B_0 = 0.37$ Tesla $= 3.7 \times 10^3$ gauss is equivalent to a circular current loop where $2\pi I/c = aB_0 = 10^4$ esu/cm. The magnet was placed 2.85 cm from the drop, so $az/(a^2 + z^2)^{3/2} = 0.130$ cm^{-1}. A typical charge on a drop was 1.5×10^{-8} esu and the horizontal force observed was of the order of 10^{-13} dyne. Substituting these numbers into Eq.(11) the equivalent drift velocity of the electrons v' representing the Amperean currents of the magnet would have to be

$$v' = 150 \text{ cm/sec.} \tag{12}$$

Although this value might seem to be too large; the Amperean current for his magnet is large, being 16,000 amperes; and we have no idea as the number of electrons that should be associated with the equivalent Amperean current in a permanent magnet.

Curé finds the force is invariant to the polarity of the magnet, as would be expected from the Weber theory; but he finds the pole face to be equivalent to a positive rather than a negative charge. Further experiments of the Curé type would be most desirable.

2.2. Weber electrodynamics predicts the Kaufmann and Bucherer experiments

Vannever Bush (science advisor to President Roosevelt when he decided to develope the nuclear bomb) [7] and subsequently Assis [8] discovered that the Weber velocity squared force predicts the result of the Kaufmann [9] experiment (which has been repeated by Bucherer [10] and others [11-17], as reviewed by Faragó and Jánossy [18]) without having to make the usual more-or-less ad hoc postulation of mass change with velocity. The Kaufmann experiment involves the force on a high velocity electron moving in the field of stationary charges. In this case the velocity squared force, Eq.(4), is not limited to the slow drift velocity v' of conduction electrons q' nor to small static charges q. Since the force of interest is now the force on q' the sign of Eq.(4) must be changed to give F'.

Kaufmann used a natural radioactive β-source for his fast electrons. He passed them between the plates of a condenser with an electric field E and simultaneously a perpendicular magnetic field B. In order for the electron to pass between the plates the electric and magnetic forces cancel each other. After passing out of the condenser only the magnetic field acts and the radius of curvature r of the is measured. According to the Maxwell theory the electric force on the electron in the condenser is limited solely to the Coulomb force, or $eE = 4\pi\sigma e$, where σ is the surface charge density on the plates. The magnetic force according to Maxwell theory is given by evB/c. Balancing the electric and magnetic forces in the condenser yields, according to the Maxwell theory,

$$E = vB/c \qquad \text{or} \qquad v/c = E/B. \tag{13}$$

When the electron moves in the magnetic field alone the magnetic force is balanced against the centrifugal force yielding

$$mv^2/r = evB/c. \tag{14}$$

Combining Eqs.(13) and (14) yields the presumed mass according to Maxwell theory as

$$m = erB^2/c^2E. \tag{15}$$

Under the essentially ad hoc assumption that the mass m of the electron varies with the velocity according to

$$m/m_0 = 1/\sqrt{1 - v^2/c^2} = 1 + \alpha_1 v^2/c^2 + \alpha_2 v^4/c^4 + \cdots, \tag{16}$$

where m_0 is the rest mass and under the assumption that the velocity is given by the Maxwell theory, Eq.(13), Kaufmann found that $\alpha_1 = 1/2$ to about a 20 percent error. Bucherer's subsequent results were somewhat less accurate. The better experiments that have been done [11-18] yield $\alpha_1 = 1/2$ to perhaps about a 5 percent error. No one has ever been able to determine α_2 or any of the coefficients of higher order terms in Eq.(16) to any accuracy at all using Kaufmann type experiments. Nor has anyone ever tried to check Eq.(16) experimentally by determining the actual velocity of electrons using a time-of-flight chopping device. All that is actually shown by the Kaufmann-Bucherer type experiment is that, using Eqs.(15) and (16),

$$erB^2/c^2E = m_0(1 + E^2/2B^2 + 3E^4/8B^4 + \cdots), \tag{17}$$

where the 1/2 coefficient on the right is accurate to about 5 percent error and the coefficients of higher order terms remain unknown. When reading the literature one should keep in mind that the mass m and the velocity v referred to are not measured quantities but are merely theoretical entities defined by

$$m = erB^2/c^2E \qquad \text{and} \qquad v/c \equiv E/B. \tag{18}$$

The Weber force (from Eq.(3), the Coulomb force plus the velocity squared force, Eq.(4)) acting on an electron of $-e$ charge with the velocity v between infinite (in the xy-plane) condenser plates, one at $z = z_0/2$ with a surface charge density $-\sigma$ and the other at $z = -z_0/2$ with a surface charge density $+\sigma$, letting $q' = \sigma dxdy$, is (dropping primes)

$$d^2\mathbf{F}_W = (\sigma e dxdy)(\mathbf{K}_+ - \mathbf{K}_-), \tag{19}$$

where

$$\mathbf{K}_\pm = (\mathbf{R}_\pm/R_\pm^3)\left[1 + v^2/c^2 - 3(\mathbf{R}_\pm\cdot\mathbf{v})^2/2R_\pm^2\right], \tag{20}$$

and

$$\mathbf{R}_\pm = x\mathbf{i} + y\mathbf{j} + (z \pm z_0/2)\mathbf{k}, \tag{21}$$

where $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ are unit vectors in the cartesian coordinate directions. Substituting Eqs.(20) and (21) into (19), placing the electron instantaneously at the origin, introducing cylindrical coordinates, and carrying out the integration over the infinite xy-plane, the Weber force is

$$\begin{gathered} F_z = 4\pi\sigma e(1 + v^2/2c^2) = eE(1 + v^2/2c^2), \\ \mathbf{F}_r = -4\pi\sigma v_z \mathbf{v}_r, \end{gathered} \tag{22}$$

where F_r and v_r are the components of the force and velocity in the radial direction parallel to the condenser plates and F_z and v_z are the components of force and velocity in the z direction perpendicular to the condenser plates. Since the experiment chooses electrons whose velocity component perpendicular to the plates is zero, $v_z = 0$; $F_r = 0$, and only the z component of the force F_z is involved.

The Weber force on the electron moving in the magnetic field reduces to the special Maxwell case, as the sources are closed current loops. The Weber magnetic force on the electron is evB/c. In the condenser the electric and magnetic forces balance each other yielding

$$E(1 + v^2/2c^2) = vB/c. \tag{23}$$

Outside of the condenser the magnetic force is balanced against the centrifugal force giving

$$m_0 v^2/r = evB/c. \tag{24}$$

To compare with Eq.(17), derived assuming Maxwell theory and mass change with velocity, Eqs.(23) and (24) may be combined to yield

$$\begin{aligned} erB^2/c^2E &= m_0(B^2/E^2)\left(1 - \sqrt{1 - 2E^2/B^2}\right) \\ &= m_0(1 + E^2/2B^2 + E^4/2B^4 + \cdot\cdot\cdot\cdot). \end{aligned} \tag{25}$$

Thus, to within the experimental errors, where only the second term on the right is to be retained, Eq.(25) is identical to (17). And Weber electrodynamics predicts the Kaufmann-Bucherer experimental results automatically without having to make the additional assumption of mass change with velocity.

3. WEBER ELECTRODYNAMICS FOR THE HYDROGEN ATOM

Bush [7] has also shown, using the old Sommerfeld [19] quantum theory with elliptical electron orbits, that Weber electrodynamics automatically yields the fine structure energy level splitting of the hydrogen atom without having to make the additional assumption of mass change with velocity. Sommerfeld [19] had to assume mass change with velocity ($m = m_0/\sqrt{1 - v^2/c^2}$) in order to obtain the same result.

As is now known the spin and magnetic moment of the electron must also be considered; and the wave behavior of submicroscopic systems, requiring the Schroedinger equation or some similar equation, must be taken into account to obtain a more complete and accurate prediction of hydrogen spectra. Unfortunately, the present-day theory of the hydrogen atom does not appear to be adequate to handel the complexities involved. The present-day theory attempts to get by using Maxwell theory, which cannot give the general interaction between two moving point charges (as amply demonstrated in the present paper). It is, thus, not at all suited for submicroscopic systems. Some of the difficulties with the present-day model of the hydrogen atom can undoubtedly be obviated by introducing Weber electrodynamics, which, being based directly upon particle-particle interactions, is ideally suited for submicroscopic systems. Bush's success in obtaining the fine structure energy level splitting of the hydrogen atom (neglecting spin) using Weber theory indicates the value of using Weber electrodynamics in submicroscopic quantum systems. Of course, Bush's success also brings into question the validity of the usually assumed mass change with velocity.

4. WEBER THEORY FOR GRAVITATION

Because of the similarity between Coulomb's law and Newton's universal law of gravitation; it is of considerable interest to see if Weber's generalization of Coulomb's law, Eq.(3), also provides a valid generalization of Newton's universal law of gravitation. In particular, for the gravitational case the product of the charges qq' in Eq.(3) is to be replaced by the product of the masses, $-Gmm'$, where G is the universal gravitational constant equal to 6.668×10^{-8} $\mathrm{cm^3/sec^2\,gm}$.

4.1. Assis' confirmation of Mach's principle

Assis [20] has shown that the Weber theory for gravitation yields the mass times acceleration force as the action of the far mass in the universe acting on an accelerating mass thereby confirming Mach's [21] principle.

The problem of interest here concerns the Weber gravitational force on a body of mass m moving with a velocity **v** and an acceleration a under the action of a static distribution of masses throughout the universe. In this case Eq.(3) becomes

$$\mathbf{F}_W = -(Gmm'\mathbf{R}/R^3)\left[1 + v^2/c^2 - 3(\mathbf{R}\cdot\mathbf{v})^2/2c^2R + \mathbf{R}\cdot\mathbf{a}/c^2\right]. \quad (26)$$

Since a distribution of masses is involved, m' is replaced by $\rho' d^3r'$, where ρ' is the static mass density. Performing the integration, the force on the body of mass m may be expressed as being due to a static gravitational potential field, Φ and **G**, defined by

$$\Phi = G\int d^3r'\rho'(\mathbf{r}')/R, \qquad \mathbf{G} = G\int d^3r'\rho'(\mathbf{r}')\mathbf{R}/R, \quad (27)$$

where

$$\mathbf{F}_W/m = (1 + v^2/2c^2)\nabla\Phi - \mathbf{v}(\mathbf{v}\cdot\nabla)\Phi/c^2 - \mathbf{a}\Phi/c^2 + (\mathbf{v}\cdot\nabla)^2\mathbf{G}/2c^2 + (\mathbf{a}\cdot\nabla)\mathbf{G}/c^2. \quad (28)$$

It may be readily verified that Eqs.(27) and (28) are mathematically isomorphic to Eq.(26) by simply substituting Eqs.(27) into (28), placing all terms under the integral sign, performing the ∇ operations, where the del operator operates only on **R** and R, and combining terms to obtain Eq.(26) as the integrand. Since the region of integration is arbitrary; the mathematical isomorphism is proved.

In the large the universe appears isotropic (the cosmological principle). Thus, the field produced by far masses cannot vary from point to point locally. Consequently all terms in Eq.(28) involving differentiation with respect to ∇ will vanish for the far contribution. The only force that remains dependent upon the far mass is the mass times acceleration term, $- m \mathbf{a} \Phi/c^2$.

For local mass sources the other terms in Eq.(28) do not vanish. Neglecting terms varying as $1/c^2$ for local sources the Newtonian limit yields

$$\mathbf{F}_W = m\nabla\Phi - m\mathbf{a}\Phi_0/c^2, \tag{29}$$

where to within terms of $1/c^2$ only the potential from the far sources Φ_0/c^2 remains.

If only gravitational forces are assumed to act, then the net Weber gravitational force on the mass m must be zero; or, Eq.(29) gives

$$m\nabla\Phi = m\mathbf{a}\Phi_0/c^2. \tag{30}$$

This result (30) is simply Newton's second law for a body of mass m; thus,

$$\mathbf{F} = m\mathbf{a}, \tag{31}$$

where the force F is the Newtonian gravitational force $m\nabla\Phi$ and where the cosmological condition

$$\Phi_0/c^2 = 1, \tag{32}$$

must hold.

This result clearly confirms Mach's principle explicitly; the mass times acceleration force does arise from the action of all the far masses in the universe acting on the accelerating body of mass m.

4.2. The radius of the universe

In order for Eq.(30) to be Newton's second law (31) the Weber cosmological condition (32) must be reasonable and not in conflict with what is known. In addition, assuming the condition (32) is correct, then it should provide us with some pertinent information about the universe. In order to proceed it is necessary to assume some sort of model for the universe. The simplest model is a spherical Newtonian universe of uniform density ρ and a finite radius R_0. To preserve the observed isotropy of this universe the body of mass m must be placed at the center of the universe. The Newtonian gravitational potential inside a sphere of uniform density ρ and radius R_0 is given by

$$\Phi = 2\pi G\rho R_0^2(1 - r^2/3R_0^2). \tag{33}$$

At the center the potential is

$$\Phi_0 = 2\pi G\rho R_0^2, \tag{34}$$

which goes to infinity as R_0^2. Substituting this expression for Φ_0 into the cosmological condition (32) and assuming a mass density for the universe of $\rho = 10^{-29}$ gm/cm^3, the finite radius of the universe predicted by this model is

$$R_0 = c/\sqrt{2\pi G\rho} \sim 5 \times 10^{27} \text{ cm} = 8 \times 10^9 \text{ light years}. \tag{35}$$

Since this result (35) is not unreasonable; it indicates the validity of the cosmological condition (32) and the interpretation of Eq.(30) as Newton's second law.

Perhaps a better estimate of Φ_0 is provided by a theory by Wesley [21] where the gravitational potential is given by Poisson's equation with the mass equivalent of the gravitational field energy itself included as part of the source mass. The potential inside a sphere of uniform density ρ and finite radius R_0 according to this theory is given by

$$\Phi = -2c^2\, ln\left[\operatorname{sech}(\beta R_0)\sinh(\beta r)/\beta r\right], \tag{36}$$

where $\beta^2 = 2\pi G\rho/c^2$. For $r = 0$ and $R_0 \rightarrow \infty$ Eq.(36) yields

$$\Phi_0 = 2c\sqrt{2\pi G\rho}\, R_0, \tag{37}$$

which goes to infinity only as R_0 instead of as R_0^2 in the Newtonian case. Ideally it would seem that Φ_0 should yield a finite limit as $R_0 \rightarrow \infty$. Substituting Eq.(37) into the cosmological condition (32) yields the finite radius of the universe as

$$R_0 = c/2\sqrt{2\pi G\rho}, \tag{38}$$

which is one half the Newtonian estimate Eq.(35) above, or $\sim 4 \times 10^9$ light years.

4.3. Conclusions concerning the Weber theory of gravitation

The following conclusions can be drawn from the Weber theory of gravitation:

1) The Weber theory confirms Mach's principle.

2) Newtonian mechanics involving the mass times acceleration force is a consequence, or one aspect of, Weber gravitation.

3) The mass times acceleration force is the gravitational analog of the inverse induction force in electrodynamics, the force on an accelerating charge due to a stationary charge, a force that is absent in the Maxwell theory.

4) Gravitational and inertial mass are necessarily identical.

5) the acceleration in Newton's second law is *absolute* acceleration; since it is defined with respect to all of the far mass in the universe.

6) The Weber theory explains why accelerations that occur in Newton's second law are empirically observed to be locally *absolute* (as stressed by both Newton and Mach).

7) The cosmological condition (32) is a valid condition that any proposed model of the universe must satisfy.

8) The estimated radius of the universe assuming a mass density of 10^{-29} gm/cm^3 is of the order of 8×10^9 light years, an interesting and not unreasonable result.

9) Local gravitational forces are not limited to $m\nabla\Phi$, such as the force terms for a static mass distribution in Eq.(28) varying as $1/c^2$.

10) Just as the Weber theory yields electromagnetic waves for rapidly varying sources in the electrical case; it yields gravity waves in the gravitational case; but they are truly of negligible energy.

11) The Weber theory predicts mass current effects, as electric current effects in electrodynamics; but they are truly negligibly small.

5. EVIDENCE AGAINST KAUFMANN MECHANICS

"Kaufmann mechanics" here means mechanics where the mass, momentum, and rest plus kinetic energy of a particle are given by

$$m = m_0 \gamma , \qquad p = m_0 \gamma v , \qquad E = c^2 m_0 \gamma , \tag{39}$$

where

$$\gamma = 1/\sqrt{1 - v^2/c^2} . \tag{40}$$

(The designation "relativistic mechanics" is avoided here as the space-time variability of "special relativity" is not needed [23] nor implied.)

5.1. Kaufmann experiment provides no evidence for mass change with velocity

The evidence usually cited as the most important evidence for mass change with velocity (and for "special relativity"), where mass is suppose to be given by $m = m_0/\sqrt{1 - v^2/c^2}$, is the Kaufmann-Bucherer type experiments [9-18]. But these experiments are explained as a natural automatic consequence of Weber electrodynamics without mass change with velocity or any other additional assumptions being necessary (as shown in Section 2.2 above). Since Weber electrodynamics adequately accounts for *all* known electrodynamic phenomena (including phenomena which the Maxwell theory cannot explain); there appears to be no reason to make the more-or-less ad hoc hypothesis of mass change with velocity. Mass change with velocity is only tenable if Maxwell electrodynamics is assumed; and there is sufficient independent evidence (as presented in parts I and II of this paper) showing that the Maxwell theory is not in general valid.

The experimental results of the Kaufmann-Buchere type provide additional evidence for Weber electrodynamics; they provide no evidence for mass change with velocity.

5.2. Splitting of H-atom energy levels provides no evidence for mass change with velocity

Another piece of evidence, which was once touted as convincing evidence for mass change with velocity (and for "special relativity"), is Sommerfeld's derivation of the fine structure splitting of the energy levels of the hydrogen atom using Maxwell theory, mass change with velocity, and his old quantum theory. But Bush [7] has shown that Weber electrodynamics automatically accounts for this result also without having to assume mass change with velocity.

It appears that, when the correct Weber electrodynamics is used, then mass change with velocity is unnecessary. It is only when the insufficient Maxwell theory is used that it becomes necessary to make the additional more-or-less ad hoc assumption of mass change with velocity in order to obtain the observed results.

5.3. No experiment measuring velocity directly has revealed mass change with velocity

The most serious evidence *against* mass change with velocity is the lack of any direct experimental evidence *for* it! No experiment has ever been performed showing mass change with velocity, where the actual velocity itself has been directly measured. As has been made clear above for the Kaufmann-Bucherer experiments neither the mass nor the velocity of the electron is measured directly. The mass and velocity assumed are merely theoretical quantities that depend upon the electrodynamic theory chosen. If one makes a serious claim that mass or any other quantity changes with velocity, then one should show experimentally that the quantity varies with velocity where the velocity is measured directly.

From the definition of velocity the velocity of a particle v is known when the time Δt it takes to travel a known distance ΔL is known; thus, $v = \Delta L/\Delta t$. A direct measurement of velocity, thus, requires two shutters, gates, or chopping devices that are a known distance apart ΔL and are opened one after the other a known time interval Δt apart. For example, Marinov [24] measured the direct oneway velocity of light to a first place accuracy by sending light through two toothed wheels mounted on the ends of a shaft of length ΔL rotating with an angular velocity Ω. The velocity was given by $c = \Delta L/\Delta t = \Delta L\,\Omega/\Delta\vartheta$, where $\Delta\vartheta$ was the angular shift of the beam as seen by the exit wheel relative to the entrance wheel. It is clear that the direct measurement of the velocity of fast particles can be readily accomplished.

The failure to perform the crucial experiments (such as suggested below in Section 7) in this area has been deplored for the last 80 years. As things now stand, there is no direct evidence for mass change with velocity or for Kaufmann mechanics.

5.4. Observations of velocity squared force do not support mass change with velocity

If mass does in fact change with velocity, then it would mean that the Weber explanation of the Kaufmann experiment has to be somehow in error. If the Weber theory itself is in error, then only the very small velocity squared force can come into question; as the other force terms in Eq.(3) are too well supported by all of the ordinary observations of electromagnetic phenomena to be doubted.

The Weber velocity squared force is a pure electrodynamic force involving charges only; the force does not depend upon mass. The Kaufmann experiment involves the mass only indirectly in a centrifugal force. The observations of Sansbury [4], Edwards et al [5], and Curé [6] involve the velocity squared force completely independent of any mass. This is independent support for the Weber explanation of the Kaufmann experiment; and further strengthens the evidence against mass change with velocity.

Further experiments are, however, sorely needed to properly confirm or reject these rather uncertain observations of Sansbury, Edwards et al, and Curé.

5.5. Weber gravitation provides evidence against Kaufmann mechanics

In Section 4 above it is shown that the Weber theory applied to gravitation yields Newtonian mechanics and confirms Mach's principle. The acceleration force is found to be $m\mathbf{a}$ and not $md(\gamma\mathbf{v})/dt$, where γ is defined by Eq.(40), as would be required by Kaufmann mechanics. The Weber theory for gravitation does not, therefore, yield Kaufmann mechanics; which is additional evidence against Kaufmann mechanics. In this case the relevant Weber force is not the velocity squared force but is the induction force on an accelerating charge or mass due to a stationary charge or mass.

6. EVIDENCE FOR KAUFMANN MECHANICS

As indicated above the *direct* evidence for mass change with velocity or Kaufmann mechanics does not exist. The question remains, however: Is there any *indirect* evidence for believing in Kaufmann mechnics? The answer is, yes: 1) The principle of mass-energy equivalence would seem to imply mass change with velocity. And 2) the photon nature of light in conjunction with the Michelson-Morley result implies Kaufmann mechanics as already shown by Wesley [23, 25].

6.1. Mass change with velocity from mass-energy equivalence

Mass-energy equivalence can probably be traced back to around 1850 when physicists were attempting to base all physics on electrodynamics. Mass was suppose to be electromagnetic mass . Since stored electric and magnetic energy could be converted to heat energy; it was believed that electromagnetic mass should be similarly convertable to thermal energy. The coefficient between the energy released and the mass converted was soon established as having to be of the order of c^2; thus, $E = kc^2m$, where k, after much speculation, was finally more-or-less accepted around 1900 as unity on seemingly more esthetic than scientific grounds.

Today

$$E = c^2 m, \tag{41}$$

can be accepted as empirically established. Mass-energy equivalence is now an ordinary useful tool in particle and nuclear physics. Although the concept may sometimes lead to difficulties (Such as where and what is the mass to be associated with potential energy?); its area of validity is large.

Does the completely accepted and confirmed principle of mass-energy equivalence imply mass change with velocity? It does, if one can argue as follows: If mass *is* energy, then energy *is* mass; and kinetic energy K of a particle is equivalent to an amount of mass Δm, where

$$K = c^2 \Delta m . \tag{42}$$

If a particle has a mass m_0 at rest, then it must have a mass m when in motion such that $\Delta m = m - m_0$ is equivalent to the kinetic energy; Eq.(42) gives

$$K = c^2(m - m_0). \tag{43}$$

Since the mass of a particle can vary; Newton's second law should read $\mathbf{F} = d(m\mathbf{v})/dt$; and the time rate of doing work is

$$\mathbf{v}\cdot\mathbf{F} = \mathbf{v}\cdot d(m\mathbf{v})/dt = dK/dt = c^2 d(m - m_0)/dt. \tag{44}$$

This Eq.(44) yields a differential equation for the variable mass m; thus,

$$m\mathbf{v}\cdot d\mathbf{v} + v^2 dm = c^2 dm. \tag{45}$$

Integrating this Eq.(45) yields

$$m = m_0 / \sqrt{1 - v^2/c^2}, \tag{46}$$

where m_0 is the constant of integration, the mass when $v = 0$. Thus, mass change with velocity, Eq.(46), is proved from mass-energy equivalence, Eq.(41).

6.2. Kaufmann mechanics from photon behavior and the Michelson-Morley result

The Voigt-Doppler effect [25,26], which yields the null Michelson-Morley result, is properly expressed in terms of the propagation constant **k** and the angular frequency ω; thus,

$$k'_x = \gamma(k_x - \omega v/c^2), \qquad k'_y = k_y,$$
$$k'_z = k_z, \qquad \omega' = \gamma(\omega - k_x v). \tag{47}$$

where γ is defined by Eq.(40) and the velocity of the primed system relative to the unprimed system v is taken along the positive x axis. This result (47) is *not* a transformation; as it does *not* represent two different mathematical views of a single physical phenomenon. This result (47) compares two different physical situations where two different physical phenomena are involved. The classical Doppler effect *is* a pure kinematical effect where a transformation *is* involved; but the Voigt-Doppler effect, Eqs.(47), involves the source and the observer actively altering the fields emitted and observed.

Introducing the momentum and energy of a photon from the de Broglie wavelength and the Planck frquency conditions, where

$$\mathbf{p} = \hbar \mathbf{k}, \qquad E = \hbar\omega, \tag{48}$$

into Eqs.(47) yields

$$p'_x = \gamma(p_x - Ev/c^2), \qquad p'_y = p_y,$$
$$p'_z = p_z, \qquad E' = \gamma(E - p_x v). \tag{49}$$

If this comparison, Eqs.(49), is postulated for the momentum and energy of all particles and not just photons, then to obtain the momentum and energy of a particle of nonzero rest mass the case may be considered when the momentum is zero in the massive moving system, $\mathbf{p}' = 0$. In this case

$$p_x = vE/c^2, \qquad p_y = p_z = 0, \qquad E' = \gamma(E - p_x v), \quad (50)$$

where E' cannot be zero. Imposing the additional condition that the momentum reduce to the Newtonian expression for small velocities, Eqs.(50) yield the usual Kaufmann mechanics, Eqs.(39) and (40), where

$$E' = m_0 c^2, \quad (51)$$

is the rest energy.

In addition, to explain the *physical* reason why the Voigt-Doppler effect differs from the classical Doppler effect it can be shown that the mechanical recoil of the massive source and massive observer alter the nature of the light emitted and received. Only by assuming the massive source and observer obey Kaufmann mechanics is the correct Voigt-Doppler effect obtained. In particular, conserving energy and momentum, using Eqs.(48) and (51) and assuming an appropriate rest mass change after emission and after absorption, the frequency of a photon emitted by a source of mass M_s moving with a velocity $\mathbf{v}_s$ is

$$\omega = \omega_0(1 - \hbar\omega_0/2M_s c^2)/\gamma_s(1 - \mathbf{v}_s\cdot\mathbf{c}/c^2), \quad (52)$$

where ω_0 is the frequency for an infinitely massive stationary source and γ_s is defined by Eq.(40) where the velocity is $\mathbf{v}_s$ of the source. When $M_s \to \infty$ the usual Voigt-Doppler result (the second of Eqs.(I.17) for $\mathbf{v}_0 = 0$) is obtained. Similarly conserving momentum and energy the frequency of an observed (absorbed) photon is given by

$$\omega'/K = -1 + \left[1 + 2\omega\gamma_0(1 - \mathbf{v}_0\cdot\mathbf{c}/c^2)/K\right]^{1/2}, \quad (53)$$

where γ_0 is defined by Eq.(40) where the velocity is $\mathbf{v}_0$ of the moving observer mass M_0 and where $K = M_0c^2/\hbar$. Again when $M_0 \to \infty$ the usual Voigt-Doppler result (the second of Eqs.(I.17)) is obtained.

In conclusion, the indirect evidence for Kaufmann mechanics appears very convincing. It would seem that a fundamental theory should be compatible with Kaufmann mechanics.

7. PROPOSED DIRECT EXPERIMENTS TO DETECT MASS CHANGE WITH VELOCITY

Despite the rather convincing indirect arguments for mass change with velocity direct experimental confirmation or rejection is sorely needed. Assuming some sort of chopping device is available to measure directly the actual velocity of a fast particle (such as Marinov [24] used to measure the oneway velocity of light), the following experiments should be done:

7.1. Velocity of a charged particle accelerated by an electric field

According to all theories when the velocity is small enough the differential equation for the motion of a particle of charge e and mass m_0 in a uniform electric field E in the x direction is

$$eE = m_0 dv/dt. \tag{54}$$

Multipying by v an integrating, assuming $v = v_0$ when $x = 0$ and $t = 0$.

$$m_0(v^2 - v_0^2)/2 - eV = 0. \tag{55}$$

where $V = Ex$ is the potential difference through which the particle moves from $x = 0$ to x. The quantities v_0, v, and V are to be measured.

According to Weber electrodynamics the force is given from Eq.(22) by $eE(1 + v^2/2c^2) \simeq eE\gamma$ accurate to v^4/c^4, where γ is defined by Eq.(40). In this case Newton's second law using Newtonian mechanics is

$$eE\gamma = m_0 dv/dt. \tag{56}$$

Integrating Eq.(56) the energy integral becomes

$$m_0(v^2 - v_0^2)/2 - eV = eV(v^2 + v_0^2)/4c^2, \tag{57}$$

where the right side is the second order departure varying as v^2/c^2 from the small velocity case, Eq.(55).

According to Maxwell electrodynamics and mass change with velocity the differential equation for the particle motion becomes

$$eE = m_0 d(\gamma v)/dt. \tag{58}$$

The energy integral of Eq.(58) becomes

$$m_0(v^2 - v_0^2)/2 = - 3eV(v^2 + v_0^2)/4c^2. \tag{59}$$

It should not be difficult to distinguish between these two possibilities, Eq.(57) or (59). Weber electrodynamics predicts a +1 for the coefficient of the right side of Eq.(57); while the Maxwell plus mass change with velocity predicts a -3 for the coefficient of the right side of Eq.(59). According to the best direct evidence presently available the Weber result (57) is to be expected.

7.2. The velocity of a charged particle in a magnetic field

According to Weber electrodynamics and Newtonian mechanics a particle of charge e and mass m_0 moving transverse to a magnetic field B moves in a circle of radius r such that

$$m_0v^2/r = evB/c, \tag{60}$$

which yields

$$m_0v - erB/c = 0. \tag{61}$$

According to Maxwell electrodynamics and mass change with velocity Eq.(60) must be replaced by

$$m_0 \gamma v^2/r = evB/c; \tag{62}$$

and to first power in v^2/c^2

$$m_0v - erB/c = - m_0v^2/2c^2. \tag{63}$$

Here the velocity v, the magnetic field B, and the radius r are to be determined experimentally to distinguish between Eq.(61) with no mass change with velocity and Eq.(63) with mass change with velocity. From the direct evidence presently available the Weber result (61) is to be expected.

8. CAN WEBER THEORY FIT KAUFMANN MECHANICS?

The primary success of the Weber theory lies in pure electrodynamics, where it predicts all of the known phenomena, including electromagnetic waves and phenomena that cannot be explained by Maxwell theory. Its success in being able to predict the Kaufmann-Bucherer experiments and to yield Mach's principle depend upon Newtonian mechanics. These additional successes then lead to the problem of the apparent incompatibility between the Weber theory and Kaufmann mechanics or mass change with velocity. Can they be made compatible?

The problem is largely a problem of insufficient experimental information. One should not really try to speculate on how the Weber theory might be made compatible with Kaufmann mechainics until one has the results of experiments such as those proposed in Section 7 above. But we have already waited for 80 years in vain for these crucial experimental results; so perhaps some premature speculation can be excused.

8.1. Present theories are good only to v^2/c^2

The essential point to be kept in mind is the fact that the experimental results known today are limited to an accuracy of v^2/c^2. There is no theory today, including the Weber theory and Kaufmann mechanics, that has been shown to be valid to order of v^4/c^4 or higher. Consequently, one is free to alter present theories if v^2/c^2 terms remain the same and only terms of the order of v^4/c^4 or higher are altered. For example, an obvious minor improvement of the Weber theory is given by the altered potential

$$U = (qq'/R)\sqrt{1 - (dR/dt)^2/c^2}\ , \tag{64}$$

(suggested by Phipps |27|) instead of the original Weber potential, Eq.(1). When only one charge is moving, this altered potential places the limit more naturally at c, rather than at the seemingly less natural limit $\sqrt{2}\,c$. This result (64) is seen to be identical to the original, Eq.(1), to within $(dR/dt)^4/c^4$. Therefore, as far as present-day observations are concerned Eqs.(64) and (1) should yield identical results.

8.2. Should forces be multiplied by γ?

Keeping in mind the limited accuracy of present-day theories, the Weber theory may be compatible with mass change with velocity for the Kaufmann-Bucherer experiments for the following reason: It may be speculated that actually all fundamental forces acting on fast particles are of the form

$$\mathbf{F} = \mathbf{F}_0\gamma\,, \tag{65}$$

where $\mathbf{F}_0$ is the force for a slowly moving particle and γ is defined by Eq.(40). This is certainly true for the Weber force in a uniform electric field, Eq.(22), where $F = eE\gamma$, to within the order v^4/c^4. The actual force in a magnetic field may be then speculated to be

$$e\gamma vB/c\,, \tag{66}$$

instead of simply evB/c (The magnetic force is already of the order of v^2/c^2; so multiplying by γ alters the force only to order v^4/c^4.). Since all forces on fast particles, according to this speculation, are to be multiplie by γ; the acceleration force should be

$$\gamma d\mathbf{p}/dt = m_0\gamma d(\gamma\mathbf{v})/dt, \tag{67}$$

instead of $m_0 d(\gamma\mathbf{v})/dt$. The equations for the Kaufmann experiment for the Weber theory plus mass change with velocity according to the present speculation is then

$$eE\gamma = e\gamma vB/c = \gamma^2 m_0 v^2/r. \tag{68}$$

Cancelling the γ's yields the result of the Maxwell theory plus mass change with velocity, which assumes only the force eE valid for the slow velocity limit.

8.3. Form of an acceptable velocity potential

When considering possible alternatives to or alterations of the Weber potential, it should be noted that any function of the separation distance R and $(dR/dt)^2/c^2$ can act as a possible velocity potential; since taking the time derivative yields

$$dU/dt = -\,\mathbf{V}\cdot\mathbf{F}, \tag{69}$$

where the force $\mathbf{F}$ is

$$\mathbf{F} = -\,(\mathbf{R}/R)\nabla U - 2(\mathbf{R}/c^2R^2)\left[V^2 - (\mathbf{R}\cdot\mathbf{V})^2/R^2 + \mathbf{R}\cdot d\mathbf{V}/dt\right]U', \tag{70}$$

where the prime indicates differentiation with respect to $(dR/dt)^2/c^2$. Energy can be conserved with this potential and force.

The static force is given by Coulomb's law or Newton's universal law of gravitation; so the velocity potentials of interest are of the form

$$U = \Phi_0(R)\, f\left\{(dR/dt)^2/c^2\right\}, \tag{71}$$

where $\Phi_0 = qq'/R$ or $- Gmm'/R$ is the static potential. Regarding the function f as a function of the small quantity $(dR/dt)^2/c^2$, it may be expanded as a series in $(dR/dt)^2/c^2$.

To satisfy the static case and to obtain a potential as successful as the Weber potential the function f must be chosen so that the constant term is unity and the coefficient of the first power term is 1/2; thus,

$$f = 1 - (dR/dt)^2/2c^2 + \alpha_2(dR/dt)^4/c^4 + \cdots, \tag{72}$$

where α_2 and the coefficients of higher order terms is a matter of indifference as far as present-day experimental observations are concerned.

8.4. A modified Weber potential for gravitation yielding Kaufmann mechanics

For electrodynamics it is a matter of indifference what function f in Eq.(71) is used, as long as it satisfies Eq.(72); but for the gravitational case the acceleration term is no longer small. From the cosmological condition (32) the acceleration term must be regarded as of order unity. in the gravitational case the coefficient α_2 in Eq. (72) must then also be considered.

In particular, the function f should be chosen to satisfy Eq.(72) and to also yield Kaufmann mechanics. An appropriate modified Weber potential satisfying these requirements is given by

$$U = -(Gmm'/3R)\left\{4 - \left[1 - (dR/dt)^2/c^2\right]^{-3/2}\right\}. \tag{73}$$

This potential, satisfying Eq.(72), yields all of the usual predictions of electrodynamics. For the problem of a mass m moving in a universe of static masses, as considered in Section 4 above, the acceleration force term F_a becomes

$$\begin{aligned} F_a &= -(Gm\rho_0/c^2)\int d^3R\, R(R\cdot \mathbf{a})/R^3(1 - v_r^2/c^2)^{5/2} \\ &\approx -(\Phi_0/c^2)m\, d(\gamma \mathbf{v})/dt = -m\, d(\gamma\mathbf{v})/dt, \end{aligned} \tag{74}$$

to order av^4/c^4 for $\Phi_0/c^2 = 1$.

Although this potential, Eq.(73), makes the Weber theory compatible with Kaufmann mechanics for the gravitational case; and although it yields all of the ordinary results for the electrodynamic case; it does not make it compatible with mass change with velocity for the Kaufmann-Bucherer experiments.

REFERENCES

1. W. E. Weber, *Abh. Leibnizens Ges., Leip.* 316 (1846); *Ann. der Phys.* **73**, 229 (1848); *Wilhelm Weber's Werke*, Vols. 1-6 (Julius Springer, Berlin, 1893).
2. G. T. Fechner, *Ann. der Phys.* **64**, 337 (1845).
3. E. Whittaker, *A History of the Theories of Aether and Electricity* (Thomas Nelson, London, 1951).
4. R. Sansbury, *Rev. Sci. Instr.* **56**, 415 (1985).
5. W. F. Edwards, C. S. Kenyon, and D. K. Lemon, *Phys. Rev.* **D14**, 922 (1976).
6. J. C. Curé, paper to be submitted for publication.
7. V. Bush, *J. Math. Phys.* **5**, 121 (1926).
8. A. K. T. Assis, *Phys. Lett. A*, **136**, 277 (1989).
9. W. Kaufmann, *Gött. Nachricht.* 143 (1901), 291 (1902), 90 (1903); *Ann. der Phys.* **19**, 487 (1906).
10. A. H. Bucherer, *Ann. der Phys.* **28**, 585; **30**, 974 (1909).
11. E. Hupka, *Ann. der Phys.* **31**, 169 (1910).
12. A. Bestelmeyer, *Ann. der Phys.* **30**, 166 (1909); **32**, 231 (1910).
13. G. Neumann, *Ann. der Phys.* **45**, 529 (1914).
14. C. E. Guye, S. Ratnowsky, and Lavanchy, *Mém. Soc. Phys. Genève*, **39**, 273 (1921).
15. R. A. Tricker, *Proc. Roy. Soc.* **A109**, 384 (1925).
16. C. T. Zahn and A. H. Spees, *Phys. Rev.* **53**, 357, 511 (1938).
17. M. M. Rogers, A. W. McReynolds, and F. T. Rogers, *Phys. Rev.* **57**, 379 (1940).
18. P. S. Faragó and L. Jánossy, *Il Nuovo Cimento*, **5**, 1411 (1957).
19. A. Sommerfeld, *Ann. der Phys.* **51**, 1 (1916).
20. A. K. T. Assis, *Found. Phys. Lett.* **2**, 301 (1989).
21. E. Mach, *The Science of Mechanics*, 8th ed. (F. A. Brockhaus, Leipzig, 1921).
22. J. P. Wesley, *Phys. Essays*, **1**, 85 (1988).
23. J. P. Wesley, *Found. Phys.* **10**, 503 (1980).
24. S. Marinov, *Spec. Sci. Tech.* **3**, 57 (1980).
25. J. P. Wesley, *Found. Phys.* **16**, 817 (1986); *Causal Quantum Theory* (Benjamin Wesley, 7712 Blumberg, West Germany,

1983) pp. 159-163.
26. W. Voigt, *Gött. Nachricht.* 41 (1887).
27. T. E. Phipps, private communication.