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Experience, Reason and Simplicity Above Authority

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Contents

Editorial Policy

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it expects to publish papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers will be reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* will generally be limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

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All papers are expected to be in the realm of physics, mathematics, astronomy or engineering; non-mathematical, philosophical considerations will generally not be accepted unless they are fairly short and have something new and outstanding to say.

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The Double-Slit Paradox

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Summary: It is shown directly from the Maxwell equations that the velocity of an electron with average v will oscillate about that value, giving rise to a non-radiating electromagnetic wave in the neighborhood of the electron. The oscillations are characterized by the de Broglie relation, which is normally simply postulated. Applying the result, the wave-particle paradox of electron diffraction by a double slit is resolved: the electron goes through only one aperture, but the wave surrounding it is diffracted by both of them. In the neighborhood of the electron the group velocity of the diffracted field is slowed to that of the electron, giving rise to the observed diffraction pattern.

1. Introduction

When a stream of electrons is "diffracted" by an object such as a crystal lattice or an aperture, it gives rise to an interference pattern reminiscent of the diffraction of waves. Since electrons are also known to be particles, this has given rise to the "Duality Principle," according to which electrons have the properties of both waves and particles.

These properties, however, are mutually exclusive, for there are at least three such properties (not counting the disputed capacity to interfere) that make a wave incompatible with a particle:

- A wave can be split into two or more parts.
- A wave does not attract or repel other waves.
- A wave is attenuated by natural dispersion even in a lossless medium.

The inconsistency of the Duality Principle appears particularly blatant in the case of an electron beam passing through two slits and producing an interference pattern that is, except for the wavelength, identical to that produced by light passing through two slits. The accepted explanation is that each electron, though it passes passes through only one of the slits, *interferes with itself.*

Such explanations seem to violate the basic faith of science in the uniformity of nature. Moreover, the Duality Principle lacks the explanation offered for some other surprising results of quantum mechanics by the Correspondence Principle: *all* nature behaves in the same way, but in the macroworld we live in we are merely used to the averages of very large numbers of microeffects. However heretic the opinion may seem, it appears that the Duality Principle simply uses words to paper over the (at least) three incompatibilities mentioned above.

In the following an alternative explanation is offered. It first derives, directly from the Maxwell equations, the natural oscillations that an electron (or other charged particle) must undergo when it moves with velocity $\mathbf{v}$, which turns out to be the mean velocity about which the instantaneous velocity fluctuates. This gives rise to a standing spherical electromagnetic wave centered at the electron and moving with it. Thus, a moving electron is always *accompanied* by an electromagnetic wave around it, which explains the correct predictions of the Duality Principle. In particular, in the double-slit paradox, the electron goes through only one of the slits, but its surrounding wave goes through both, the *two* diffracted waves interfering by the usual rules of physical optics. The reason why the wavelength is shorter than the free-space wavelength is that in the neighborhood of the electron the diffracted waves are slowed to the velocity of the electron; and the reason why the oscillating (accelerated) electron does not radiate is that it is undergoing natural, not forced, oscillations — akin to the electron oscillations in a matched transmission line, whose fields do not radiate either.

2. Electron Oscillations

Let an observer's inertial frame be fixed with respect to the earth's gravitational field (or even to an ether entrained by the earth) to make it acceptable to all relativity theories, and let an electron traverse this rest frame with velocity $\mathbf{v}$.

The reason why the electron undergoes natural oscillations is essentially the same as in the case of a tuned circuit, for a moving electron exhibits self-inductance and stores its electrical energy in space rather than a man-made capacitor. The inductance comes about as follows: as the electron accelerates (from its original rest position, for example), a magnetic field builds up, which by Faraday's Law induces an electric field opposed to the change and eventually decelerating the electron. This decreases the magnetic field and induces a Faraday field accelerating the electron again. Thus the instantaneous velocity oscillates about a mean velocity.

No energy is lost in these oscillations, for the energy of the oscillating field simply moves between the magnetic and electric field surrounding the electron; since the two are 90° out of phase, the direction of the Poynting vector oscillates back and forth rather than being constant as it is in the case of radiation.

It is true that radiation occurs only when a charge is accelerated; but the converse, that an accelerated charge *must* radiate, does not hold, as demonstrated by the electrons in any well-terminated transmission line. What we have here are the *natural* oscillations of an electron rather than the forced ones in an antenna.

To formulate these ideas quantitatively, we shall use Poynting's Theorem to find the total energy of a moving electron in terms of its velocity and show that the latter satisfies the differential equation for sinusoidal oscillations.

First, we note that the electric field in Maxwell's equations is the sum of two fields, the irrotational Coulomb field and the Faraday field whose curl is proportional to the rate of change of the magnetic field:

$$\mathbf{E} = \mathbf{E_c} + \boldsymbol{\psi} \quad (1)$$

where the Faraday field, in terms of the static potential ϕ and the vector potential $\mathbf{A}$, is

$$\boldsymbol{\psi} = -\frac{\partial \mathbf{A}}{\partial t} = -\frac{\partial}{\partial t}\frac{\phi \mathbf{v}}{c^2} \approx -\frac{\phi}{c^2}\frac{d\mathbf{v}}{dt} \quad (2)$$

Since the velocity of a charge does not change the energy of its Coulomb field, we need not concern ourselves with it (or: we investigate only the electron's *excess* energy above its Coulomb energy). Moreover, since the Maxwell equations are linear, they must by (1) hold if we replace $\mathbf{E}$ by its linear component $\boldsymbol{\psi}$ in them. Hence the electric energy density of interest is

$$\tfrac{1}{2}\epsilon\psi^2 = \frac{\epsilon\phi^2}{2c^4}\dot{v}^2 \quad (3)$$

To find the magnetic energy density, we use the well known formula [which follows on substituting (2) in $\boldsymbol{\psi} = \nabla \times \mathbf{A}$ and expanding the curl]

$$\mathbf{B} = \frac{\mathbf{v} \times \mathbf{E_c}}{\mathbf{c^2}} \quad (4)$$

to obtain the magnetic energy density (with θ the angle made by $\mathbf{v}$ and $\mathbf{E_c}$)

$$\tfrac{1}{2}\mu H^2 = \frac{{E_c}^2 \sin^2\theta}{2c^4}v^2 \quad (5)$$

Now consider the Poynting-Heaviside Theorem derived in the usual way from the Maxwell equations with $\boldsymbol{\psi}$ substituted for $\mathbf{E}$ as explained above:

$$\iint (\boldsymbol{\psi} \times \mathbf{H}) \cdot d\mathbf{S} + \iint \mathbf{J} \cdot \boldsymbol{\psi} dV = -\frac{\partial}{\partial t}\iiint [\tfrac{1}{2}\epsilon\psi^2 + \tfrac{1}{2}\mu H^2]dV \quad (6)$$

where the integration is performed over all space outside a small sphere surrounding the electron in a coordinate system moving with the average position of the electron, and v is the electron's velocity with respect to that system.

The right side of (6) is the change in total energy within the volume V. If this is to be conserved, the right side must vanish. On substituting (3) and (5) in the non-negative integrand, it follows that

$$\frac{\partial}{\partial t}(C_1\dot{v}^2 + C_2 v^2) = 0$$

where the constants C_1 and C_2 are by (3) and (5) positive. Performing the differentiation, canceling by $2\dot{v}$ and setting the positive ratio $C2/C1 = \omega^2$, we have

$$\ddot{v} + \omega^2 v = 0 \quad (7)$$

where v is the velocity with respect to the moving system; if that system moves with velocity v_0 (about which the electron velocity fluctuates) with respect to the laboratory, we need only replace v in (7) by $v - v_0$. Choosing the time origin so that only the sine is retained, (7) yields

$$v = v_0(1 + A\sin\omega t) \quad (8)$$

where the constant A can be shown small (of order $\beta^2 = v^2/c^2$, [1]), but will not be further needed here.

Thus, as expected from physical considerations, the velocity of an electron moving through the laboratory fluctuates sinusoidally about an average velocity v_0 as a small part of the field energy moves back and forth between the magnetic field and the induced Faraday field.

Let the frequency of these natural oscillations be $\nu = \omega/2\pi$; then the distance λ between two successive points along the electron path where the velocity attains an extreme value (the "electron wavelength") is related to the velocity $v \approx v_0$ by elementary ***kinematic*** (not electromagnetic!) considerations through

$$v = \lambda\nu \quad (9)$$

a relation reminiscent of, but not to be confused with,

$$c = \Lambda\nu \quad (10)$$

where Λ is the free-space wavelength of a radiated electromagnetic wave with frequency ν.

There is a relation between the electron wavelength λ and its energy. As an electron is accelerated from velocity 0 to v, it acquires both kinetic and magnetic energy. The latter can be found by integrating the magnetic energy density (5) over all space (volume element $2\pi r^2 \sin\theta\, dr\, d\theta$) surrounding a charged sphere (the electron) with radius R :

$$T_{mag} = \iint \tfrac{1}{2}\mu H^2\, dV = \int_R^\infty \int_0^\pi \frac{v^2 E_c^2 \sin^3\theta \pi r^2}{\mu c^2}\, dr\, d\theta = \frac{\mu q^2}{12\pi R}v^2 \quad (11)$$

where we have substituted for the Coulomb field E_c and used the relation $c^2 \doteq 1/\epsilon\mu$.

It will be seen that the quantity

$$m_{elmag} = \frac{\mu q^2}{12\pi R} \quad (12)$$

plays the role of a mass: it resists acceleration of an electric charge in exactly the same way as the Newtonian mass m_N resists acceleration of uncharged matter. ΩThe total energy of the electron, kinetic plus magnetic, is therefore on using (9)

$$T = \tfrac{1}{2}(m_{elmag} + m) = \tfrac{1}{2}m_t\lambda v\nu \quad (13)$$

where m_t is the sum of the two masses. This may be written as

$$T = h\nu \quad (14)$$

where

$$h = \tfrac{1}{2}m_t\lambda v \quad (15)$$

It appears from experimental measurements that for an electron the two masses are equal, so that $m_t = 2m$, for in that case we have

$$h = m\lambda v \quad (16)$$

where h is Planck's constant and (16) is the de Broglie relation. However, as far as this paper is concerned, h is a humble constant of proportionality, and (16) is a special case of (15) for equal masses. This attitude is adopted to dispel suspicions that the results of quantum mechanics are somehow being used in the following.

3. Electron Diffraction

An electron beam passing through an aperture is subject to widening (divergence). The beam has a non-zero cross section, so that only with zero probability will the center of an electron coincide with the center point or line of the aperture. Any other electron is in an asymmetrical position with respect to the aperture, causing an electrostatic force to bend its path toward the nearest edge, thus causing an originally parallel beam to diverge.

To formulate this quantitatively, consider a circular aperture with radius R_a and an electron going through it at a distance r_1 from the center. The force on the electron is easily calculated by the method of images: the force is the same as that exerted by an equal charge of opposite sign at a distance r_2 such that $r_1 r_2 = R^2$. [2]. The distance between the two charges is therefore $\rho = (R^2 - r_1^2)/r_1$, and if the thickness of the screen containing the aperture is τ, the momentum of the electron perpendicular to its original path is (on neglecting edge effects, i.e., assuming that the electron is acted on only while it goes through the aperture)

$$I_x = \int F_x \, dt = \frac{K\tau}{\rho^2 v} \tag{17}$$

where v is the electron's velocity and $K = 1/(4\pi\epsilon_0)$ is the constant in Coulomb's Law. Dividing this by the momentum mv in the direction of arrival (perpendicular to the plane of the aperture), the angle ϕ by which the electron deviates from the original direction is

$$\tan\phi = \frac{K\tau}{\rho^2 m v^2} \tag{18}$$

This shows that an electron beam will disperse on passing through an aperture; however, because edge effects were replaced by discontinuities, the formula should be considered only as a qualitative guide.

Now consider an electron moving along such an off-center direction accompanied by its own oscillating field described in Section 2. As the electron approaches and transverses the aperture, this wave will induce currents in the edges of this and nearby apertures. When such currents are induced by an incident electromagnetic wave from a *distant* source, they re-radiate waves producing the well understood interference patterns of physical optics.[1] The only remarkable thing here is that since the incident wave, as shown in Sec. 2, has its electric and magnetic fields shifted by 90°, the same will be true for the reradiated, interfering waves. However, the presence of the electron with its accompanying wave changes the interference field in its neighborhood: the group velocity of the interfering waves is slowed down from the free-space velocity c to velocity of the electron.

The net force of the electromagnetic field generated by the electron oscillations on the electron in the x direction is zero, and in the following we disregard it as a linear superposition on the other fields that does not modify them, nor does it result in a deviation of the electron path from the direction in which it emerges from the aperture.

The remaining fields are (1) the plane waves (in the Fraunhofer zone) radiated from the slits $(\mathbf{E}, \mathbf{B})$, and (2) the fields of the electron caused by its motion under the action of the fields (1). The resulting magnetic induction is thus on using (4)

$$B_t = B + \frac{v_x q^2 \sin\theta}{4\pi\epsilon r c^2} = B + \frac{v_x \mu q^2 \sin\theta}{4\pi r^2} \tag{19}$$

where B is the z component (the only component) of $\mathbf{B}$ of the plane wave propagating in the y direction, v_x is the velocity imparted to the electron by this plane wave, and r, θ are polar coordinates in the x, y plane, centered in the electron.

For differentiating this with respect to time, we note that

$$\frac{dv}{dt} = \frac{qE}{m} = \frac{6\pi RE}{\mu q} \tag{20}$$

where we have used (12) and multiplied by two since the force involves the sum of the electromagnetic and Newtonian mass. For harmonic variation with time at frequency ω this yields

$$\mu\frac{\partial H_t}{\partial t} = i\omega\mu H + \frac{3RE\sin\theta}{2r^2} \tag{21}$$

We now come to a small, but critical detail, which may well explain why this simple calculation, which must surely have been performed some 70 years ago, failed: to substitute for E, we must not use $E = HZ$, where $Z = \sqrt{(\mu/\epsilon)}$ is the impedance of free space, since E and H are, for the reasons given qualitatively in Sec. 2 (and more rigorously in [1]), 90° out of phase. Hence $E = iHZ$ (not HZ), so that

$$\nabla \times \mathbf{E} = i\omega\mu\mathbf{H}\left(1 - \frac{3Rc^2\sin\theta}{2r^2\omega}\right) \tag{22}$$

and the others are unaltered. But this is the equation for an electromagnetic field in a medium with modified permeability, and hence modified index of refraction

$$n = \sqrt{\mu'\epsilon'} = 1 - \frac{3Rc^2\sin\theta}{2r^2\omega} \tag{23}$$

where μ' and ϵ' are the relative permeabilitiy and relative permittivity, respectively.

The rest is well known from ionospheric propagation and plasma physics. At a distance

$$r = \sqrt{\frac{3Rc^2}{2\omega}} \tag{24}$$

the refractive index (23) vanishes, indicating that the wave has come to a "standstill" with respect to the electron, which means that *its group velocity has been slowed down to the velocity of the electron.* For values of r smaller than (24), the index (23) turns imaginary, implying an attenuated wave (of the same velocity); for values greater than (24) the group velocity increases, until for sufficiently large r, as can be seen from (23), the index of refraction reaches its free-space value 1, and the electromagnetic wave becomes an unperturbed free-space plane wave again.

To map the field in detail, we note that the surfaces of constant phase for a plane wave propagating in the y direction (up) are given by $i(\omega t - ky) =$ const, or $ny =$ const. From (23) and $y = r\sin\theta$ we then obtain the family of curves of constant phase shown in Fig.1.

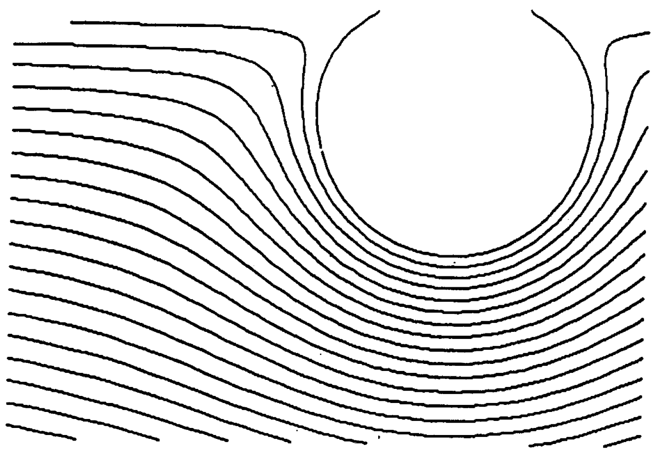

Fig.1. Plot of lines of constant phase. The unperturbed wave (left) is slowed down the neigborhood of the electron, resulting in compression of its wavelength. The mapping was calculated by substituting (23) in the condition of phase constancy.

For $\beta = v/c = 0.1$, we find on using (16) and (12) that the critical value (24) is reached at a distance of order $10^{-12.5}$ m from the electron — 3 milliangströms or less than 0.1 of a Bohr radius, i.e., in the immediate neighborhood of the electron. At a distance of 10^{-12} m the group velocity of the wave radiated from the slits is already up to 90% of its free-space value c, and at 10^{-11} it is up to $0.999c$.

Now consider how two such plane waves, slowed down in the neighborhood of the electron, will interfere, when their wavelength decreases from Λ to λ as they propagate from the slits to the electron. Let r now stand for the distance to the electron, with r_1 and r_2 the distances from the two slits, and let $L(r)$ be the function describing the wavelength, so that

$$L(0) = \Lambda, \qquad L(r_1) \approx L(r_2) = \lambda \tag{25}$$

Then the phase difference between the two rays at the electron is

$$\Delta\Phi = 2\pi \int_0^{r_2} \frac{dr}{L(r)} - 2\pi \int_0^{r_1} \frac{dr}{L(r)}$$
$$= 2\pi \int_{r_1}^{r_2} \frac{dr}{L(r)} = \frac{2\pi}{\lambda} \tag{26}$$

where the last equality follows from (25). The acceleration (20) of the electron is, since **E** is sinusoidal in time, proportional to its position; it is determined by the amplitude of the **E** resulting from the interference pattern of the two plane waves; the maxima of these plane waves travel with the *group* velocity determined by the index of refraction (23); and the wavelength determining the interference pattern in the neighborhood of the electron is by (26) the de Broglie wavelength λ. All of this agrees with the diffraction pattern observed in the diffraction of electrons.

4. Conclusions

The derivation given above needs no additional postulates to supplement recognized physical principles such as the validity of the Maxwell Equations. In particular, it does not demand that the two mutually exclusive concepts of particle and wave be decreed identical.

This derivation rests on the electron oscillations deduced directly from the Maxwell equations in Sec. 2. They were used here only to explain electron diffraction, but their general use is more fundamental: [1]

- The derived (rather than postulated) de Broglie relation (16) quickly leads to a derived Schrödinger Equation, in which the "wave function" ψ is simply the Faraday field generated by the electron oscillations;
- the existence of the electron oscillations, which (barring a mathematical error) are as valid as the Maxwell Equations, refute the idea that the velocity implicit in these equations — namely, in $\mathbf{J} = \rho\mathbf{v}$ and in the magnetic part of the Lorentz force $\mathbf{v} \times \mathbf{B}$ — is the velocity with respect to an *observer* , for an observer moving with the electron, unlike observers in other inertial frames, would see no such oscillations, thus killing the Relativity Principle. Hence the (undisputed) fact that the Maxwell Equations are Lorentz-invariant is reduced to a trivial curiosity; the Relativity Principle then requires that the velocity that makes the Maxwell Equations valid be a velocity relative to some *objective* standard or medium — the medium with respect to which the velocity of light is constant.

The hypothesis consistent with all the available experimental evidence is that the velocity of light is constant with respect to the local gravitational field through which it propagates [1].

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[1] P. Beckmann, *Einstein Plus Two*, Golem Press, Box 1342, Boulder, CO 80306.

[2] Becker, *Electromagnetic Fields and Interactions*, Dover Publ., New York, 1964, pp.75–77.

[3] J.A. Stratton, *Electromagnetic Theory*, McGraw Hill, New York, 1941, pp.327–333,

NOTES

[1] This formulation in terms of edge currents is equivalent to (and possibly nearer physical reality than) Huygens' principle as applied to apertures.

The Role of Inertial Force in Energy Exchanges

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Summary: The simplest concept of physics is that of the equality of the forces of action and reaction. If two objects interact by contact, an equality of magnitudes between the applied and inertial forces is required. The applied force does work upon the object with which it is in contact. The inertial force, it is thought, does no work. The problem is how to define which force is the one applied and which object exerts the inertial force. In the absence of an external reference frame, we can say the second object was at rest when it was struck by the first. Therefore the inertial force was generated by the second object. The viewpoint that the second object was struck by the first is just as valid, but requires that the inertial force should be generated by the first object. Since it is impossible to define which which force is inertial, and which is not, we abandon the concept that the inertial force does no work. The analysis then leads to the internal energy of matter.

1. Introduction

The point of failure of classical mechanics can be found by the analysis of a force **F** applied to an object as in Fig.1. For an applied force **F**, we have

$$\mathbf{F} = m\mathbf{a} \qquad (1.1)$$

where **a** represents the acceleration and m is the mass of the object. Use of the linear acceleration formula

$$v^2 = {v_0}^2 + 2as \qquad (1.2)$$

for an object initially at rest yields

$$Fs = mas = \tfrac{1}{2}mv^2 \qquad (1.3)$$

to represent the work done in the process of putting the object into motion with a final velocity v. The interpretation of (1.3) as the kinetic energy added then yields

$$E_k = \tfrac{1}{2}mv^2 \qquad (1.4)$$

Then we conclude that whatever energy the object may have had in the beginning is augmented by the addition of the energy given by (1.4). If this is the case, the hypothetical limit of infinity is implied.

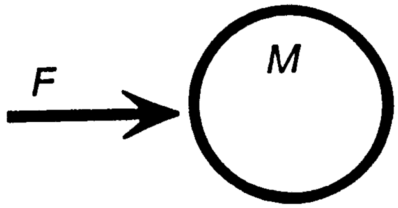

Fig. 1

2. Inertia

Certain questions may be asked. The first one is concerned with the origin of the force applied. If it is a field force, there must be an object to generate the field. If it is a contact force, there must be an object to make the contact. In either case a second object is required. It follows that Fig. 1 represents an impossible abstraction. The simplest system which can be considered is that of two objects with forces acting between them. Such a representative system is shown in Fig.2.

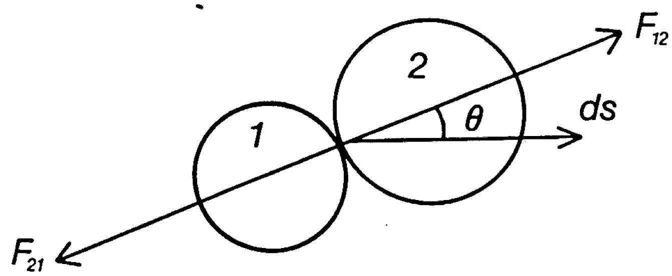

Fig. 2

In order to make the analysis as simple as possible, we assume contact forces only. Further, we assume frictionless surfaces so that tangential components can be neglected. In this case, the line of action of the forces is that connecting mass centers. In order to generalize, a glancing impact is assumed. We assume object *1* moving in the direction of ds. The force $\mathbf{F}_{12}$ is that force which object *1*exerts on object *2*on impact. In this case $\mathbf{F}_{21}$ must be considered the inertial force that object *2*exerts upon the acting object *1*. The fallacy of classical mechanics is that the inertial force does no work. Since action and reaction are equal and opposite, we write

$$\mathbf{F}_{12} + \mathbf{F}_{21} = 0 \qquad (2.1)$$

In this case the work integral becomes

$$\int_0^s (F_{12} + F_{21}) \cos\theta \, ds = 0 \tag{2.2}$$

where s represents the distance through which contact is maintained and θ is the angle of the line of forces with respect to the direction of motion. Then we have

$$\int_0^s F_{12} \cos\theta \, ds = -\int_0^s F_{21} \cos\theta \, ds \tag{2.3}$$

The left member of equation (2.3) is a positive work integral by the hypothesis that F_{12} is positive. It is identified as the work that object *1* does on object *2* during contact. Since F_{21} must be negative by (2.1), the negative sign before the right member of (2.3) renders the integral positive. By the fact that the reactive force F_{21} is involved, this integral is defined as the work that object *2*does on object *1* . Then we write

$$W_{12} = W_{21} \tag{2.4}$$

This equation requires that the acting object has just as much work done upon it as it does upon the object which it strikes.

2. Internal Energy

We are now in a position to analyze energy exchanges. We consider two types of energy to exist. These are kinetic and potential energies. Assuming object *2*initially at rest, it must have gained kinetic energy. However, (2.4) requires that it lost as much energy as it gained. This can be true only if it lost potential energy since it had no kinetic energy to lose. The analysis of the impacting object requires that it should lose kinetic energy and gain an equivalent amount of potential energy.

This analysis reveals that the interior of matter as an energy reservoir. In the absence of external potential energy fields, we can only say that the act of putting an object into motion resulted in the reduction of internal energy. By the same analysis, we can state that the reduction of the energy of motion of object *1* resulted in an increase in the internal energy of that object.

In view of the above discussion, we observe that the total energy of an object is implied to be a constant. In this case we may be inclined to question the variation of mass with velocity as given by Einstein. Further analysis is now indicated.

We extend the analysis of impact and contact forces to include the action of fields. The analysis of impacts indicated an energy conservation law. By analogy, we write

$$E_p + E_k = E_{p0} \tag{3.1}$$

as applied to the conservative field. The interpretation of (3.1) is that of a free fall. If an object is raised to any elevation in the field and then released, potential energy of position is reduced as the kinetic energy of motion is increased in such a manner that the original value of E_{p0} is preserved.

The difficulty is that E_{p0} varies with elevation. As applied to the earth's gravitational field, it is given the value zero at infinity and and is negative at all other points. Since the implication is that the object is stopped at a point of elevation in order to fall from that point, we must consider radiation of energy from the object to have occurred in the process of bringing it to rest in a field. We would like to be able to analyze radiation terms.

4. Radiation mass increase

The analysis of impact suffers from the fact that no radiation loss from the system was indicated. As it stands, the energy condition is equivalent to that of free fall. Since impact results in radiation, and retardation from free fall results in radiation, we see that the analysis of impact is equivalent to that of short range field forces. The fact that (1.4) yields experimentally correct results is in itself an indication of the relatively enormous internal energy which must be involved in the creation of matter.

In order to analyze mass changes, we write

$$\mathbf{F} = \frac{d}{dt}(m\mathbf{v}) \tag{4.1}$$

which reduces to (1.1) in the case of a constant mass. The use of

$$dE = c_0^2 dm \tag{4.2}$$

and

$$F\,ds = dE = \frac{ds}{dt}\,d(mv) = v\,d(mv) \tag{4.3}$$

then yields

$$c_0^2\,dm = v\,d(mv) \tag{4.4}$$

[To dispel the suspicion of circularity, it should be pointed out that (4.2) can be derived in a number of ways that do not use the Einstein theory.]

If (4.4) is multiplied by the integrating factor m, we have

$$c_0^2 m\,dm = mv\,d(mv) \tag{4.5}$$

or in integrated form

$$c_0^2(m^2 - m_0^2) = m^2 v^2 \tag{4.6}$$

this yields the mass form

$$m = \frac{m_0}{\sqrt{1 - v^2/c_0^2}} \tag{4.7}$$

where m is the final mass and m_0 is the mass applying to a condition of rest. The energy form is then

$$mc_0 = \frac{m_0 c_0^2}{\sqrt{1 - v^2/c_0^2}} \tag{4.8}$$

where c_0 represents the uncontracted velocity of light. We conclude by (4.8) that if radiation is absorbed by an object the resulting mass increase is given by (4.7).

5. Free fall

If an object falls from rest at infinity the Relativity firm may be written

$$m_0 c_0^2 + E_{p0} = \frac{m_0 c_0^2}{\sqrt{1 - v^2/c_0{}^2}} \tag{5.1}$$

This equation uses the results of (4.8), but is in error by the fact that free fall occurs without an energy increase. If we write

$$(m_0c_0^2 + E_{po})\sqrt{1 - v^2/c_0^2} = m_0c_0^2 \qquad (5.2)$$

the right member if the equation expresses the fact that the rest of the energy is conserved. The symbol E_{p0} in this case is the uncontracted potential energy change that must occur in the process of falling. The kinetic energy of motion is given by

$$E_{p0}\sqrt{1 - v^2/c_0^2} = m_0c_o^2(1 - \sqrt{1 - v^2/c_0^2}) \qquad (5.3)$$

We conclude that in the case of free fall, the mass of an object is a constant independent of velocity.
Ω

6. Radiation loss

Equation (5.3) is subject to another interpretation. If we write

$$\left(m - m_0\sqrt{1 - v^2/c_0^2}\right) c_0^2 = \Delta m c_0^2 \qquad (6.1)$$

we then have

$$(m - m_0)c_0^2 = \Delta E \qquad (6.2)$$

where the reduced mass is given by

$$m = m_0\sqrt{1 - v^2/c_0^2} \qquad (6.3)$$

and (6.2) represents a radiation element.

If an orbit is to be formed, the velocity of an object in a field must be reduced below that of free fall. In order that this may occur, the object must radiate energy. Then we modify (5.2) in the form

$$(mc_0^2 + E_{p0} - K)\sqrt{1 - v^2/c_0^2} = mc_0^2 \qquad (6.4)$$

where the radiation term K is given by

$$K = mc_0^2\left(1 - \sqrt{1 - v^2/c_0^2}\right) \qquad (6.5)$$

for any general mass m.The use of (6.5) in (6.4) then yields

$$E_{p0}\sqrt{1 - v^2/c_0^2} = mv^2 \qquad (6.6))$$

When (6.3) is applied, we find

$$E_{p0} = m_0v^2 \qquad (6.7)$$

This may be written as

$$\frac{Gm_em_0}{r} = m_0v^2 \qquad (6.8)$$

as applied to the earth. Then we have confirmation of the centrifugal force form for circular orbits

$$\frac{Gm_em_0}{r^2} = \frac{m_0v^2}{r} \qquad (6.9)$$

7. Summary of results

To this point we have found three mass transformations, all of which are valid for certain conditions of existence. We write

$$\left.\begin{aligned} m &= \frac{m_0}{\sqrt{1 - v^2/c_0^2}} \\ m &= m_0 \\ m &= m_0\sqrt{1 - v^2/c_0^2} \end{aligned}\right\} \qquad (7.1)$$

In terms of field theory, we interpret the first as applying to a collapsing field in which the object is driven to a velocity higher than that of free fall. The second applies to free fall in a static field, and the third applies to a condition of retardation below that of free fall in the field. There is no indication that an infinite energy can be applied to an object as required by (1.4) for v approaching infinity. Further, there is no indication that an object at the velocity of light must have infinite mass. If a particle is accelerated in the collapsing field of a particle accelerator, a mass increase is indicated. The possibility of zero mass by radiation of the total energy also appears. The conclusion is that Relativistic Mechanics as well as classical mechanics must be reinterpreted. If the radical appearing on the right of (5.3) is expanded with the assumption that v is small, the expression for the kinetic energy of free fall reduces to that given by (1.4) to an accuracy of about one percent for velocities less than the velocity of light. It follows that (1.4) must must yield experimentally correct results within this limit, but is not valid for greater velocities.

8. Concluding remarks

The most glaring error in present theory is that an object at the velocity of light must have infinite mass. The analysis presented here corrects that error. As applied to space travel, a rocket system in outer space is isolated from the rest of the universe in such a manner that a condition equivalent to free fall must apply at all times.

EXPERIMENTUM CRUCIS

The following letter by Prof. Howard C. Hayden was sent to a number of physicists and scientists, both orthodox and dissident. It was received by this editor via Usenet on 28 August 1989, at a time when it was still quite unknown what the outcome of the experiment would be.

Gentle Folks,

I am taking this time to write up a little blurb about an experiment which I am currently doing. It's a Trouton-Noble experiment with 10,000 times the sensitivity of the original 1903 experiment. It is not merely an exercise in high precision, but an experiment relating to a fundamental interaction, and may say something about relativity theory. At least the original was taken as some sort of proof of the veracity of relativity theory.

But first, a few words of background.

Introduction

There were several "ether drift" experiments performed in the late 19th and early 20th centuries, including the Michelson-Morley and the Trouton-Noble experiments, all yielding "null" results. The question raised by many (Beckmann, Zapffe, ...) is whether the null results occurred because the effect is zero or because nothing moved. For example, a speed of sound experiment performed inside a moving train would not detect the velocity of the train through the air, simply because there is no velocity of the train with respect to that entrained air.

All experiments performed were fully consistent with the entrained ether model which Michelson seems to have preferred. The trouble with entrained ether is that it would be carried with the earth, even on mountain tops, but could not rotate with the earth. If one imagines the electromagnetic ether to be a "fluid" pervading all space, these problems make it seem a bit ludicrous. However, if the electromagnetic ether is the local gravitational field (Beckmann) or the geomagnetic field (Zapffe), the properties required for the ether are quite naturally met.

In ether drift experiments it has been customary to ignore the rotational velocity of the earth, because the velocity (350 m/s as 40 degrees latitude) is small compared to the orbital velocity of 30,000 m/s, which in turn may be small compared to the velocity of the solar system through "space". The background blackbody radiation is decidedly not isotropic, and corresponds to a Doppler shift due to a velocity of about 400,000 m/s in the direction of the Virgo Cluster.

In an entrained ether model, however, the large orbital and possibly larger space drift velocity should produce no effects, but the rotational velocity should. A speed of sound experiment done on a cart moving through a train should detect the velocity of the cart with respect to the train, but not the larger velocity of the train with respect to the grazing cows.

It is therefore interesting to investigate whether some decisive experiments might be done which might detect the small rotational velocity. It usually comes as a surprise to physicists educated with the canonical texts that some experiments have already been done, with non-null results.

Speed of light on the rotating earth

It is widely unknown, but experimentally demonstrated in three experiments published in refereed journals, that on the rotating earth, the speed of light is NOT isotropic (i.e., the speed of light is not the same in all directions). I discuss these in non-historical order:

1) The Hafele-Keating experiment [*Science* **177**, 166 (1972)] was the well-known but rarely read one in which atomic clocks were carried around the world on commercial aircraft. What everybody knows is that the results "supported" special relativity theory, but what practically nobody knows is that the westbound clocks ran *faster* than the laboratory clock. In order to explain it, special relativity theory (SRT) invokes a preferred reference frame, one which does not rotate with the earth: moving successively faster, and with clocks successively slower are the west-bound clock (still moving east), the lab clock, and the east-bound clock.

Let us ignore that explanation for a moment, and address the question of what happens in the frame of the rotating earth. Go immediately to Washington DC, and head to the Naval Observatory where there are lab reference clocks. Sit down at a desk, pick up any elementary physics text or relativity text, and follow the derivation from whence relativity theory begins. Light speed is constant, and as a result, moving clocks are slowed, *independently* of direction. That is, west-bound clocks are slowed the same as east-bound ones. Data say otherwise. *QED*.

There is a proof, for anyone who wants it, that the speed of light *cannot* be constant with respect to the lab in Washington.

2) In an experiment whose sensitivity has been unapproached in six decades, including three decades of lasers, Michelson and Gale measured the phase difference between light traveling clockwise and counterclockwise around a rectangle of dimensions about 1000 ft by 2000 ft, at about 40 degrees latitude. There *is* a phase shift; the results are not null. The result is fully consistent with a velocity of $c - v$ for light traveling east and $c + v$ for light traveling west, where is the rotational velocity rho omega at that latitude. (v is not the same on the northern as on the southern leg.) The measurement was accurate enough to determine omega to ±3%.

3) Brillet and Hall [*Physical Review Letters* **42**, 549 (1979)] did a quasi-Michelson-Morley experiment with a laser mounted on a turntable, and a Fabry-Perot interferometer for a length standard. To make a long story short, they measured a frequency shift as a function of laboratory angle, translated the lab angles to sidereal angles, and concluded that no frequency shift exists.

I quarrel with their analysis of the data, and will here show why. Imagine a Michelson-Morley experiment performed with infinite precision, and the job is to measure effects due to the rotation of the earth. When the two axes are at 45° to the compass points, the round-trip travel time is identical for both paths. Maximum shifts should occur for both the east-west and the north-south orientations of either arm of the apparatus. Introduce some noise W (for bath Water), and the 45° orientations yield W. The 0, 90, 180 or other angle orientations yield $W + B$ (for Baby, the signal). Subtract, and you get B; it is the effect due to the rotation of the earth.

But this is not what Brillet and Hall did. Take the *plot* implied above of frequency shift versus lab angle. It is $A \cos 2\theta$, (signal B, a function of θ) + noise (W). When the data are retaken (say) 6 hours later, the lab angles correspond to different sidereal angles, but by the present model, still $W + B$. The B&H analysis is (in effect) to subtract the earlier $W + B$ (the whole plot) from the later value of $W + B$, and not surprisingly, they get zero. The baby went out with the bathwater.

Brillet and Hall do give one graph with the laboratory referenced data; it is most assuredly *not* isotropic in the laboratory frame, and is within a factor of 2 (with noise that large) of equalling the frequency shift ($A \cos 2\theta$) which would occur if the velocity of light adds vectorially with rotational velocity.

Results: the measured velocity of light on the rotating earth is the vector combination of light velocity and rotational velocity.

What motivates this whole problem is Petr Beckmann's book (*Einstein Plus Two*, Golem Press, P. O. Box 1342 Boulder, CO 80306, 1987) which asserts that the constancy of the speed of light has never been proven. On that score he is more than correct. *In*constancy *has* been proven to anybody who cares to look at the data.

Trouton-Noble

Now to the experiment. Trouton and Nobel suspended a capacitor on a fine torsion fiber, charged the capacitor, and sought the torque which would be expected (in ether theory) to tend to align the capacitor plates perpendicular to the velocity vector through the ether. [F. T. Trouton and H. R. Noble, "The Mechanical Forces Acting on a Charged Electric Condenser moving through Space," *Phil. Trans. Roy. Soc. London*, hp2.A 202,:ehp2., 165-181 (1903).]

The theory is simple enough. A moving charge produces a magnetic field. A charge moving in a magnetic field experiences a force. In special relativity theory, of course, velocity is defined with respect to the observer, but in ether theory, velocity is defined with respect to the ether. (Either theory will give the same equation, but the definition for v is different.)

Take a charged multi-plate capacitor moving with velocity v, and do a line integral of H around a single plate where the loop is orthogonal to the velocity; the result is the current $I = dQ/dt$. The energy is $\frac{1}{2}H^2/\mu$, and the torque is $dU/d\theta$. Make a few substitutions, and the result is torque $= \frac{1}{2}CV^2(v/c)^2$, the energy times beta squared. The T-N experiment showed negligible torque, at least if one thought that the relevant velocity is the *orbital* velocity of the earth, 30,000 m/s.

Of interest is whether there is a torque occasioned by the *rotational* velocity of the earth, 350 m/s at moderate latitudes, and that is my experiment. In order to detect any torque, I must have about 10,000 times the sensitivity, since the velocity is about 100 times smaller. While T&N stored about 7 mJ on their capacitor, I am storing about 45 J on mine. I am constructing a feedback stabilizer, the output of which will be a voltage which will be proportional to restoring torque, and it should give me the requisite sensitivity.

If I succeed in getting the requisite sensitivity and stability, I can't lose. If I support special relativity theory, I do so with considerable improvement over the 1903 experiment. If the results do otherwise, that is interesting in itself.

I do have some preliminary data, but I won't tell you just now what they look like: 1) They are too preliminary, and I don't want to shoot from the hip. 2) I am interested in what *your* prediction is, and the reasons for it.

It is my (feeble) understanding that various versions of GRT make different predictions about the speed of light on a rotating planet, and they will undoubtedly make different predictions about the TN experiment in the same environment.

Prediction is difficult, particularly when it involves the future.

Best regards,

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BOOK REVIEW

Ian McCausland: *The Relativity Question*, Dept. of Electrical Engineering, University of Toronto, Toronto, Canada M5S 1A4.

Reviewed by Petr Beckmann

Herbert Dingle (1890–1978), Professor of Natural Philosophy at Imperial College, London, was an outstanding intellect who spent most of his life in association with the Einstein Theory. He started out as one of its most articulate exponents with a lucid book in 1922, but gradually realized that the theory was self-contradictory. He constructed a number of paradoxes, of which the clock paradox became the most famous. From about 1958 he tried to persuade the scientific community that the theory was untenable, crusading by articles, lectures and by his book *Science at the Crossroads* (1972). But the scientific community left his questions unanswered, preferring to ridicule, sidestep, and eventually to stonewall his challenges, treating him as an obstinate crank who had no understanding of the issues.

By this time the issue had become an ethical one: can the scientific establishment simply refuse to answer a simple question, or give a variety of mutually exclusive answers, or engage in other dishonest maneuvers to evade a simple argument, no matter whether it is correct or false? Dingle took this *ethical* complaint as high as the Archbishop of Canterbury; but in what must be judged as pure cowardice, he, too, evaded the challenge, quite falsely designating it a *scientific* issue.

Prof. McCausland, Dingle's personal friend with access to hitherto unpublished correspondence, traces the history of what is probably the simplest of Dingle's paradoxes: if two clocks travel in two inertial frames, which of the two runs more slowly?

He received a multitude of answers, including a clearly wrong one from Nobel Prize winner Max Born, but none of them answered the question. For example, this was considered an answer: "the fastest working clock between any two events is the one that travels between them in free fall."

Einstein himself had compounded the issue by claiming that a clock on the equator (considered in instantaneously linear motion) runs more slowly than one on the North Pole — clearly an error by his own theory, since neither of the two is supposed to be privileged. So Dingle was attacked as condemning the whole theory by splitting hairs over one little error by Einstein.

Prof. McCausland gives a dispassionate history of the clock question, a question repeated over two decades and met by ridicule, maneuvering, personal attacks, and mostly by silence. It is a spellbinding, chilling account that no scientist, and perhaps no reader of any type, should miss.

The author lets the facts speak for themselves and makes no accusations. Nor does he have to: the dishonesty of *Nature* editor John Maddox, for example, is impossible to miss, regardless of any scientific issues.

"I trust you will not think me impatient if I ask for an early reply," wrote the 86-year old Dingle to the President of the Royal Society demanding that the scientific community face up to its ethical responsibilities. "At my age I am finding that, in more than one respect, the physical effects of a few weeks are equivalent to those of several months not so long ago..."

The man who left this desperate cry unanswered was Lord Todd, and no more can be done now than to hold up his name for contempt.

On a purely scientific level, Dingle's crusade was, I think, predestined to fail. Like most people, including scientists, Dingle made the tacit assumption that there is a world out there that runs by laws independent of those who observe them. It is a faith shared by many who erroneously consider themselves Einsteinians; and those who are *genuine* Einsteinians rarely come out of the closet on this point. Their answer is "If I sit on Clock One, it runs faster; if I sit on Clock Two, *it* runs faster." And they show that this must be so by plotting the two points on a Minkowski world diagram, as if it were not itself based on the same attitude denying that nature runs its course independently of all observers.

Dingle assumed that two clocks could not *each* run slower than the other, and had the Einsteinians been more honest (or had they known their own theory better), they would have had to answer "Why not?"

McCausland's book does not really aim to go into this aspect of the controversy, yet its dispassionate account of Dingle's struggle forces the reader to think about it. When the Einstein theory is defeated by experiment contradicting its own subjective credo, as I believe it eventually will be, this book will surely become a much-read document of what happened to reason in this century.

Meanwhile those who can see beyond accepted orthodoxy are already privileged to have it available now.

DISSIDENT NEWS

A perplexing experimental result on the velocity of light is reported by Dr. E.W. Silvertooth in "Motion through the ether," *Electronics and Wireless World* (London), May 1989, which is an update of his previous paper "Experimental detection of the ether," *Speculations in Sci. & Techn.*, vol. 10, pp.3D7, 1987. (Is it not strange that an *experiment* should have to be published in a journal of speculations?)

Silvertooth points out that none of the interference experiments to determine the velocity of light have ever measured its one-way velocity; if there is a change in forward-backward velocity, simple interference experiments cannot detect such changes.

He therefore used a special photomultiplier to observe the standing waves formed by laser light in opposite directions. If one of the waves is phase-modulated with respect to the "standard" wave, certain phase effects can be detected.

When the apparatus was rotated, Silvertooth found a consistently privileged direction regardless of time of day or year; it pointed to the constellation Leo, toward which the earth is claimed to be moving with a velocity of 378 km/s. This is claimed in reasonable agreement with data from galactic radio sources.

Dr Silverthooth's experiment is now running in Oregon, and he invited the editor of this journal to witness it. Duplication may not be easy as there are only three of the standing wave detectors, manufactured by General Electric, in existence.

The theory put forward by Silvertooth in 1987 uses an ad hoc assumption based on the lack of a shift from assumedly different forward and backward velocities in either arm of the Michelson-Morley experiment. In "A preliminary analysis of the Silvertooth experiment," *Phys. Essays* (Canada), vol. 1, no.4, pp. 272–274, B.A. Manning finds the basic approach sound, though not without possible minor flaws, and recommends accepting "something that is very difficult to explain."

A new measurement technology of this type may bring in hidden flaws, of course, but it is hard to imagine any that would show a consistent direction with respect to the stars. On the other hand, the absence of a diurnal aberration in terrestrial light sources (also a "one way" effect) would appear to contradict the existence of such a direction.

Duplications and variations of the experiment should shed more light on this puzzle; the fact that none have been attempted in the three years since the discovery was announced (*Nature*, vol. 322, p. 590, 8/14/1986) does not speak well of the interest in experiments that contradict accepted theory. No leading physics journal seems to have found it worthy of discussion; but we will keep readers informed of any further developments.

GALILEAN ELECTRODYNAMICS

Experience, Reason and Simplicity Above Authority

March/April 1990 (Vol. 1, no. 2) **Box 251, Boulder, Colorado 80306**

Contents

Editorial Policy

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it expects to publish papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers will be reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* will generally be limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

No paper contradicting experiment will be accepted; however, papers making a case why the current interpretation of observed effects may be erroneous will be considered for publication.

Papers reporting experimental results will be given preference over theoretical papers of equally high standard.

All papers are expected to be in the realm of physics, mathematics, astronomy or engineering; non-mathematical, philosophical considerations will generally not be accepted unless they are fairly short and have something new and outstanding to say.

Shorter papers will be preferred over long papers of comparable quality; and papers easily grasped at the level of keen seniors and graduate students will be given emphatic preference over esoteric analyses accessible only to a limited number of specialists.

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Light Speed as a Function of Gravitational Potential

By Howard C. Hayden
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Summary: Beckmann makes the case that light speed is constant with respect to the gravitational field. His model, however, does not specify how the speed varies with such things as the mass of the locally dominant body and its distance from the point of interest. In the present paper, we derive the result from the conservation of energy, and use it to predict the deflection of starlight. The results agree with those of General Relativity Theory, and more importantly with measurement.

Introduction

That the speed of light is not isotropic in the laboratory frame (Hayden 1989) is easily proven by looking at the Hafele-Keating (1972) experiment which showed west-bound clocks to be it faster than the laboratory clock. The experiment does not, however, decide whether the speed of light might vary with altitude, or with other parameters; indeed it does not say it how light speed varies, only that it is not constant.

In the Einstein model, it is *expected* that light speed might not be constant, merely because the lab frame revolves around the center of the earth (it need not *rotate*). Special relativity theory confines itself to inertial systems, and does not ask questions about coordinates in accelerated frames, but insists that the speed of light is constant in any inertial frame. On a hypothetical *non-rotating* planet, for example, light speed would be constant, by which we mean it independent of direction and independent of location .

Beckmann's (1987) model says that the inconstancy of light speed occurs because the earth's surface moves at its rotational speed through the gravitational field of the earth. It makes a specific prediction that the velocity of light with respect to an observer moving at velocity **u** through the field is **c**−**u**, i.e., that light velocity combines vectorially with field velocity. On the other hand it makes no specific prediction about how light velocity varies with the mass of the body responsible for the dominant field, or the distance from its center.

Robert Low (private communication) suggested that the speed of light could not vary with distance from the body, because energy conservation would be violated. Necessarily the permittivity (or equivalently, the dielectric constant), and therefore, the force between two charges, would vary with radius. Consequently, a perpetual motion machine could be made by 1) applying an external force to bring the (positive) charges close together at one radius, 2) lifting them to a larger radius, keeping the distance constant, 3) allowing the forces to move apart to the original separation, and 4) dropping the charges to the original radius. Step 3 returns more energy than is done in step 1 because the permittivity is higher at lower radius.

Missing from the argument as presented is the gravitational attraction of the electrostatic energy's equivalent mass to the body. The argument thus provides a method of determining the permittivity as a function of radius. The mere existence of an equation does not guarantee its worth however. Therefore the equation is used to calculate the deflection of starlight passing by the sun.

The relative permittivity

Consider two positive charges, with no loss of generality taken to be equal (q), separated by a distance D, and at some distance R from the center of, e.g., the sun. We consider the four-step process given above. We adopt the convention that the permittivity of free space ϵ_0 is multiplied by the dimensionless relative permittivity ϵ_r, the latter being equivalent to a dielectric constant for a material medium. The relative permittivity ϵ_r is a function of R.

We calculate the work done by an external force in the four steps, beginning with that required to reduce the distance between the charges to $d < D$.

$$w_1 = \frac{q^2}{4\pi\epsilon_0}\frac{1}{\epsilon_r}\left(\frac{1}{d} - \frac{1}{D}\right) \tag{1}$$

In the second step the assembly is raised an amount dR. The work done is

$$w_2 = GM\left(m + \frac{q^2}{4\pi\epsilon_0\epsilon_r d}\,\frac{1}{c^2}\right)\frac{dR}{R^2} \tag{2}$$

where we assume that ϵ_r varies slowly with R. The mass m here is any mass associated with the apparatus and will soon cancel out. The term added to m is the equivalent mass of the electrostatic energy. In step 3 the charges separate to their original separation D, the work is

$$w_3 = \frac{q^2}{4\pi\epsilon_0}\frac{1}{\epsilon'_r}\left(\frac{1}{d} - \frac{1}{D}\right) \tag{3}$$

Here the relative permittivity takes the value ϵ'_r. As we expect ϵ'_r to be less than ϵ_r, this term is larger than w_1. Finally step 4 puts the system back to its original configuration

$$w_4 = GM\left(m + \frac{q^2}{4\pi\epsilon_0\epsilon_r D}\,\frac{1}{c^2}\right)\frac{dR}{R^2} \tag{4}$$

We now apply two constraints: First, the total work done in the loop be zero, and second that the magnetic permeability $\mu_0\mu_r$ have the same dependence upon R and M as does the permittivity. The latter constraint assures that the impedance $\sqrt{\mu/\epsilon}$ remains constant, and that dispersion of light not occur. We obtain after some algebra

$$\frac{d\epsilon_r}{\epsilon_r} = -\frac{GM}{c^2}\frac{dR}{R^2} \tag{5}$$

Constraint 2 requires that c be $c_0\epsilon_r$, so our differential equation becomes

$$\frac{d\epsilon_r}{\epsilon_r^3} = -\frac{GM}{c_0^2}\frac{dR}{R^2} \tag{6}$$

We now integrate, assigning a value to ϵ_r of 1 when $R = \infty$. The result is

$$\epsilon_r = \sqrt{\frac{1}{1 - \frac{2GM}{Rc_0^2}}} \tag{7}$$

Since $n = \mu_r = \epsilon_r$, as noted above, it follows that the index of refraction $n = \epsilon_r$ also. Finally we have for the speed of light

$$c = c_0\sqrt{1 - \frac{2GM}{Rc_0^2}} \tag{8}$$

where c_0 is the speed of light far from the body.

Deflection of starlight by the sun

There are two reasons for light to be deflected toward the sun as it passes by. First, the "classical" reason: light has an equivalent mass E/c^2, and secondly light is refracted continuously as calculated above.

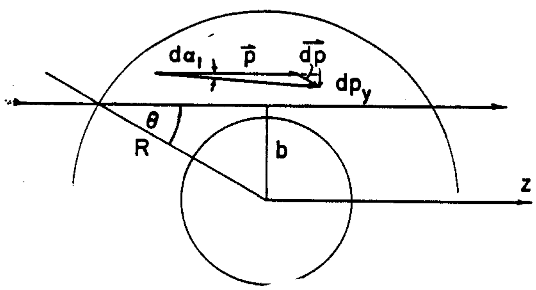

Fig. 1. Deflection of light momentum by gravity. Light with impact parameter b has momentum E/c when at R, but receives an impulse dE/c along the radius in moving from R to $R-dR$. The component of the impulse perpendicular to the velocity is obtained by multiplying by $\sin\theta$.

In Fig. 1, the deflection angle $d\alpha_1$ is the transverse impulse divided by the momentum, dp_y/p, where the former is

$$dp = \frac{dE}{c}\frac{1}{c}\frac{GM\left(\frac{h\nu}{c^2}\right)}{R^2}d \tag{9}$$

and the momentum is $p = E/c$. A little algebra results in

$$d\alpha_1 = \frac{GM}{c^2}\frac{b\,dz}{(b^2+z^2)^{3/2}} \tag{10}$$

which is shortly to be integrated; b is the impact parameter (in this case the distance of closest approach).

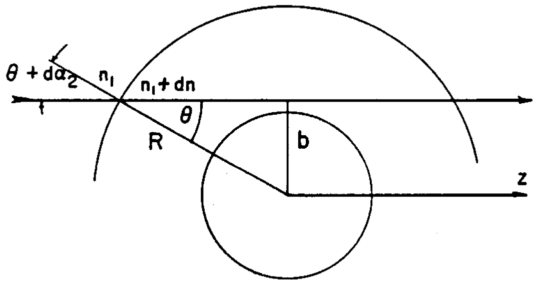

Fig. 2. Refraction of light by gravity
Light travels in the direction z at impact parameter b. It encounters an imaginary sphere of radius R at an angle $\theta+\alpha_2$ and refracts at θ. The index of refraction to a first approximation varies as $1+GM/c^2R$.

In Fig. 2, light is refracted. We apply Snell's law (An exegete may prefer to use Fermat's principle, but the present method is too direct and simple to require a more sophisticated technique): $n_1\sin(\theta + d\alpha_2) = (n_1 + dn)\sin\theta$. Expanding, and using $\cos(d\alpha_2) \sim 1$, and $dn = (dn/dR)(dR/dz)\,dz$ we obtain

$$d\alpha_2 = \frac{\tan\theta}{n}\frac{dn}{dR}\frac{dR}{dz}dz \tag{11}$$

from which we obtain after calculating (8) to first order and differentiating

$$d\alpha_2 = \frac{GM}{c^2}\frac{b\,dz}{(b^2+z^2)^{3/2}} \tag{12}$$

which is the same as (10), though for different reasons. We obtain the total deflection angle by summing (10) and (12) and integrating from $z = \infty$ to 0, and doubling. Letting $b = z\tan\theta$, and letting θ run from 0 to $\pi/2$, we obtain

$$\alpha_{\text{total}} = \frac{4GM}{bc^2} \tag{13}$$

in agreement with experiment (Campbell 1928). General Relativity Theory (Moeller 1952) obtains the same result at the expense of more mathematics.

Conclusions

The deflection of starlight by the sun was measured in 1919 as a check on general relativity theory (GRT). The agreement thus obtained was heralded as support for GRT; "curved spacetime" has since become a part of the literature.

The problem solved by GRT was, however, one created by special relativity theory (SRT) in assuming that the speed of light is constant.

We show here that the "curved spacetime" invention is totally unnecessary for the calculation of the deflection of starlight. The identical result can be had with a few lines of high school algebra and a couple of trivial integrals, using Newtonian time and Euclidian geometry.

Briefly the method is as follows:

The principle of conservation of energy allows calculation of the relative permittivity (ϵ_r) as a function of the mass of the dominant body and the radius from the center thereof. The experimentally observed lack of dispersion implies that the ratio μ/ϵ should not vary with the same parameters, therefore ϵ and μ should scale in the same way. The index of refraction obeys the same scaling and the speed of light is correspondingly given by (8).

The deflection of starlight by the sun is calculated by integrating the deflections due to both the impulse from gravitational attraction and the varying index of refraction. For light grazing the sun, the result is given by (13), which is in agreement with experiment and with General Relativity Theory.

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Light Path in Gravitational Field by Hayden's Formula and Fermat's Principle

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The optical part of the trajectory of light in a gravitational field is derived from Hayden's expression for the refractive index and Fermat's principle. The bending angle obtainable from it agrees with Hayden's result. Unlike the approximate trajectory derived under the assumptions of Einstein's General Theory, the trajectory derived from Fermat's principle is an exact result in closed form.

The following derives the light trajectory at any point in a gravitational field based on Hayden's formula for the index of refraction (8) in his paper [1]. The bending angle obtained from the entire trajectory agrees with that derived by Hayden, protecting it from possible criticism that the approximations are made *before* the integration.

Fermat's principle says that light propagates along a path that will minimize the time interval for propagation between two points. Since the velocity of light is $c_0/n(R,\varphi)$, where n is the index of refraction as a function of polar coordinates, the time elapsed in transit between two point along the path with element ds is from Hayden's equation (8) in [1]

$$T = \frac{1}{c_0}\int n\,ds = \frac{1}{c_0}\int \sqrt{1-\frac{H}{R}}\,\sqrt{R^2+R'^2}\,d\varphi = \text{minimum} \tag{1}$$

where

$$H = \frac{2GM}{c_0^2} \tag{2}$$

As shown in any textbook of the calculus of variations, the path of integration that will minimize the integral (1) is the solution of the Euler-Lagrange equation found from the integrand. In the present case, when the integrand F contains only R and R', but not the independent variable φ, the Euler-Lagrange equation simplifies to

$$F - R'\frac{\partial F}{\partial R'} = K \tag{3}$$

where the constant of integration K is found from the conditon that $R' = dR/d\varphi = 0$ for $R = b$ (we also set $\varphi = 0$ at that point). This yields after elementary manipulations

$$K = b\sqrt{1-\frac{H}{R}} \tag{4}$$

On substituting the integrand F from (1) in (3) and some manipulation we obtain the differential equation

$$R' = \frac{R}{K}\sqrt{R^2\left(1-\frac{H}{R}\right)-K^2} \tag{5}$$

On separating the variables and integrating (see [2]) we find the following exact solution for the light trajectory:

$$\begin{aligned}\varphi(R) &= K\int_b^R \frac{dR}{R\sqrt{R^2-HR-K^2}}\,dR \\ &= -\arcsin\left(\frac{2K^2+HR}{R\sqrt{H^2+4K^2}}\right) \\ &\quad + \arcsin\left(\frac{2K^2+Hb}{R\sqrt{H^2+4K^2}}\right)\end{aligned} \tag{6}$$

The bending angle at any distance R is then $\zeta = \varphi(R) - \pi/2$, so that the total bending angle is

$$\zeta_{\text{total}} = \varphi(\infty) - \frac{\pi}{2} = -\arcsin\left(\frac{H}{\sqrt{H^2+4K^2}}\right) \tag{7}$$

It is only at this point that approximations are now introduced. For the small angle (7) the arc sine is replaced by its argument, and H (of order 10^2m) is neglected compared with b and K (both of order 10^8m). This yields

$$\zeta_{\text{total}} = -\frac{H}{2K} = -\frac{GM}{bc^2} \tag{8}$$

which after doubling (for the incoming part of the path) and doubling again (for the gravitational attraction of the photon mass, not a part of geometric optics or Fermat's principle) agrees with Hayden's expression (13) as well as with the General Einstein Theory. (The negative sign is due to the present choice of coordinates and means that $\zeta = \alpha/4$ increases clockwise from the $\varphi = 0$ axis, i.e., toward the mass at the origin.)

The total bending angle, which is at present the only measurable quantity, agrees with the Einstein theory; the light trajectory (6) is slightly different. Its derivation is not only far simpler than that by Einstein's General Theory, but within Fermat's principle (geometric optics) it is exact, whereas the Einsteinian trajectory is found under the assumptions of the General Einstein Theory by successive approximations of the resulting differential equation.

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Experimental Data and Simultaneity

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Summary: According to the Special Theory of Relativity, events taking place simultaneously in one inertial frame cannot be simultaneous in another, and the time of an event viewed by an observer in another inertial frame depends on his coordinates. The data observed by satellite clocks contradict both of these predictions and demonstrate the need to revise accepted views of simultaneity and synchronization.

The Train-Embankment Experiment

To set the stage for determining how relativity of simultaneity can be tested experimentally, it is useful to review an exchange of views published in the *American Journal of Physics* on the subject of Einstein's famous train-embankment thought experiment. Brown [1] considered two observers, one on a train, the other on the embankment, both midway between two lightning strikes a distance d apart. Both would observe the strikes at a time $d/2c$ after emission, and both would find them simultaneous. Robinson and Denholm [2] agreed that the time for light from the flashes to reach the observer on the embankment would be $d/2c$, but they used the Lorentz transformation to show that the light from both flashes would reach the observer on the train at time $\gamma d/2c$ after emission, where $\gamma = (1 - v^2/c^2)^{-1/2}$. This latter result simply reflects the fact that Robinson and Denholm included space contraction in their calculations, whereas Brown did not. However, the main point of the dispute was the assertion of Robinson and Denholm that the equal travel times for light from the flashes to reach the observer on the train did not result in simultaneous arrival at this observer because the origination times of the flashes would be different in the reference frame of the train. This conclusion results from an interpretation of the Lorentz transformation equation

$$t' = \gamma\left(t - \frac{vx}{c^2}\right) \tag{1}$$

where t' is the time of an event in reference frame S' of the train and t and x are the time and space coordinates of the same event in the reference frame S of the embankment.

We can arbitrarily assign coordinates in the frame of the embankment to the two strikes; for example, $t = t_1$ and $x = a$ for strike number one, and $t = t_2$ and $x = a + d$ for strike number two. Inserting these values in (1) and bearing in mind that $t_1 = t_2$,

$$t'_1 = \gamma\left(t_1 - \frac{va}{c^2}\right) \tag{2}$$

$$t'_2 = \gamma\left(t_1 - \frac{v(a+d)}{c^2}\right) \tag{3}$$

According to (2) and (3), calculated by the Lorentz transformation, strike *2* occurs earlier than strike *1* in frame S'.

It is important to realize that the x and t parameters in (1), (2) and (3) have two separate meanings. They are point coordinates and are also the magnitudes of time and space intervals between a pair of events. These equations were derived under the assumption that the origins of the two systems are coincident when all their clocks were set to zero. We therefore identify an initial synchronizing event with coordinates $x = x' = t = t' = 0$. Time interval *1* is defined as the interval between the initial event and lightning strike *1*; its magnitude is t_1 in frame S and its magnitude in frame S' is given by (2). Time interval *2* is defined as the interval between the initial event and lightning strike *2*. Its magnitude in S is t_1 and its magnitude in S' is given by (3).

We now calculate another set of values for time intervals *1* and *2*, based on time dilation. This can be done in different ways. French [3] derives the time dilation expression using the Lorentz transformation, while Feynman [4] derives the expression using a light clock and applying the principle of the constancy of the speed of light directly without reference to the Lorentz transformation. In either case the result is that a time interval Δt between two events as measured in frame S' is related to the time interval in frame S by

$$\Delta t' = \frac{\Delta t}{\gamma} \tag{4}$$

Now we can apply (4) in the train-embankment experiment to calculate the magnitudes of the time intervals between the initial event and the lightning strikes as measured in S'.

$$t'_1 = \frac{t_1}{\gamma} \tag{5}$$

$$t'_2 = \frac{t_2}{\gamma} \tag{6}$$

Obviously (5) and (6) are in conflict with (2) and (3). Equations (2) and (3) have never been verified experimentally. Equ. (4), the basis for (5) and (6), can be expressed in terms of a series expansion of γ as follows:

$$\Delta t' = \Delta t\left(1 - \frac{v}{2c^2}\right) \tag{7}$$

Equ. (7) has been verified many times since 1971 and is, in fact, being verified daily at present.

Data from Atomic Clocks

In 1971 Hafele and Keating [5] flew atomic clocks around the world in opposite directions to test relativistic effects on clocks. For the special relativity effect, they used (7), calculating the velocities of the clocks relative to a hypothetical non-rotating earth as an inertial system. Subsequently Alley and his associates [6,7] conducted a variety of experiments under various conditions, further verifying the accuracy of (7) in predicting the effect of motion on clocks.

Alley's work led to the introduction of the Global Positioning System (GPS) [8] now in operational use. The essence of the GPS is that a number of atomic clocks in 12-hour circular orbits are all synchronized with each other and with a network of ground stations.Periodic emissions by the satellites contain information on the time of the emission and the satellite's location at that time. By noting the time delay in the reception of a satellite signal, a ground observer can calculate the precise distance to the known satellite position. Signals from several satellites provide a navigation fix.

The precisely known satellite orbits and velocities allow a prediction of the time gains of the satellite clocks due to general relativity effects and the time losses due to special relativity as expressed in (7). The gains exceed the losses, so the net result is a gain of approximately 44,000 nanoseconds per day. By adjusting the orbital clocks so that they will run slow by 44,000 ns/day when placed next to a ground based GPS master clock, the orbital clocks will be synchronous with the master clock when placed in orbit. The fact that a single adjustment of an orbital clock's rate, based on (7) and the general relativity effect, can place the clock in synchronization with GPS ground-based time, is convincing evidence that moving clocks are affected as predicted by (7), not by (2) and (3). That is, the synchronization of all the clocks on the ground with all the clocks in orbit, and the rate at which these clocks operate, does not depend on their space coordinates as predicted by (2) and (3) following directly from the Lorentz time transformation (1).

Returning to the train-embankment thought experiment, the clock in frame S' located at strikes *1* and *2* will both read t_1/γ, which means that the strikes will be simultaneous in S', although they occur at a different time in S' from that measured in S.

All of this leads to what might be called the "reciprocity of simultaneity," which is similar to the reciprocity of time dilation and space contraction. Just as each of two observers in two inertial frames finds *the other* observer's clock running slow and *the other* observer's rod shortened, each will find the same two events simultaneous by his own measurements and will conclude that they cannot be simultaneous in the other frame – yet by (4) and (7) they are simultaneous in *all* inertial frames.

Conclusion

By confirming (7) rather than (1) to (3), the experimental measurements by satellite clocks refute the generally accepted opinion that two events simultaneous in one inertial frame cannot also be simultaneous in another — a position clearly stated by Albert Einstein himself [9]. They also refute the prediction of the Lorentz time transformation (1) that the rate at which a clock operates depends on the space coordinate (x) of the observer.

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An Overlay of Fieldlets

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Summary: Grave sacrifices were made in order to formulate a self-consistent description of electrodynamics after the Michelson-Morley experiment refuted the existence of an ether. In an alternate view submitted here, the superimposed electrostatic fields of individual charged particles are offered as the long-sought medium. The interaction of one electric "fieldlet" moving with respect to all others is discussed. A crucial experiment is suggested, and the gravitational bending of light is reinterpreted.

Introduction

At the time of the null result of the Michelson-Moreley experiment physicists generally agreed that electromagnetic radiation was a wave phenomenon, that is, a disturbance propagating through a medium. This medium was assumed to be omnipresent, more or less self-static, and more or less self- existent, that is, independent of the matter in the universe. Serious difficulties were encountered in trying to reconcile this view of the medium with the result of the Michelson-Morley experiment. A different view of the problem is offered here.

The old notion of the medium, the static ether, is discarded here. But the charged particles of the universe and their electrostatic fields are considered in some detail. To distinguish these fields clearly from the net electric field of their agglomeration, the electrostatic field of an individual particle will be referred to as a "fieldlet."

Associated with each charged particle is a fieldlet of infinite extent, the strength of which falls off with the inverse square of the distance from the particle, and which is spherically symmetrical in the absence of motion *in some sense.* Each volume element of the fieldlet has a unique spatial relationship to its neighbors and to the charged particle. The fieldlet itself has a self-preserving or self- restoring quality.

The fieldlets of all charged particles are superimposed at each point in space. Normally we are interested only in the net vector electric field at a point, since it is this which acts upon a test charge. Since matter is generally charge-balanced, this net field is usually small.

To appreciate the immensity of the actual field energy at any location, consider the following example. Imagine that somehow it were possible to snatch away all the electrons from the planet. Then by a crude calculation the resulting electric field strength at the surface of the planet would be about $6 \times 10^28\,\mathrm{V/m}$.

The superimposed electric fieldlets of the charged particles constitute the medium of electromagnetic disturbances. This is so because when a charged particle moves with respect to this "overlay" of fieldlets, the fieldlet of the particle interacts with the overlay. The interaction gives rise to all the familiar phenomena of electrodynamics.

When a charged particle is moving with respect to the local overlay, the fieldlet elements experience a dragging in such a manner that each new increment of particle motion is "telegraphed" outward at the local characteristic speed of the medium. The fieldlet always seeks to return to its symmetrical, undistorted condition, and each fieldlet element mimics the motion of the charged particle, but delayed according to its distance from the particle. Were it not for this interaction-induced distortion and delay, one might expect the entire fieldlet to track instantaneously with the particle.

Along with the fieldlet distortion the major effect arising with the interaction is that of magnetic fields. A fieldlet element traversing the overlay gives rise to a local condition to which other moving charges are susceptible.

Consider the equation for the magnetic field produced by a moving charge,

$$\mathbf{B} = \frac{\mu_0}{4\pi} q \frac{\mathbf{v} \times \mathbf{r}}{r^2} \tag{1}$$

Using a redefined magnetic field vector $\mathbf{M} = c\mathbf{B}$, where c is the local characteristic speed, and $\beta = v/c$, we have

$$\mathbf{M} = \frac{\mu_0}{4\pi} c^2 q \frac{\boldsymbol{\beta} \times \mathbf{r}}{r^2} \tag{2}$$

Substituting $c = 1/(\mu_0\epsilon_0)$, we have

$$\mathbf{M} = \frac{1}{4\pi\epsilon_0} q \frac{\boldsymbol{\beta} \times \mathbf{r}}{r^2} = \boldsymbol{\beta} \times \frac{q}{4\pi\epsilon_0} \frac{\mathbf{r}}{r^2} = \boldsymbol{\beta} \times \mathbf{E} \tag{3}$$

This can be interpreted to mean that the magnetic field is determined by the rate of transverse motion of the electric fieldlet element across the overlay at the point in question. The direction of the magnetic field vector defines the plane of the potential action on other moving charges. The action is implicit in the Lorentz force,

$$\mathbf{F}_r = q_r \mathbf{v_r} \times \mathbf{B_s} \tag{4}$$

where the subscript r is used for the respondent particle and the subscript s for the source particle. This equation can be rewritten as

$$\mathbf{F_r} = \mathbf{q_r v_r} \times \frac{\mathbf{1}}{\mathbf{c}}\mathbf{M_s} = \mathbf{q_r}\boldsymbol{\beta} \times \mathbf{M_s} = \mathbf{q_r}\boldsymbol{\beta}_\mathbf{r} \times (\boldsymbol{\beta}_\mathbf{s} \times \mathbf{E_s}) \tag{5}$$

This can be interpreted to mean that the moving respondent particle experiences a centripetal acceleration proportional to the rate of transverse motion of the source **E** field *and* the rate of motion of the respondent particle in the plane of the **E** fieldlet motion.

With isolated moving charges, unless both and β_s and β_r are large, the magnetic force is utterly dwarfed by the electrostatic force $\mathbf{F}_r = q_r \mathbf{E}_s$. From this point of view the magnetic force is only a second-order effect. The magnetic effects emerge in those special cases when the charges are thoroughly balanced, as with a current flowing in a conductor.

Uniform motion of the source particle through the overlay has been assumed. When this motion is non-uniform, and therefore the fieldlet lines have some curvature, a third-order effect arises. There is then a tangential component of respondent particle acceleration, familiar as magnetic induction.

It is true that other heavenly bodies contribute to the local overlay, but a simple calculation will show that at the surface of the earth the predominant contribution is due to the charged particles of the earth itself. Hence the medium mostly moves with the earth. It is not surprising that the Michelson-Morley experiment, or the modern equivalent by Brillet and Hall [1] yielded a null result. Only by moving rapidly through the medium as in a satellite or a space shuttle can one obtain the asymmetry expected by Michelson.

Since the aggregate strength or "energy density" of the overlay of fieldlets varies from place to place, so too does the characteristic speed in the medium vary. Nowhere is the variation in the speed of light more evident than in the bending of light near a massive object as, for example, the observed displacement of star locations near the limb of the sun.

Strong gravitational fields are coincidentally places of high density of the overlay. When the starlight passes near the sun, it is in a region of high gradient of overlay density. The higher the density of the overlay, the slower the characteristic speed of the medium. Thus the starlight is bent in the sense that the wave front is tilted as the nearer position is more retarded.

The notion of the overlay of "electrostatic" fieldlets somehow comprising the medium of electromagnetic disturbances is not entirely new. Michael Faraday [2] speculated along these lines in a letter written in 1846.

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LETTERS

The Double Slit Paradox

In "The Double Slit Paradox" (Jan. 1990), Petr Beckmann first points out that the quite different properties of classical waves and particles are inconsistent with the "Duality Principle." However, the workers in quantum mechanics would say that their "things" behave like waves and particles at times, but they are definitely not the waves and particles of classical physics.

For example: I think of electric charges as points of concentration of the related fields (with nothing inside the "classical radius") and that the fields are formed by myriads of tiny elements. To obtain stationary states I give the ensemble a characteristic propagation velocity (*c*) and, with a granular structure, they can behave like waves under some circumstances. The stable states are those where the elements, on average, appear stationary as if viewed with a stroboscope.

More importantly, Beckmann considers that the Faraday Function can be expressed as an irrotational field with energy properties similar to those of the static electric field. Contrariwise, to me the Faraday effect on an accelerating charge is directly associated with the rate of change of the energy in the related magnetic field, so there is only one energy of interest in the dynamic problem and the oscillations he depicts will not take place. However, a concept such as the above distributed electron might serve as a basis for his later discussions of electron diffraction.

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Author's reply:

The properties of waves and particles (whether quantum mechanical or classical) are not just different, but as I pointed out, incompatible. Since I wrote the paper, I found a report [1] of measurements by detectors behind the two slits. They demonstrated what I must interpret as an electron going through a single slit, but two interfering waves behind the slits, for the detectors showed a high *anti*-correlation for the one particle and a high positive correlation for the two diffracted waves. Among the explanations offered is a relativistic one [2] which proposes "that light exhibits wave and particle properties alternatively, but that the succession of the two states is so quick that our measurements are only able to record one state or the other . . . " When explanations get this complicated, surely it is time to apply Occam's razor.

As for my alleged claim that the Faraday field can be expressed as an irrotational field, I made no such claim; to the contrary, I *define* it as that part of the electric field whose curl is nonzero. But perhaps Dr Bertram alludes to the "static" Coulomb field which does indeed partly determine the Faraday field. I have put the "static" in quotation marks, for when the Coulomb field belongs to a moving charge, it is no longer static, but varies in time at a given point, is associated with a varying magnetic field, and hence, exactly as Dr Bertram says, with the rate of change of the energy in the related magnetic field.

To formulate this argument quantitatively, we have for $\boldsymbol{\psi}$, the irrotational part of $\mathbf{E}$, directly from the Maxwell equations $\nabla\times\boldsymbol{\psi} = -\partial\mathbf{B}/\partial t = -\partial(\nabla\times\mathbf{A})/\partial t$, where $\mathbf{A}$ is the vector potential, whence $\psi = -\partial \mathbf{A}/\partial t$. As shown in any electromagnetic textbook, **A** obeys the simple wave equation with $-\mu \mathbf{J}$ or $-\mu\rho\mathbf{v}$ on the right, which yields the integral

$$\mathbf{A} = \frac{\phi \mathbf{v}}{c^2} \quad (1)$$

where ϕ is the "static" Coulomb potential of the moving charge – and that is how it gets into the Faraday field. Differentiating the last expression, we have

$$\psi = -\frac{1}{c^2}\left(\phi \frac{d\mathbf{v}}{dt} + \mathbf{v}\frac{d\phi}{dt}\right) \quad (2)$$

and this shows that the Faraday field consists of two parts: the Coulomb potential moving with its source charge through the considered point, and the field induced by acceleration of that charge. There is indeed only one energy of interest, namely $\frac{1}{2}\varepsilon\psi^2$ integrated over space, but the ψ has two terms, one proportional to the velocity of the charge, the other to its acceleration; hence the differential equation for an oscillating velocity.

To show that this alternative derivation is equivalent to the one given in the paper, we need only take the curl of both sides in (1). Since $\nabla \times \mathbf{v} = 0$, this yields $\mathbf{B} = \mathbf{v} \times \mathbf{E}_c$, which was used in the paper for substitution in the energy $\frac{1}{2}\mu H^2$.

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DISSIDENT NEWS

The 1989 USSR Conference on the Problem of Space and Time in the Natural Sciences

[Condensed from a report by]
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The international scientific conference was held at Pulkovo Observatory near Leningrad in the year that marked the 150th anniversary of the founding of the Observatory. The March 14th starting date of the conference was the 110th anniversary of Einstein's birth, and the conference was a major turning point in the popular acceptance of Einstein's relativity theories.

The 1961 interplanetary radar contact with Venus presented the first opportunity to overcome technological limitations and perform a conclusive test of the relative velocity of light in space. The radar was supposed to be accurate to 1.5 km and the Earth's rotation alone would cause a maximum difference in calculated distances of 260 km between the c and $c + v$ models when Venus was at its closest point. The published plot [1] of the values for the astronomical unit obtained using Newcomb's orbits for the earth and Venus, and calculated using the 1961 Millstone radar observations based on Einstein's c model for the speed of light in space, showed large, impossible variations in the a.u. that ranged to over 2000 km. There should be only one value for the a.u., and the variations in the calculated values were far larger than their maximum estimate of all possible errors. The variations contained a daily component that was proportional to the velocity due to the Earth's rotation, a 30-day component proportional to the velocity due to the Earth-Moon rotation, and a synodic component proportional to the relative solar orbital velocities.

I analyzed eight of the published 1961 Venus radar observations [2] and published the results in [3]. The radar data present evidence against the Einstein c theory because the discrepancies are far larger than any possible error. On the other hand, the close fit between the ephemeris points and the curve calculated by the Galilean velocity addition is dramatic evidence in favor of the Galilean-Newtonian $c + v$ model for the transit of photons of light in space. Over the years I have received a large number of reprint requests for this paper from around the world, and many of these requests have come from the USSR.

In October 1987 I received a letter from Dr. Vladimir Ilich Sekerin of the Russian science city of Novosibirsk, who confirmed my findings: "Just as you do, I also compute that the speed of light in a vacuum from a moving source is equal to $c + v$." He included a copy of his article "Gnosiological Peculiarities in the Interpretation of Observations (For example the Observation of Double Stars)", which gives yet another demonstration of this proposition.

In July 1988 I received a letter from Dr. Svetlana Tolchelnikova-Murri of Pulkovo Observatory who had obtained a copy of my paper [3] from Dr. Sekerin. She regarded the intrusion of relativistic theories into fundamental astrometry as quite a failure, though not yet comprehended by the majority. Thanks to *perestroika* she was able to write openly, but "Pulkovo Observatory is one of the outposts of orthodox relativity. Two scientists were dismissed because they discovered some facts which contradicted Einstein. It is not only dangerous to speak against Einstein, but which is worse it is impossible to publish anything which might be considered as contradiction to his theory. It seems the same situation is in our Academy."

She mentioned the upcoming 1989 conference of Space and Time in Modern Science, and although it was not in her power to invite me officially, she suggested I come, for the conference was hoped to give the dissidents a chance to have their papers published.

We continued corresponding, and in November 1988 she wrote "the best guarantee that our scientific papers will be published not in ten or thirty years [but soon] would be the presence of some objective observer or participant from your country at the conference. And it would be easier for us not to use Aesopian language."

In an effort to comply with Svetlana Tolchelnikova's request to bring Western scientists and journalists to the conference, I used my personal copy machine, computer, and daisy wheel printer to send a 4 page personal letter to 23 journalists and 43 scientists, along with a copy of her letter that contained the conference invitation and information. In her letter of 2/12/89 Svetlana wrote that "If 1/5 of the people you have invited will come it will cost me my head." During my visit I learned that the Observatory had received a large number of letters from Western scientists expressing dismay over the fact that such a conference was being held. The only one I found to accompany me to the conference was Robert Fritzius of the Magnolia Scientific Research Group at Starkville, Mississippi.

During my visit I had many intimate conversations with regard to just about any subject of interest from politics to science, and in several conversations with people who seemed to have intimate knowledge of what was happening behind the scenes, I learned that my correspondence with Svetlana was being monitored, and that Gorbachev had read Vladimir Sekerin's book *Studies in the Theory of Relativity*.

Among the people we met were Dr. Konstantin Manuilov, who gave a talk at the conference on the solution of the *n*-body problem by Newtonian mechanics. Prof. Pavel F. Parshin, Chief of the Department of Physics at the Aeroflot Academy of Civil Aviation, who is working on a modern variation of the Ives experiment, was able to publish the details of the experiment and the resultant data in a prominent USSR scientific journal, but he was not able to publish his theoretical analysis because it was not consistent with Einstein's special relativity theory.

The Director of the Observatory, Alabakin, flew in from Moscow to deliver the opening address of the conference, and then flew back to Moscow. Svetlana was surprised by the objective tone of Abalakin's speech. Before he had become the Director, he had been an anti-relativist, then after he obtained the position, he switched camps and became a relativist, and even won a state prize for introducing relativity into celestial mechanics. During his administration she had been reduced to the lowest pay rate possible for a Ph.D., 200 rubles a month, and her desk had been moved into a hallway next to the door to the men's room. It seems that since she has a daughter and is a member of the Communist Party, it is almost impossible to fire her. Also under his administration, two of the other women anti-relativists had been forced into early retirement, but now it seems that things have changed, and they are back at work.

A humorous twist to the conference was the fact that some of the relativists at the conference complained that they were being persecuted. A number of relativists withdrew their papers, and that changed the length of the conference from three to two days. Because of the many changes that had taken place, the printed program was no longer valid. Svetlana delivered her talk concerning her anti-relativistic views with regard to positional astronomy. Vladimir presented the binary star evidence showing the speed of light in space was $c + v$.

There was a meeting of the conference committee, in which it was decided that Robert and myself would become members of the committee and that there would be another conference to be held in Leningrad two years from now. I suggested, and it was accepted, that H. Aspden of England, J. P. Vigier of France, and J. P. Wesley of West Germany be invited to become members of the committee. Vigier is a member of the Institute Henri Poincaré in Paris and an editor of *Physics Letters A*. He had expressed an interest in the results from the conference, and suggested that participants submit papers to him for possible publication in his journal. Svetlana announced that V. N. Bezwerchy had contacted her and offered to publish the proceedings of the conference. I suggested to him that we consider publishing the proceedings in English as well as Russian, and it was agreed to investigate that possibility.

The title of my own talk was "The Problem of Space and Time in Modern Physics." Robert's log with his notes on the lecture allowed me to create a written version which will be published in the conference proceedings. The talk was based on the arguments and information in my papers [4] and [5], which was in part a rebuttal of I. Shapiro's reply [6] to the first paper. At question time I was asked to summarize my opinions with regard to relativity theory, which I did, adding that in general, much of relativity theory is true, but many of the original arguments are not. The real problem with modern science is the lack of scientific objectivity and integrity on the part of many prominent scientists; they are little more than politicians, and are far more concerned with the advancement of their careers and status than the advancement of science. What is needed are true scientific journals that publish all arguments and evidence in a reasonable time and at a modest cost. The peer review should take place after publication, and should involve all scientists, and not just a privileged few. The key to the more rapid advancement of scientific knowledge, is a more efficient and democratic forum for communication.

Robert has recently sent me a translation of an advertisement for a book dealing with a grand synthesis based on the concept of a gaseous ether. The author, Vladimir Atsyukovsky, gave a paper on measuring the general flow of the gaseous ether with respect to the earth at the conference. The arguments in the advertisement sound similar to the arguments contained in my own work on unified theory. The major difference seems to be that the author has used purely analytical methods for the mathematics to his models, while I was forced, for the most part, to use computer simulation and numerical methods to attack the problems. I expect that eventually most theorists will abandon the static ether (vacuum) model made popular by Einstein's Special Relativity Theory, and advance to the dynamic ether model. The dynamic ether has far more potential for explaining all physical phenomena using intuitively simple mechanical models, than the static ether has.

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GALILEAN ELECTRODYNAMICS

Experience, Reason and Simplicity Above Authority

May/June1990 (Vol. 1, no. 3) **Box 251, Boulder, Colorado 80306**

Contents

Editorial Policy

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it expects to publish papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers will be reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* will generally be limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

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Unipolar Induction Experiments and Relativistic Electrodynamics

By Francisco J. Müller
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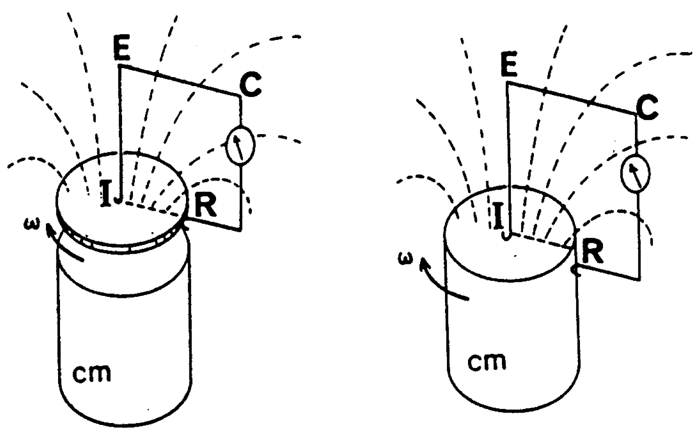
The relativistic requirement of relative motion between a conductor and a magnet to produce electromagnetic induction is critically re-examined both historically and by original experiments. That no such requirement is needed for a rotating system was demonstrated by Kennard in 1917 and is acknowledged by some relativists, who have therefore resorted to General Relativity for an explanation of the rotational unipolar inductor. But the additional experimental tests with a modified, rectilinear version of the unipolar inductor reported here rule out General Relativity as well. There appears therefore to be a need for some new theoretical formulation of the problem, based either on classical (Maxwellian or Amperian) electrodynamics or on an altogether new approach.

1. Historical Background

In the third opening sentence of his famous relativity paper of 1905 [1], Einstein stated that the phenomenon of electromagnetic induction "depends only upon the relative motion between a magnet and a wire". In effect, all physics students are familiar with the image of a coil of wires near a magnet. If the magnet moves inside and outside the coil a current is induced in it. Reciprocally, if the magnet stays at rest but the coil moves to link and unlink with the lines of force imagined to emanate from the magnet, the result is exactly the same. This perfect kinematical and mathematical reciprocity in the phenomenon of electromagnetic induction was to "force" Einstein, as he wrote again in 1919, to formulate the principle of relativity. This article will revise, both historically and experimentally, the exact validity of the requirement of relative motion between magnet and conductor to produce induction, both in rotational and translational motions.

The experiments described below can be considered a natural development of on-going research that had its origin with Michael Faraday himself. Having already discovered the phenomenon of induction with changing magnetic (B) fields in 1831 as described above, in the following year he investigated if a similar induction could be produced by constant magnetic fields [2]. The answer was "yes," as he demonstrated with a copper disk rotating in a fixed magnetic field (Fig. 1). The potential difference generated across the radius IR (due to the "cutting" of the magnetic lines by the rotating metal) maintained a current through the fixed external connector, ECR, contacting the disk at I and R. To ensure that the points of the disk always traversed a constant magnetic intensity, Faraday next decided to rotate the magnet with the disk. He found the same results as when only the disk rotated above the magnet. He then suppressed the disk altogether and used the metallic mass of the magnet itself as a rotating conductor (Fig. 2). Surprisingly, the results were again identical. Thus was born what Weber later called the "unipolar inductor" (or homopolar generator in more recent terminology). Crooks *et al.* rediscovered this almost forgotten device 150 years later, renaming it "Faraday's one-piece paradoxical generator" [3].

Why paradoxical? Because it seems to deny the need of relative motion between conductor and magnet, as clearly evident from Fig. 1.



Figs. 1 and 2. Faraday's experiments.

Supporters of motional relativity between conductor and magnet, however, will interpret Fig. 2 as induction occurring not along IR as in Fig. 1, but along ECR, with respect to which the magnet is rotating. This opinion coincides with Faraday's hypothesis of 1851, in which he visualized the magnetic lines as fixed to the magnet and rotating with it. The lines will thus be "cut" by the external branch ECR, so that the seat of EMF induction would be located there. Absolutists, on the other hand, insist that the seat of induction lies along IR in Fig. 2 (as in Fig. 1), so the magnet would be "cutting" its own lines of force. (In this view, the lines will in no way take part in the rotational motion of the magnet, This was, indeed, Faraday's original idea in 1832).

Measurements of the induced voltage and/or current in Fig. 2 cannot discriminate between one theory or the other since in both cases the generated intensities are the same. Both theories were hotly debated and the whole problem "baffled the greatest electrodynamicists of the 19th century," said physicist-historian A. Miller. It was at this juncture that Einstein entered the problem, but only to dismiss it. At the end of Section 6 of his 1905 paper [1], he stated that "questions as to the seat of electrodynamic electromotive forces (unipolar machines) now have no point".

But unipolar induction, being basically a rotational phenomenon, lies entirely outside the jurisdiction of Special Relativity theory. In fact, shortly before the 1905 paper, Henri Poincaré had written in *Science and Hypothesis* [4] that "the most remarkable electrodynamical experiments are those in which continuous rotations are produced, and which are called unipolar induction experiments." So Poincaré continued studying, even after 1905, the localization problem in Fig. 2, as did Pegram, Barnett and Kennard. The latter author, from Minnesota, USA, achieved a breakthrough in 1917 [5] when he suppressed the *ECR* branch and was capable of measuring an induced potential difference along *IR* when the whole system rotated as a unit. Thus, the absolutist position was greatly reinforced, and Kennard concluded that his experiment proved not only that the lines do not rotate with the rotation of their source, but that an ether must exist, with respect to which the absolute rotation of his apparatus could derive its electromagnetic behavior.

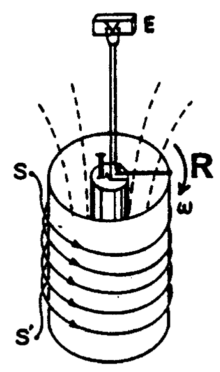


Fig 3.
Kennard's experiment.

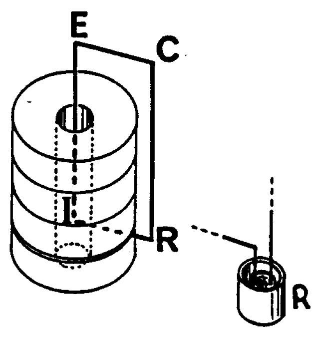


Fig. 4.
Basic rotational setup.

Kennard's experiment, however, consisted of a cylindrical capacitor and a coaxial solenoid (as field source), as shown in Fig. 3. The radial conductor *IR* between the two cylinders performed the same line "cutting" role as the imaginary radius *IR* of Figs. 1 and 2. The induced electrostatic charge separation was measured by inserting an electrometer *E* by means of two leads located along the axis. Rotation of the solenoid alone produced no charge separation; but rotation of the capacitor alone, or of the whole apparatus as a unit, did produce a potential difference across *IR*. Hence, when Tate [5] in 1922 reviewed the whole problem, he acknowledged Kennard's results and the implied disproof of the theory of rotating lines of force. But Tate restricted Kennard's results to solenoidal sources, excluding permanent magnets. The need arose, therefore, to extend Kennard's results also to permanent magnets, if the absolutist theory was to gain total applicability and respectability. This is believed to have been accomplished by some original experiments as described below.

2. Some original experiments: (a) rotation

To eliminate the ambiguity between *IR* and *ECR* as possible seats of an EMF in Fig. 2, one may suppress *ECR* as Kennard did. But another possibility is to retain both *IR* and *ECR*, and shield the *ECR* branch from the magnetic field. This was accomplished by confining the "aerial" magnetic lines of Fig. 2 into a well defined ferromagnetic path as shown in Fig. 5. Here the steel plates *fghk* perform this confining task so that *ECR* now lies in an essentially field-free region ($B = 0$).

There is now only a single wire along the radius *IR*. It is inserted through (and insulated from) an equatorial gap into the **B** field of the cylindrical permanent (ceramic) magnet. Actually the cylindrical magnet was formed by stacking four or five ring ceramic magnets, of outside radius 2.78 cm and inside radius 1.20 cm (see Fig. 4; the magnet poles are the upper and lower flat surfaces of the rings). Thus an axial hole 1.20 cm in radius is formed, and the axial branch *IE* can be passed through it. The equatorial gap is produced by slightly separating two of the stacked ring magnets.

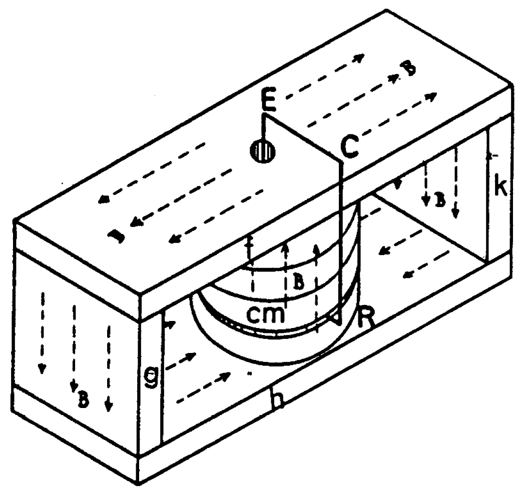


Fig. 5. Disabling *ECR* by magnetic screening.

A sliding contact at *R* (a drop of mercury, for example, as illustrated in the insert of Fig. 4) allows minute rotations (or angular oscillations) of the three elements involved, *IR*, *ECR* and the magnet, independently of each other. This results in eight possible combinations of motion (m) or no motion (0) between the three elements as shown in Table 1, first three columns.

Table 1.

Case	IR	ECR	Magnet	Resulting EMFs (E) Fig. 5	Resulting EMFs (E) Fig. 8
1	0	0	0	0	0
2	m	0	0	E	E
3	0	m	0	0	0
4	0	0	m	0	0
5	m	m	0	E	E
6	m	0	m	E	E
7	0	m	m	0	0
8	m	m	m	E	E

The resulting EMFs are also indicated in Table 1 for each case, (E indicating that an EMF is observed; 0 meaning that *no* EMF is observed). It will be seen that in the column of results for Fig. 5 there is an E only in the cases in which IR moves, (cases 2, 5, 6, 8). Motion of ECR is irrelevant (case 3), since ECR, in the language of Faraday, "cuts" no **B** lines when moving. Rotation of the magnet alone (case 4), is also irrelevant, thus disproving again the rotating lines of force theory (if the lines rotated they should be "cut" by the stationary wire IR and an EMF should be obtained, which is contrary to the facts). The essentially anti-relativistic nature of the results can be seen by comparing the reciprocal pairs of cases: 1–8; 2–7; 3–6 and 4–5. Instead of showing identical results in each pair, the results are opposite: 0 for 1, but E for 8; E for 2, but 0 for 7; and so on. Case 8 is particularly striking, since the whole circuit $RIEC$ is co-moving with the magnet, and yet an EMF results. No relative motion between magnet and wire exists, in direct violation of the Einstenian statements quoted above.

Rotation of the whole apparatus, including the yoke $fghk$, however, results in no net EMF. When the motion of the yoke is included, eight more cases arise, (16 altogether). This complicates the analysis, but by introducing a capacitative branch between IR and ECR as described in Wesley [7] and Marinov [8], the seat of induction can still be located. The resulting EMFs for all 16 cases have also been given in [8]. These details will not be discussed here since the non-relativistic nature of cases 8 (and even 7) is sufficient for the present purpose. In fact, most reasonable relativists now recognize that the rotating unipolar inductor cannot be explained by the electrodynamics of Special Relativity. Resort to General Relativity is needed.

3. Recourse to the General Theory of Relativity

Webster, for example, writing in the *American Journal of Physics*, admits that rotating circuits and magnets are "hazardous" for Special Relativity [9], even to the extent that no "local application of the Lorentz transformations" should be made "to a spinning magnet" [10].

Some years earlier Panofsky and Phillips more explicitly acknowledged that in Faraday's disk there is a difference "with our transformation laws for linear motion" [11]. And this "is an indication that the 'absolute' rotational motion of the disk ... can in principle be determined," (which is what Kennard already accomplished in 1917). They conclude: "It is not possible to discuss the problem consistently in both the stationary and the rotating frames without recourse to General Relativity". They refer the reader to a 1939 paper by Schiff [12].

In this paper Schiff calculates the "warping" of space which is "ascribed to the rotation of the distant masses" of the universe and which shows that an "extra current appears and modifies the electromagnetic tensor equations" in a rotating frame of reference. This means, in ordinary language, that the peculiar effects occurring in a rotating electromagnetic system are supposedly due to the violent "backward" rotation of all fixed stars and extragalactic nebulae as seen by an observer stationed at the rotating magnet itself. No physical explanation is given as to how such a mysterious interaction takes place. At this point, therefore, we can go back to reality and consider some more crucial experiments.

4. Crucial experiments: (b) linear translation

To avoid the need of General Relativity, an attempt was made to duplicate the results of the previous experiments in rectilinear uniform translation, rather than rotation, of the magnet and wire RI.

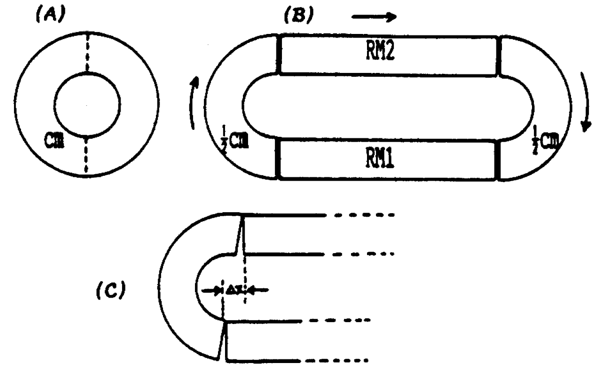


Fig. 6. Test of induction by linear translation.

Consider Fig. 6a, which is a top view of the cylindrical magnet in Fig. 5, (the magnetization is perpendicular to the paper). This magnet is cut into two semicylindrical halves as shown by the dotted lines and inserted to bridge the rectangular (ceramic) magnets, RM_l and RM_2 (5 inches long), as shown in Fig. 6b. (The semicircular magnets are labeled $\frac{1}{2}CM$). This "race-track" shaped magnet could be moved continuously as indicated by the arrows if it were flexible (like an endless magnetized belt). In reality, the solid ceramic magnets can only be slightly displaced back and forth. The gaps between the RMs and the semicylinders will then be slightly distorted into wedge-shaped gaps as shown in Fig. 6c, but this is of no consequence for the experimental results.

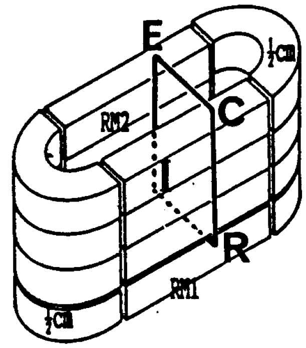


Fig. 7. Set-up for testing linear translation.

The $RIEC$ circuit is now inserted through a gap in RM_l as shown in the perspective view of Fig. 7. Finally the plates $fghk$ are added to obtain Fig. 8. This is identical with Fig. 5 except for the shape of the central magnets.

With this arrangement it was found that the resulting EMFs are qualitatively identical with those of Fig. 5. (See Table 1, column for Fig. 8). Again we note the striking case 8: The $RI + EC + RM$ magnets are all moving together in rectilinear (inertial) motion. And yet a positive EMF results! This again violates the requirement of relative motion prescribed by Einstein in his 1905 paper. But this time the violation is fatal for the Special Theory. Since we are now dealing with rectilinear motion, there is no possible recourse to the General Theory. (The main observed effect is due to the time interval in which v is constant, so only the results of *Special* Relativity are needed. The linear dependence of the EMF on velocity was checked by a dual channel osciloscope.) Special relativity now seems to fail right in its own domain. The analytical proof of this failure is as follows.

a) In a (primed) reference system moving with RM and RI (where a charge q is located), the proper field values are $\mathbf{B}' = \mathbf{B}'$ and $\mathbf{E}' = \mathbf{0}$ (the magnet is electrostatically uncharged in its proper frame). An observer applying the Lorentz force

$$\mathbf{F}' = q(\mathbf{E}' + \mathbf{v} \times \mathbf{B}') \tag{1}$$

in this frame, in which $\mathbf{v} = 0$ for q, will get

$$\mathbf{F}' = 0$$

contrary to the experimentally observed EMF.

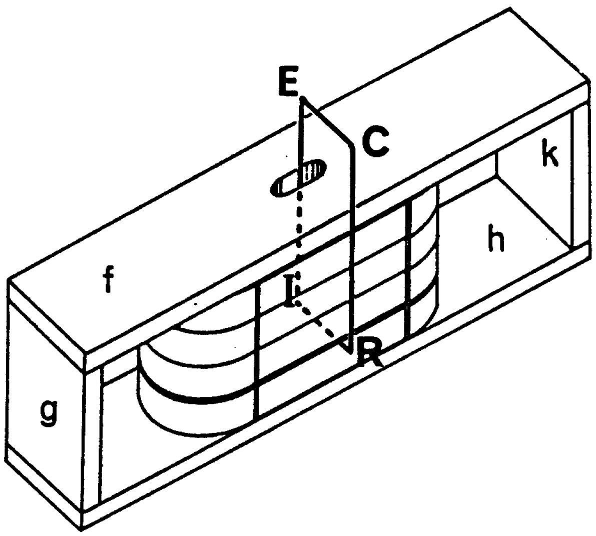


Fig. 8. Linear translation with magnetic screening.

b) On the other hand, an observer fixed in the Lab who sees the magnet traveling with velocity $\mathbf{v}$ (say, to the right), application of the same (relativistically invariant) form of the Lorentz equation,

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{2}$$

requires evaluation of $\mathbf{E}$ and $\mathbf{B}$ via the (perpendicular component) field transformation equations, namely:

$$\mathbf{B} = \gamma\left(\mathbf{B}' + \frac{\mathbf{v} \times \mathbf{E}'}{c^2}\right) \tag{3a}$$

and

$$\mathbf{E} = \gamma(\mathbf{E}' - \mathbf{v} \times \mathbf{B}') \tag{3b}$$

where

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

The latter equations yield

$$\mathbf{B} = \gamma \mathbf{B}'$$

and

$$\mathbf{E} = -\gamma \mathbf{v} \times \mathbf{B}'$$

Substituting these values in (2) we obtain:

$$\mathbf{F} = 0 \tag{4}$$

again in contradiction with the observed EMF.

5. Discussion

Consider the following questions:

(1) If no relative motion between magnet and wire is required in case 8 (and even 7) of Fig. 8 to produce an EMF, why does the mere translation of the system of the earth through sidereal spaces not result in an EMF that could disclose the magnitude and direction of such an (absolute) rectilinear translation?

(2) Could it be that motion relative to the yoke $fghk$ is essential in Fig. 8?

(3) Is motion relative to the Lab observer, or relative to the earth's gravitational field, required for case 8 of Fig. 8?

Additional experimental variations that cannot be fully developed here might help us to answer some of these questions. For example, motion of the yoke, while the magnets stay at rest in Fig. 8, produces practically no EMF, thus answering point (2) in the negative. Likewise mounting of the whole system in Fig. 8 in a wheeled vehicle and moving it with respect to the Lab results in no EMF. So (3) is also answered in the negative. Why, then, is absolute motion not detected?

It is not detected just as motion in the vehicle through the Lab is not detected, because the essential condition for unipolar induction to occur is not fulfilled. This condition, as demonstrated by both Figs. 5 and 8 is that the motion given to the magnets entails no magnetic changes, (no dB/dt) anywhere in the universe. Such is the case of "continuous rotations," as Poincaré said, or of a linear translation that has being made continuous by mixing it or "closing" it with some semicircular portions as in Fig. 6b. Obviously the translation of Fig. 8 (absolutely in sidereal spaces or just relative to the Lab), entails dB/dt effects at the edges of the magnets, (of the yoke plates g and k, or of the semicircular borders of the magnets).

Relativity theory, when applying the field transformation equations to the local area where the wire RI is immersed in a (constant) $\mathbf{B}$ field as done above, predicts a zero net EMF, in agreement with the non-detectability of the translational (sidereal) motion of the whole system. But then it fails to account for the positive EMF observed in case 8 (or 7) of Fig. 8, where exactly the same relativistic analysis, contrary to the facts, again predicts a zero net EMF.

Classical theories, on the other hand, might be able to discriminate between the positive unipolar induction effect of Fig. 8, case 8, and the zero net effect of absolute translational motion. An exact analysis of how this could be done either using the convective operator $\mathbf{v}\cdot\nabla\mathbf{B}$, (or $\mathbf{v}\cdot\nabla\mathbf{A}$) leading to a motional $-\mathbf{v} \times \mathbf{B}$, or by using Maxwell's flux rule or some of the formulations of the Amperian electrodynamics of direct actions at a distance without field concepts, is outside the scope of this article and will be considered elsewhere.

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Editor's Note

Mr. Müller's paper on unipolar induction reports experiments of fundamental importance.

However, the discussion of possible interpretations lacks what many readers will consider the simplest explanation of all eight cases in Table 1: that the free electrons in the wire *IR* are subject to the EMF-causing force $\mathbf{F} = \mathbf{v} \times \mathbf{B}$, where $\mathbf{v}$ is the velocity of the conductor with respect to the field. This explanation is undisputed for the relative motion of a wire in the field near the end of a bar magnet, and in hundreds of other cases. We are therefore entitled to use this law as a criterion of whether the field moves. This entails no more circularity than using other successful laws as defining criteria (for example, using conservation of energy to infer the energy of a term in the energy balance without actually measuring it). Using this procedure, it simply means that the field is not moving with the magnet in cases 5 and 8, so that the conductor has a velocity $\mathbf{v}$ with respect to the field and obeys the $\mathbf{v} \times \mathbf{B}$ law.

This point was discussed with Mr Müller, who does not believe in the physical existence of a field with lines of force, and could not be persuaded either by the argument above, or by the case of iron filings which would, in freedom from friction, trace these lines and demonstrate the motion (or its absence) of the field.

It was nevertheless considered appropriate to inform the reader of this interpretation of Mr. Müller's observations as an alternative to his "essential condition" (which would apply exclusively to *unipolar* induction).

Entrainment by Non-Refractive Media

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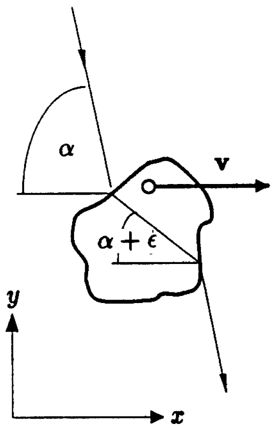
Summary: The often misunderstood difference between refraction and entrainment is examined. It is shown that a wave incident on a moving, non-refractive medium will change its direction within the medium by aberration only, but must emerge from it in the direction of incidence, regardless of the local normals to the interface at the entry and exit points.

1. The problem

Hayden [1] has shown that the assumption of constant light speed with respect to the local gravitational field leads to a refractive index very close to one; in the solar system, the only body massive enough to cause measurable refraction is the sun itself. Yet there have been numerous objections that the light of a star seen through the moving gravitational field of the moon or a planet would lead to a deviation of the star from its regularly observed direction.



The objection appears to be based on the confusion of refraction (the slowing of light in a medium) with entrainment (the motion of a medium in which the light is propagating). Both may lead to a change of direction of a wave incident on the interface, but for very different reasons. This note will treat the progress of a wave crest incident at an arbitrary angle onto the interface with a non-refractive "blob" of arbitrary shape (provided only its radii of curvature are large compared with the wavelength), and by extension through several other such blobs, any of which may contain the observer.

The problem is equivalent to a number of analogies, such as that of a sound beam propagating through water and traversing a water-filled, moving container (made of a material with the same acoustic refractive index as water). Experimental laboratory testing is thus possible.

2. Solution

Let the propagation vector $\mathbf{k}$ of a plane wave of frequency ω lie in the xy plane, making an angle α with the x axis. Then at time t a wave crest goes through the points x, y, where the phase is constant. Without loss of generality we choose a representation $[\cos(\omega t + \mathbf{k}\cdot\mathbf{r})]$ in which this constant is zero:

$$\omega t + kx\cos\alpha + ky\sin\alpha = 0 \tag{1}$$

where α is the angle made by $\mathbf{k}$ and the x axis. The lines of constant phase at time $t = 0$ are therefore $y = -x\cot\alpha$, with the direction of propagation defined, as always, as the normal to the lines of constant phase, i.e.,

$$y = x\tan\alpha \tag{2}$$

Now let those wave crests be incident onto a moving "blob" of some other medium. In general, the propagation constant in this new medium would be $k_2 = \omega n_2/c$, but since the medium is non-refracting ($n_1 = n_2 = n$), we have $k_2 = k$.

To find the effect of entrainment in this non-refractive medium moving with velocity v, assumed along the x axis, we substitute $t = x/v$ in (1), and using $k = \omega/c$, the same procedure now yields the normal to the lines of constant phase as

$$y = x\,\frac{\beta\sin(\alpha+\epsilon)}{1+\beta\cos(\alpha+\epsilon)} \tag{3}$$

where ϵ is a small increment of the angle α. Denoting y/x in (3) as $\arctan(\alpha+\epsilon)$ we have from (3) and (2) for small β and ϵ on neglecting quantities of second order (i.e., setting $\tan\epsilon \approx \sin\epsilon \approx \epsilon$, $\cos\epsilon \approx 1$, and neglecting the product $\beta\epsilon$),

$$\epsilon \approx \tan\alpha - \tan(\alpha+\epsilon) \approx \frac{\beta\sin\alpha}{1+\beta\cos\alpha} \tag{4}$$

The reason why this is identical with the formula for aberration is that entrainment *is* the cause of aberration; in fact, this is exactly how an observer traveling with the non-refractive blob would calculate aberration. Note that in the entire derivation the local normal to the boundary is irrelevant.

The rest is plain sailing: for the exit from the blob, we may simply use (2) with angle of arrival $\alpha+\epsilon$, and hence exit angle α. Thus, the direction of the outgoing ray must be parallel to the incident ray.

This result may now be generalized to any number of blobs with arbitrary velocities. In particular, for the original problem, the original frame may be chosen as that of the sun, a second blob as a planet or its moon, and a third blob as the earth. Then the direction of a ray from a star within the solar system is unaffected by any celestial body whose gravitational field it traverses; as it enters the gravitational field of the earth, it suffers an aberration which does not differ from that of other stars, but which is not compensated by the exiting angle if the ray ends in a telescope or other detector.

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Possible Explanation for the Edwards Effect

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An experiment performed by Edwards *et al.* demonstrates the existence of a negative potential on the surface of a superconducting wire which was proportional to the square of the slowly diminishing current in the wire. Conventional electromagnetic theory predicts that this potential should not exist. It is proposed here that the potential results from a force on a charge at rest caused by a magnetic field in motion.

Introduction

An experiment performed by Edwards *et al.* [1976] demonstrated the existence, quite contradictory to conventional electromagnetic theory, of a potential on the surface of a superconducting wire which was proportional to the square of the current. The circuit comprised a large counterwound inductance, a small coil, and a low resistance shunted by a superconducting wire with a small loop which served as a switch which opened when heated. A current was initially induced in the circuit and the connections were removed while the switch remained closed. The switch was then opened, and the circuit became a simple L-R circuit whose current decayed with a time constant of the order of 30 minutes. The current was measured via a Hall probe in proximity to the small coil in the superconductor, and the voltage relative to ground was measured with a high impedance electrometer. The electrometer formed the only conducting path between the wire and ground. Many variations of the experiment were performed, all of which produced the same result. It was as if there existed an excess negative charge $Q = CV$ on the surface, and that it bled away as the current diminished. In one variation of the experiment, the conducting wire was grounded, and in this case, it acted as if it had been charged inductively, because as the current diminished, the wire attained a positive charge which remained when the current was zero.

The authors showed that conventional theory was inadequate to explain the results, even through the invocation of Lienard-Wiechert potentials (which one might not ordinarily use because of the extremely small electron drift velocities involved). It is here attempted to provide an alternative explanation.

The effect of magnetic fields on stationary charges

The effect of a magnetic field on a moving charge is the force $\mathbf{v} \times \mathbf{B}$, but the effect of a moving magnetic field on a stationary charge is taken as zero. After all, many experiments have shown no measurable force on a stationary charge which is in proximity to a current-carrying wire. No measurable force, however, does not necessarily mean no force at all. The model described below postulates that a force exerted by moving magnetic field on a moving charge, normally extremely small, is adequate to account for the experimental results. Figure 1 shows a test charge q_t at rest and another charge q moving with velocity $\mathbf{v}_2$ with respect to q_t. If $\mathbf{E}$ and $\mathbf{B}$ are respectively the electric and magnetic fields of the moving charge q at the location of q_t, the force on q_t is given by the Lorentz force

$$\mathbf{F} = q_t(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{1}$$

We take the magnetic field at q_t, due to the motion of q, to be $k(\mathbf{v}_2 \times \mathbf{E})/c^2$, where $\mathbf{E}$ is the electrostatic field at q_t due to q. The parameter k is normally taken as unity, but we allow herein for a recent model [Mirchandaney 1988] which follows the methods of Riemann with $k = \frac{1}{2}$. Ordinarily, one presumes that the magnetic force on q_t is zero, because the velocity $\mathbf{v}_1$ of q_t, taken with respect to the observer, is zero.

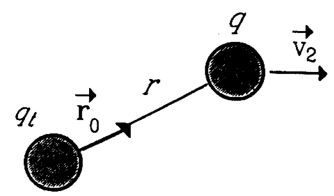

Fig. 1. Two charges in relative motion.

We herein break with that tradition, and postulate that there is a real force due to the moving magnetic field [Beckmann 1987]. Specifically, we assert that the velocity appearing in $\mathbf{v}_1 \times \mathbf{B}$ is not velocity with respect to the observer, but rather, the velocity of the charge q_t with respect to the moving magnetic field (hence, with respect to q). In other words, we postulate that the effect-producing velocity is that of the charge with respect to the magnetic field. That is, $\mathbf{v}_1 = -\mathbf{v}_2 = -\mathbf{v}$. Note that this postulate is not in contradiction to Maxwell's equations, which make no stipulation about the matter. Defining $\beta = v/c$, we obtain for the force on q_t

$$\mathbf{F} = q_t \left[\mathbf{E}(1 + k\beta_2) - k\frac{\mathbf{v}(\mathbf{v} \cdot \mathbf{E})}{c_2}\right] \tag{2}$$

Both terms in (2) appearing in addition to the normally considered electrostatic force are of the order of v^2/c^2, but they have different directions. Viewed under the present hypothesis, it is not surprising that these contributions to the force, if indeed they do exist, should go unnoticed. With drift velocities in wires being about 1 mm/s, the v^2/c^2 values are of the order of 10^{-22}. (We ignore any contribution from acceleration of charges in the present application.)

A direct experiment on a pair of charges in relative motion sufficiently sensitive to detect the contribution due to v^2/c^2 has not been performed. It seems prohibitively difficult to do so because of the overwhelming strength of the electrostatic force.

Accordingly, we adopt the hypothesis stipulated above, that the velocity in $\mathbf{v} \times \mathbf{B}$ is the velocity of the charge q_t with respect to the magnetic field. The assumption above is equivalent to the notion that if a charge moving through a magnetic field experiences a force, then a magnetic field sweeping past a charge should also cause a force.

Application to the Edwards experiment

Imagine a test charge q_t residing on the surface of the superconducting wire, and an electron moving past with the drift velocity v_d. By (2), the force on the test charge is the Coulomb force modified by the factor $(1+\beta_2)$, because $\mathbf{v}$ is perpendicular to $\mathbf{E}$. In other words, the electron at $\mathbf{r} = r\mathbf{r}_0$ from the test point contributes an electric field $\mathbf{E} = -(1+k\beta_2)\{e\mathbf{r}_0/4\pi\epsilon_0 r^2\}$ at the surface. Alternatively, one may think of the charge of the moving electron as appearing to be $(1+k\beta^2)$ times as large as e. A proton at the same location of the moving electron contributes a field in the opposite direction but without the velocity term. An imbalance is then due to an apparent charge $k\beta^2(-e)$.

We may apply Gauss's Law to this imbalance of charge, because the field at the surface of the superconductor is entirely due to a $1/r^2$ force. That is, the integral of the electric flux over the surface integral of $\mathbf{E}\cdot\mathbf{n}_0\, dS$ is just the net charge $Q_{\text{eff}} = -ANe\beta^2$, where N is the number of electrons moving at the drift velocity. Note that this is not a charge due to an increased electron count, but rather an effective charge due entirely to the magnetic field of the electrons moving at the drift velocity. The voltage on the wire is just Q_{eff}/C, where C is the capacitance of the wire. Finally, we have

$$V = -\frac{kNv_d^2 e}{c^2 C} \tag{3}$$

Here it is obvious why the voltage should be negative and why it should be proportional to the square of the current as Edwards [1976] found. The negative sign occurs because of the effective increase in the charge of the moving electrons. Since the voltage is proportional to the square of the velocity, it should be proportional to the square of the current.

Beyond that, however, there are some quantitative difficulties pertaining to inexact knowledge of electron velocity. A 1 ampere current in a loop of 1 meter length may be one uniformly distributed Coulomb traveling the meter's length in one second, or $10^3 C$ traveling the same loop in 1000 seconds at 1 mm/s. The force calculated above directly depends upon drift velocity, but only indirectly upon current. Suppose that $\mathbf{J}$ is uniform, and that the length and radius of the wire are L and R respectively. If in (3) we replace Ne with ρAL, and use $\rho = -Ne/AL$, and $v_d = I/\rho A$, where ρ is the charge density, I is the current, L is the length of the wire, and A its cross section, we obtain

$$V = \frac{kLI^2}{c^2 C\rho A} \tag{4}$$

where C is the capacitance of the wire. Equation (4) assumes that the current density is uniform and represents a lower limit to the (magnitude of the) voltage appearing on the wire. To account for non-uniform $\mathbf{J}$ values, which will result in higher velocities and hence higher voltages, define (as does Edwards) a parameter α by

$$\alpha = \frac{A}{I^2}\int J^2\, dA \tag{5}$$

to obtain

$$V = -\frac{k\alpha LI^2}{c^2 \rho CA} \tag{6}$$

Equation (6) is identical with (12) of Edwards except for k and another parameter introduced by Edwards as a factor to account for other possible models. In the present notation, Edwards's results were in agreement with (6), with $k\alpha$ values of about 20.

Comparison with other results

Sansbury [1985] performed an experiment which was similar in many ways and different in others. In his apparatus the current was 900 amperes, the conductor was a copper rod of about 1 cm diameter formed in the shape of a rectangular U, and the detector was a charged foil placed near the short (20 cm) end of the U, and positioned on the end of a light, balanced rod suspended by a torsion fiber. The voltage applied to the detector induced an image charge in the copper conductor, and exerted a torque which moved the detector to a new equilibrium position. The experiment detected, although not quantitatively, deflections from the new equilibrium.

Sansbury's results showed a deflection caused by the current, and that the deflection was independent of the direction of the current. In this experiment the direction of the deflection was always that of a positive charge on the surface of the conductor. Apart from any models, this experiment apparently contradicts the Edwards paper. The author believes that the Edwards paper is the more carefully done and definitive, and that there is a simple explanation for the results of the Sansbury paper.

For a current in a given direction in the U, the magnetic field due to the 900 A current in the sides is experienced by the current in the end. The pinch effect caused by the large current should concentrate the current density, and the Hall effect caused by the magnetic field in the sides of the U should shift the electron density toward the inside, leaving an unbalanced positive charge on the outside near the measuring probe. It would have been nice if Sansbury had also measured the field on the inside of the U to see whether it was negative, as it must be if the magnetic field forced the current density inward. We note that the superconductor used in the Edwards experiment would exclude magnetic fields.

Conclusions

The negative voltage appearing on a superconducting wire [Edwards 1976] proportional to the square of the current I in the wire has defied explanation within the context of conventional electromagnetic theory. The results can all be explained by the hypothesis that there is force on a stationary charge due to a moving magnetic field, just as there is one on a charge which moves through a magnetic field. It is normally so small, owing to low drift velocities in currents, as to have escaped detection.

Because the electric field discussed here is proportional to I^2, it might be argued that the random motion of electrons in their orbits should, contrary to fact, cause a negative potential always to occur on any surface whatsoever, the direction of the electron velocity being of no concern. The test charge q_t, however, responds to the field, which arrives at q_t from such electrons with random phase and direction, resulting in zero net field. Only the systematic effect of a unidirectional drift velocity contributes a non-vanishing resultant.

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CORRESPONDENCE

Comment on several papers

In "The Double Slit Paradox" [1] the author accepts Maxwell's equations as a part of his theory. Then he has nonradiating oscillating electrons, and says this is OK by making an analogy with a terminated transmission line. But his oscillating electron is in empty space, and any textbook on classical electrodynamics shows that a charge oscillating in empty space radiates. So, where is the mistake in the standard textbooks?

His equation (8) is not a solution to the differential equation (7); you do have to make the replacement as stated in the paper. But what justifies replacing v by $v - v_0$? Why does he say that v is the velocity with respect to the moving system, when earlier in the calculation v was the velocity with respect to your preferred inertial rest frame? Is (7) correct as it stands? If so, then the solution is for the velocity to oscillate about v = 0 and with an undetermined amplitude since (7) is a linear equation.

Now I'll go to the conclusion of the paper. The author does not appreciate the role of the wavefunction in physics. It is a state of knowledge about a physical system that allows predictions to be made about the results of measurements on that system. A wavefunction is not a physically real object like an electric field. Rather it is a probability amplitude; it has the same kind of reality as a probability distribution, and it does for quantum physics what the familiar probability distribution does for classical physics. In particular, the wavefunction can suddenly change when new information is learned as a consequence of a measurement. There is a small minority of physicists who believe that the wavefunction has physical reality, but they are stuck with having to explain how the wavefunction can change faster than the speed of light. This is one of two reasons why the author's ψ field cannot possibly be a wavefunction. The second reason is that the wavefunction is defined over configuration space, so that for an N-particle system, the wavefunction is a function on $3N$-dimensional space.

Finally, there is this ad hoc notion that light propagates with speed c with respect to the local gravitational field. Consider the observed fixed position of the stars on the celestial sphere. What happens to the observed position of a star when the moon approaches in a near occultation? The starlight passing through the moon's gravitational field is entrained by that field and carried along and also it is refracted at the boundary where the Moon's field dominates. It then emerges into the earth's field and gets refracted again. Have you calculated how a star's apparent position gets distorted by the moon's nearby passage?

Next, I'll comment on Howard Hayden's letter. I cannot understand why entrained ether is carried with the earth in its motion around the sun but not with its rotation. After all, in a small enough volume, the velocity of rotation is indistinguishable from linear motion. In his paragraph that begins "Let us ignore that explanation ...", Hayden mistakenly assumes that special relativity can be applied in a rotating frame. That just isn't so: the "special" in special relativity means inertial systems only. As for the Michelson-Gale experiment, the results are also consistent with a constant speed of light, but with round trip path lengths different for CW and CCW propagating light beams because in one case the mirrors are moving in the same direction as the light and in the other case the mirrors are moving in the opposite direction.

As for your book review, I remember reading Dingle's letters in *Nature* many years ago. He impressed me as someone who never took the trouble to understand relativity. It is unfortunate when scientists resort to ridicule, but that does not imply that the ridiculed ideas must be valid. I'll answer the clock paradox for you. Within special relativity, a moving clock appears to run slower. But if both clocks are fixed in inertial frames, they cannot cannot be brought into coincidence at two events of spacetime, and one can't experimentally measure which clock runs faster, for according to relativity, there is no observer independent notion of simultaneity. If one clock is accelerated to return it to the location of the other, then the symmetry is broken and Dingle's reasoning no longer applies. The reviewer seems to object to the answer: "the fastest working clock between any two events is the one that travels between them in free fall." But this is a theorem of general relativity, whether or not general relativity is physically correct. Now why does the reviewer think that answer is unsatisfactory? The entire problem seems to be an adherence to the ancient concept of time as some kind of observer independent universal coordinate. But this is contrary to relativity. If you wish to persuade the believers in Einstein's theory that they are wrong, you have to exhibit an internal inconsistency of that theory.

Going now to the second issue. It starts right off with sloppy reasoning in the first paragraph and a display of ignorance in the second. In the first paragraph, Howard Hayden concludes that the speed of light is not isotropic from experiments in which clocks were transported in various directions. The actual experiment involved a transport of clocks not light, so what justifies the conclusion? The next paragraph illustrates a typical phenomenon: misrepresent a theory you don't understand. In Einstein's theory of general relativity, the speed of light is expected to be constant because a constant speed of light was built into the theory: at any point of spacetime, the curved spacetime can be approximated by a flat tangent spacetime in which special relativity holds. The approximation amounts to neglecting gravitational gradients. This has no bearing the conclusions of the paper; it's just that if Hayden hopes to make a positive impression on establishment physicists, he should not make false statements about establishment physics.

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PETR BECKMANN'S REPLY:

The mistake of standard textbooks [in stating that an accelerated electron must radiate] is tying the radiation to acceleration, authority, impermissible corollaries, and anything else but the Poynting vector, which alone can tell us about the flow of energy and radiation. If an electron undergoes forced oscillations with **E** and **H** in phase, the Poynting vector always has the same direction, that of the propagating radiation. That is not the case here. **E** and **H** were shown to be in phase quadrature, so that the resulting Poynting vector will change direction twice every cycle, the energy flowing from the magnetic to the electric field of the oscillating electron exactly as it should. A detailed analysis of the entire field at all points and all time phases, including field plots, is given in [2], pp. 157–162.

Equation (7) applies to a system moving with the average velocity of the electron with respect to the screen (laboratory). We then leave this system for good and change to the screen system, for which the solution is (8). In the spirit of normalization (before and after) and integration (variable and limit) I have used the same letter v for velocity before and after the change, but the reader who finds this too difficult can use v' for velocity up to and including (7) and v thereafter, the two being related by $v = v' - v_0$.

The function ψ in my paper represents that part of the **E** field whose curl is not zero, and in the source cited in my paper, namely [2], it is shown that this field satisfies the Schrödinger equation. In my paper I went out of my way to dispel any suspicions that this somehow uses quantum mechanics [following (16)], and even put "wave function" in quotation marks to stress that it is physically something different, even though it satisfies the same equation. I will not quarrel with Dr. Salamin's assertions that the QM wave function, as distinct from the Faraday field my ψ, is either something that has no physical reality or alternatively must be endowed with weird and wondrous properties; but I fail to see why I should be held responsible for such weird wonders.

As for starlight passing through the Moon's gravitational field — entrainment yes, refraction no. I would have thought this obvious after Prof. Hayden proved the refractive index of the gravitational field surrounding any body in the solar system (except the Sun itself) virtually equal to unity; but since Dr. Salamin was not the only one to overlook the point, I show elsewhere [3] in more detail and with significantly more generality that the rays entering and leaving a moving gravitational field (with $n = 1$) must necessarily be parallel.

The reason why the terrestrial gravitational field is carried along with the translation of its source, but not with its rotation, is explained in [2], p.43; but there is also a direct analogy in the *magnetic* field of a symmetrical body — for its magnetic field also will travel with it when the magnet is translated, but not when it is rotated about the axis of symmetry of the field [4].

Nobody claimed that the Michelson-Gale result cannot be also explained by the Einstein theory (or several others). But the investigated theory derives it by a few lines of high-school algebra, the Einstein theory by complicated and abstract tensor calculus. Dr. Salamin's explanation, incidentally, is also complicated, but otherwise wrong: each of the two round-trip paths has mirrors moving *both* with and against the light.

To call the late Prof. Herbert Dingle "someone who never took the trouble to understand relativity" is, to make a strong understatement, cruel. For Dingle published books and papers *explaining and supporting* Einsteinian relativity since 1922, and his little book *The Special Theory of Relativity*, opened the field for hundreds of thousands of beginning students (myself included) ever since the first of many editions was published in 1940; he did not discover contradictions in the theory until he was in his mid-sixties. "Why does the reviewer think the answer about the fastest clock being the one in free fall unsatisfactory?" Because it does not answer Dingle's question, (essentially) "Which of the clocks in two inertial frames runs faster?" Among possible answers, right or wrong, are that it is no. 1, or no. 2, or neither, or the answer Dr. Salamin has given, namely that the question is not answerable because, in Einstein's theory, it cannot be subjected to experiment. The fallacy of the free-fall answer is the tacit assumption that if a statement is true, or at least consistent with chosen assumptions, it must also be relevant; as an answer it is therefore in the same class as "Because tightrope walkers pay higher insurance rates."

Dr. Salamin says "The entire problem seems to be an adherence to the ancient concept of time as some kind of observer independent universal coordinate. But this is contrary to relativity." This is indeed *almost* the entire problem. The remainder is that (Einsteinian) relativity is not only contrary to this concept, but also to the experimental evidence. As shown by Claybourne [5], if time were dependent on, and different for, the coordinates and velocity of each individual observer, the discrepancy between local time and that of clocks on satellites would not be the same for *all* observers, nor could all of these clocks be synchronized simultaneously for all of these observers with different coordinates and velocities.

[1] P Beckmann, "The double-slit paradox," *Gal. Electr.* vol. 1, pp. 3-6, Jan./Feb. 1990.

[2] P. Beckmann, *Einstein Plus Two*, Golem Press, Box 1342, Boulder, CO 80306, 1987.

[3] P. Beckmann, "Entrainment by non-refractive media," *Gal. Electr.* vol. 1, no. 3, p.31, May/June 1990.

[4] F. Müller, "Unipolar induction experiments and relativistic electrodynamics," *Gal. Electr.* vol. 1, no. 3, pp. 27–30, May/June 1990.

[5] J.P. Claybourne, "Experimental data and simultaneity," *Gal. Electr.* vol. 1, pp. 19–20, March/Apr. 1990.

Petr Beckmann
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HOWARD HAYDEN'S REPLY:

"...entrained ether is carried with the earth in its motion about the sun but not with its rotation." For "ether," this is indeed a problem. But Dr. Salamin would surely not deny that the earth's gravitational field is carried with it around the sun. Does he imagine that the gravitational field rotates, and if so, what evidence can he present? If he were in a box, could he do an experiment to detect whether the sun rotates? By way of analogy, one of Faraday's experiments showed conclusively that when a permanent magnet rotates, the magnetic field does *not* rotate. [See Wallace' article in this issue.]

"Hayden mistakenly assumes that special relativity can be applied in a rotating frame":

1. One may for the purpose of argument assume *anything*, even something known to be false. For the Häfele-Keating experiment, I assume *for the sake of argument* the speed of light is constant w.r.t the lab. That the derived result (*all* moving clocks run slowly) is contradicted by the data (westbound clocks run fast) only goes to prove that the assumption is false. One would be in a poor logical position to insist simultaneously that the speed of light is constant *only* in an inertial frame *and* is still constant w.r.t an earth-based lab.

2. I have no direct evidence of this, but I assume that Dr. Salamin applies SRT on a regular basis for calculating, for example, "relativistic energy," "relativistic momentum," and the like for accelerator experiments in spite of his saying, "Hayden mistakenly assumes that special relativity can be applied in a rotating frame." The earth rotates just as fast in one case as in the other. If it can't be applied, don't do it. If it can, do it. If it can under some conditions, but not under others, what are the conditions?

3. With respect to the last point, the canonical explanation of the Häfele-Keating experiment in SRT says that the lab frame is accelerating, so one must use a non-accelerated frame, for example one at the North Pole which doesn't rotate. In that frame, the west-bound clock moves slowly east, the lab moves faster, and the east-bound plane fastest; the clocks are slow, slower, and slowest, respectively.

I don't quarrel that a good SRT argument can be found to explain Häfele-Keating, but the canonical one isn't it. Let's look at numbers. At 40° latitude, the centripetal acceleration is 0.02 m/s^2. By the SRT argument, that acceleration makes the system non-inertial. OK. So choose the North Pole system. The chosen system goes around the sun 1.5^11 m distant at $3.0 \cdot 10^4$ m/s, which makes the centripetal acceleration 0.006 m/s^2. How can it be that of all possible accelerations from zip to those in accelerators that the dividing line between "inertial" and "non-inertial" occurs between those two numbers which differ by only a measly factor of about 3?

4. I did *not* mistakenly or otherwise assume that SRT can be applied in a non-inertial frame.

5. Dingle raised this question which was ignored by all, despite his persistent pleas: OK, OK! We should use inertial frames in SRT. *However*, when one is not available, what rules exist for preferring one *non*-inertial frame over another? (In other words, go back to point (3) and provide a rational reason for preferring the 0.006 m/s^2 over the 0.02 m/s^2.)

If one (rightfully) assumes that SRT cannot be applied in a non-inertial frame, and then begs GRT to provide the answers, here is what results: The speed of light is triply forbidden from being constant in GRT. In a rotating frame, the speed of light (for one who deigns to define velocity by D/t) is $c \pm v$ backwards/forwards along the velocity vector, is different near a gravitating body than in free space far from such bodies, and is different radially than it is tangentially near such a body. In other words, despite the effort in SRT to keep the speed of light constant by forcing time and space to fit the preconceived notion, GRT overrules it anyway. Is it not time to rethink the whole thing?

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Inertial Force in Energy Exchanges

"The role of inertial force in energy exchanges" by R.L. Carroll (*Gal. Electr.*, vol. 1, no. 1) opens with remarks that cloud the points that he is trying to get across. For example, Fig. 1 is not "an impossible abstraction." It is used to "consider apart" (abstract) a piece of a real problem as an aid in studying basic relationships.

Above (2.1) Carroll writes "The fallacy of classical mechanics is that the inertial force does no work." If the spheres are billiard balls, classical mechanics would say that their impact causes a slight, but elastic, deformation of the balls (taking energy and storing it as potential energy related to the deformation) which is then given back to the system as the balls separate. In elementary mechanics, where interest is in determining the paths of the balls, the deformation and related energy changes are not important so they are "abstracted out."

If the spheres are like charges, when they move together their mutual energy increases (causing the repulsive forces). After the "reflection," when the charges separate, the mutual energy decreases to its original value when the charges are at their original separation. The only change in the energy at that point is in the magnetic fields and is related to the $\frac{1}{2}mv^2$ of the charges. There is no "internal energy" of the charges associated with the slowing of one charge and acceleration of the other.

Classical physics accounts for all of the energy interchanges in both cases.

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AUTHOR'S REPLY:

Fig. 1 is in error in that there is no consideration of the effect of the reaction force either on the source or on the object being accelerated.

The interchange of energy between billiard balls in elastic impact considers only the conservation of the original kinetic energy. It has nothing to do with the reduction of internal energy resulting from the act of putting the object into motion in the first place.

The point of the paper is to show that there is a basic error in physics that has been perpetuated as long as the study of physics has existed. This is the assumption that the reactive force does no work. It is inherent in the work of Einstein as well as all of the others.

Since theory can be argued forever to no point, let us turn to a consideration of experimental fact. The atomic clock exists. When it is put into motion in the static field of the earth, the period of internal oscillation is described by

$$T = \frac{T_0}{\sqrt{1 - v^2/c_0^2}} \tag{1}$$

where v is the velocity of the clock and c_0 is the standard velocity of light, and T is the period resulting from putting the clock into motion. Since the period is the reciprocal of frequency, we have

$$f = f_0\sqrt{1 - v^2/c_0^2} \tag{2}$$

We conclude that the frequency is reduced with respect to that at rest. A physical fact requires a physical interpretation. If (2) is multiplied by Planck's constant, we find

$$E = hf = hf_0\sqrt{1 - v^2/c_0^2} \tag{3}$$

where (3) is now a measure of internal energy.

The conclusion to be drawn is that the internal energy of an aggregate mass in a static field is reduced as the kinetic energy of motion is increased. This is in exact agreement with the article in question.

Since the time transformation does not exist as a physical entity, it is necessary to conclude that the Einstein theory is a mathematical imitation of physical truth. The fact of measurement requires the present analysis to be correct.

Dr Robert L. Carroll
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Experimental Data and Simultaneity [1]

Claybourne's paper on "Experimental data and simultaneity," *Gal. Electr.*, vol. 1, no. 2 contains a misunderstanding. Claybourne correctly quotes the Lorentz transformation for time,

$$t_1' = \gamma(t_1 - \frac{va}{c^2}) \tag{1}$$

that the moving system reads at t_1 at a. However, (4), (5) and (6) are not what he claims. All derivations in the literature that result in those equations refer to the time interval of a single moving clock compared to two of the base system's clocks. In connection with (2) and (3), the fixed system's clocks are all light-set relative to one clock in that system, and the moving system's clocks are light-set relative to one clock in that moving system. Only one clock (the original zero time clock) in the moving system is ever synchronized with the fixed system clocks. Thus, to apply (5), *that* clock must be used. This can only be done by letting $a = vt$, which *does* result in (2) taking the form of (5). All of the experimental data he quotes agree with both equations when used properly.

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AUTHOR'S REPLY:

Prof. Dishington's comments contain three significant errors or omissions.

First, he sidesteps the main thrust of the paper. Equns. (1), (2) and (3) show the time of an event in the moving system to be a function of x, the location of the event in the fixed system. Equns. (4), (5) and (6) show the time in the moving system to be a function of γ, or v^2. Experimental data confirm the latter, refuting the former. Prof. Dishington states "All the experimental data agree with both equations when used properly." This is not so. I suppose "both equations" means (2) and (5). According to (2), t' can vary from a large negative value to zero to a large positive value, depending on a (and v). Obviously, somewhere in this large range it gives the correct value, which is $t'_1 = t_1/\gamma$ when $a = vt_1$. In general, (2) and (3) give different results and the statement quoted above can be true only if one assumes that letting $a = vt_1$ is the only way (2) can be "used properly."

Second, he states "Only one clock ... in the moving system is ever synchronized with the fixed system clocks." If we set only the moving master clock and the stationary master clock to zero when they are coincident, then both are out of synch with other clocks in their frames and even the stationary clocks cannot provide a meaningful reading for the next event. When the theoreticians speak of setting clocks to zero, they assume that all clocks in with frames are set to zero, neglecting the practical difficulties in accomplishing this. The only reason for using zero as a common point for both systems is to simplify the calculations; it is convenient, but not necessary. If the base master clock reads t_1 when it coincides with the moving master clock reading t'_1, we can adopt the idea of letting t_1 be the "zero time" in the moving system. The time interval between this first coordinating event and a second event at t_2 in the base and t'_2 in the moving system will be $t_2 - t_1$ in the base, and $t'_2 - t'_1$ in the moving system. Since the synchronization of the clocks in with systems has not been upset, clocks in both systems will read the same time as their master clocks at the second event.

Finally, he states "Equns. (4), (5) and (6) are not what he claims," claiming that all time dilation derivations compare the readings of a single moving clock with those of two fixed clocks. If a system contains an array of clocks synchronized with a master clock and at known distances from it, signals from an event at the master clock permit an observer at any other clock to measure the time of the event by subtracting the calculated travel time from the measured arrival time. This process can be repeated for a second event, from which the interval between events can be calculated. It is therefore irrelevant whether a time interval is measured only by one clock or by several, since all observers in the same frame will agree on the measurement.

J.P. Claybourne
2919 Bronco Lane, Orlando, FL 32822

Eperimental Data and Simultaneity [2]

Your article by J.P. Claybourne with the title above [*Gal. Electr.* vol. 1, no 2) requires comment.

It is easy to show that (1) and (4) represent the Lorentz transformation and are mutually compatible. Then if (2) and (3) are rightly deduced from (1) while (5) and (6) are rightly deduced from (4), these deductions should also be mutually compatible. But they are not. You claim this is due to flawed special relativity or wrong conclusions generally accepted on its basis. Your "Conclusions" sums up these flaws.

However, a theory must be applied on its own terms in order to test it. You have, inadvertently I am sure, violated this principle.

As you point out, "These equations were derived under the assumption that the origin of the *two* [my emphasis] systems are coincident when all their clocks were set to zero $\ldots x = x' = t = t' = 0$." But your equations involve not two, but rather *three*, systems.

The derivations of (2) and (3) depend upon, respectively, $a = vt_1$ and $a+d = vt_2$; your condition $t_1 = t_2$ cannot hold.* Your moving systems *1* and *2* have only a constant difference of time d/v, but they are different systems nevertheless. They cannot be treated as though one system without such inconsistency with the theory being tested expressing themselves as inconsistent results. The embankment system, of course, is the third system of the trio.

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* A. Einstein *et al.*, *The Principle of Relativity*, (Dover, reprint of Methuen & Co, 1923), p.43, third paragraph.

AUTHOR'S REPLY:

The parameters a and $(a+d)$ were intended to represent the coordinates of the two lightning strikes in the stationary frame of the embankment. Perhaps the embankment in reference 2 (Robinson and Denholm) in my paper will clarify that there are only two reference frames involved, not three.

The logic in Dr. Driscoll's statement regarding the relationships between the first six equations is impeccable.

Since (4) is verified by experimental data, we must look for a new interpretation of (1) to bring its predictions into agreement.

The Lorentz transformation basically compares time and space *intervals*; I shall define the x parameter in (1) as the distance between any particular clock and in the moving system travels during the time interval t. The clock located at $x = a$ when $t = t_1$ was at $x = 0$ when $t = 0$; its distance traveled at $a - 0 = a$. The clock located at $x = a + d$ when $t = t_1$ (or t_2, which is the same) moved the same distance as the first clock. It therefore was located at $x = d$ when $t = 0$ and traveled a distance $(a + d) - d = a$.

We now have

$$a = vt_1 \quad \text{and} \quad a = vt_2$$

If $t_1 = t_2$ (as described by Robinson and Denholm), then the flashes are simultaneous in both frames, occurring at t_1 on the embankment and at t_1/γ on the train. If t_1 and t_2 are not equal, the flashes are *not* simultaneous in either frame.

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BOOK REVIEW

Progress in Space-Time Physics, ed. J.P. Wesley, 280 pp. sftbd., $32 from J.P. Wesley, Weiherdammstr. 24, 7712 Blumberg, West Germany.

Reviewed by Petr Beckmann

The book, printed in reduced typewriter offset, contains 27 papers by 24 authors; all but one German paper are in English.

The common thread of the papers is rejection of the Einstein theory; most are positive in proposing alternatives.

It is a book that no one interested in the subject can afford to ignore. He will assuredly disagree with at least some of the authors, for they often disagree among each other. But it contains no papers by cranks (people who object to the Einstein theory without following accepted rules of scientific logic and strict abidance by the experimental evidence), and it offers much original, valuable material that is difficult or impossible to get without actively searching for this type of dissident point of view. This reviewer, for example, was unaware of the extent of experimental evidence appearing to decide against the Lorentz force and in favor of the Ampère force law, nor did he realize that it was directly derivable from the Weber potential – itself an almost forgotten relic now retrievable perhaps only from O'Rahilly's masterful critique of accepted electromagnetics [1].

Most of the papers are written by supporters of absolute space and an absolute ether, as distinct from what one might call a "local" ether (if the word is necessary) in local domains formed by the dominant gravitational or electromagnetic fields. This point of view has received strong support from Silvertooth's experiment, and will receive more if that experiment proves reproducible and explainable by a theory that is not contradicted by other experiments; but at present this approach is not without difficulty.

For example, there have been several attempts to reconcile the Michelson-Moreley experiment with the concept of a universal ether, but none of the two main attempts seem very inviting.

One is presented in this collection by J.P. Wesley, who explains the absence of a shift by the Voigt-Doppler effect, better and more fully explained in vol. 1 of [1], and by the introduction of a phase velocity, distinct from the group ("energy") velocity, for light in free space. This version of the Doppler effect is highly labored, introducing the quantity $\gamma = 1/\sqrt{1 - v^2/c^2}$ into the result by a cumbersome derivation (which Wesley bypasses by accepting the result as "empirical"). Moreover, a difference between phase and group velocity appears only in dispersive media, and dispersion of the proposed ether has not appear to have been observed in any other instance. It therefore seems doubtful whether Occam's razor would prefer this reasoning over the Einstein theory.

A second attempt, not well represented in this volume, is the Lorentz theory itself, or some relation of it which defines a velocity-dependent – but not observer-dependent – time. Once again this involves the Lorentz transformation and the inevitable γ, without much attempt at simplicity or at Einstein's forte: simple basic assumptions. As the Czechs say, "Why go to the tinkerer when I can go to the blacksmith?"

That said, it should be admitted that a third point sometimes made by the ether proponents (including Silvertooth) is that the one-way velocity of light has never been measured. Until quite recently, this reviewer was of the opinion that the absence of aberration (a one-way effect) of terrestrial sources could not be reconciled with an "ether wind." This objection had to be withdrawn in light of the paper on entrainment in this issue; a side-effect of the calculation shows that an ether wind, as against its absence, would entrain a different ray of the source, but deliver it to the telescope at the same angle of arrival.

However, all of the papers, whether the reader agrees with their point of view or not, are very much worth reading. The two that on a first reading seem most fundamentally important are those on rotating magnets by F.J. Müller (whose paper in this issue generalizes the experiment further and includes linear displacement), and J.P. Wesley's paper on Weber electrodynamics.

The former lends strong support to the idea that the effect-producing velocity in electromagnetics is the velocity with respect to the field rather than with respect to the observer, and does so more decisively than Faraday's little known experiments with rotating magnets. Wesley's paper gives a cogent explanation of the observed discrepancies between certain experiments and the Lorentz force, in particular its component based on the Biot-Savart law.

The book's flaws are minor. The Lorentz force is not, as one of the authors writes, an empirical law independent of the field equations; it follows from the Maxwell equations via the stress tensor as explained in any better text on electromagnetics, including [1]. Nor is the Sagnac experiment, an experiment with a rotating inteference loop, a refutation of Einstein's theory, as another author claims: the fact that the classical explanation is incomparably simpler is not a refutation of a more cumbersome theory. And though mathematical rigor is usually an exaggerated requirement in physical texts, it becomes important in claims that a law widely accepted by the orthodox establishment is absurd: the demonstration of absurdity must include proof, or at least a discussion, that the absurd result is not due to some mathematical artifact – in this case a double integral which changes value with different ways of integrating, regardless of any physical phenomenon it represents.

But overall this little volume has a remarkable quantity of food for thought in it, and no doubter of establishment physics should miss it – nor, for that matter, should Einsteinians, if they consider their beliefs unassailable (as most of them do).

[1] Alfred O'Rahilly, *Electromagnetics*, Cork University Press, U.K., 1938; reprinted as *Electromagnetic Theory*, by Dover Publ., New York, 1965.

GALILEAN ELECTRODYNAMICS

Experience, Reason and Simplicity Above Authority

July/August 1990 (Vol. 1, no. 4) **Box 251, Boulder, Colorado 80306**

Contents

Editorial Policy

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it expects to publish papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers will be reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* will generally be limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

No paper contradicting experiment will be accepted; however, papers making a case why the current interpretation of observed effects may be erroneous will be considered for publication.

Papers reporting experimental results will be given preference over theoretical papers of equally high standard.

All papers are expected to be in the realm of physics, mathematics, astronomy or engineering; non-mathematical, philosophical considerations will generally not be accepted unless they are fairly short and have something new and outstanding to say.

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Space Medium Theory Applied to Lunar and Stellar Aberration

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The paper discusses lunar and stellar aberration, and the absence of aberration in terrestrial sources, based on a space medium of separate ethers in which a Galilean electrodynamic theory is valid.

Introduction

Space medium theory [Barnes 1986] proposes a reactive and propagative medium in space. Its reactive property provides the inertial reaction for Newton's third law. Since this paper is restricted to the application of the theory to lunar and stellar aberration the property of interest is the propagation of electromagnetic waves in the medium.[1]

One might think of the space medium as "hidden electric and magnetic fields." They consist of the independent elementary electric and magnetic fields of all the electrons and protons in the universe. The reason they are hidden is that they are only components of the net electric and magnetic fields. Whereas it is the net field that acts on charges. But propagation of light waves in free space does not involve force on charges.

It is known that the components of a vector never vanish. These component fields do exist in all space. Near an astronomical body the component fields from its electrons and protons are the dominant fields. Let these fields be called ether fields. They propagate light, in accordance with Maxwell's equations, at speed c with respect to that ether. So the space medium has these separate ethers.

Sources of Ether

Sources of ether are the electrons and protons in the earth and the astronomical bodies. Each electron and proton has its own independent electric field, a vector field. In the quiescent state the net vector is zero, but the component vectors do not vanish. These electric component vectors are constituents of the ether.

A wave vector is generated in the ether by the Faraday repulsion between adjacent lines of force, lines that have the same direction. There is no such thing as attraction between adjacent lines. A line of force emitted by a radiating atom exerts this repulsion on the adjacent line in the ether. This "pressure" on that particular vector component, amplifies it. This generates a net electric vector in the ether. Similarly a net magnetic vector is generated in the magnetic vector components, which are also constituents of the ether.

From that point on, it is Maxwellian electromagnetic theory of light. These incident electric and magnetic wave vectors are propagated in the ether with the speed of light c.

Separate Ethers

One may classify ether into separate ethers, according to their sources. The separate ethers are independent of each other. Of particular interest are: the earth's ether, the sun's ether, the moon's ether, and a composite ether of the bodies in the sky.

The earth's ether is dominant in the vicinity of the earth. It rotates with the earth and stays with the earth in its orbit. The effective spatial extent of the earth's ether is of the same order of magnitude as the extent of its gravitational field. Likewise for the sun and for the moon.

The sun's ether also exists near the earth, but it is so much weaker there that it can often be neglected. This is somewhat like neglecting the sun's gravitational field on the path of an object dropped from the Leaning Tower of Pisa.

Maxwell's equations apply to the ether in which light is propagating. The speed of light c is with respect to that ether. In the Michelson-Morley experiment the dominant ether was the earth's ether. There was no motion of the instrument through the earth's ether. It is no wonder that it gave a null result, or possibly a near-null result.

Ether Fixed in Celestial Space

Starlight is propagated from a star in celestial space toward the earth in the composite ether, a more or less fixed frame of reference. Even the cosmologists abandon special relativity and adopt a fixed frame of reference on the large-scale. Martin Harwit states in Astrophysical Concepts, [Harwit 1973] "...special relativity is really only meant to deal with small-scale phenomena and that phenomena on larger scales allow us to determine a preferred frame of reference."

Light from a star is propagated in the composite ether until it enters the sun's ether. It propagates in the sun's ether until it enters the earth's ether. There are transition regions in the "transfer" of light from one ether to the other. It turns out, in so far as aberration angles are concerned, that the transition regions have negligible effect. This is similar to the acoustic theory where a uniform wind translates acoustic rays, but does not refract them. It takes a wind gradient to refract the rays.

For a more general treatment of light propagation through a moving, non-refractive medium, showing that the emerging ray direction is the same as the incident ray direction, see [Beckmann 1990].

Stellar Aberration

Aberration of starlight is the displacement of the apparent position of the star from its true position. In 1728 James Bradley showed that this optical displacement is due to the orbital motion of the earth. The displacement direction is always forward, in the same direction as the motion. For example, since light from a star located at the ecliptic pole is always perpendicular to the earth's motion, the star describes each year a small circle of angular diameter 2θ ($\theta = 20.48''$) on the celestial sphere. A star located on the ecliptic appears to oscillate back and forth along an arc of length 2θ. Stars at intermediate positions on the celestial sphere describe small ellipses whose longest axes are 2θ. The value of this measured stellar aberration angle, $\theta = 20.48$ seconds of arc, or 9.929×10^{-5} radians.

The theoretical equation for stellar aberration is

$$\tan\theta = \frac{v}{c}$$

where θ is the aberration angle, v is the earth's orbital speed, and c is the speed of light. The aberration angle is so small that, to an excellent approximation, the tangent of the angle may be replaced by the angle in radians. Thus the aberration equation reduces to

$$\theta = \frac{v}{c} \qquad (1)$$

As a check on this stellar aberration equation, two computations are made:

[1] The earth's orbital speed is computed from (1) using the measured aberration angle for stellar aberration.

[2] The earth's orbital speed is computed from the orbital circumference divided by orbital period.

The computations

[1] $\theta = 9.929 \times 10^{-5}$ radians and $c = 2.998 \times 10^{8}$ meter/sec in (1) yields:

Earth's orbital speed $= 2.977 \times 10^4$ meter/sec.

[2] circumference $9.36\times10^{11} meters \div 3.156\times10^{7}$ seconds yields:

Earth's orbital speed $= 2.97 \times 10^4$ meter/sec.

The earth's orbital speed computed from the aberration checks with its speed computed from circumference and period, to within the accuracy of the data. This supports the aberration equation.

In this model there is only one ether, the fixed frame of reference. The star and sun are fixed in it. The earth moves through it with speed v in its orbital motion around the sun. In a later section the appropriate ethers will be included and the effect of relative motion of the ethers included.

In the fixed frame the light ray is straight down the y-axis as shown in Fig. 1a. In the moving frame the light ray is tilted as shown in Fig. 1b. The aberration angle $\theta' = v/c$ radians. The view through the telescope is in the opposite direction of the light propagation down the ray in Fig. 1b.

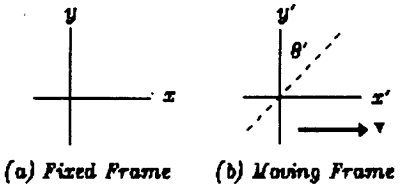

Fig. 1. Stellar aberration shown by the dashed line.

Some of the textbooks [Jackson 1962] derive the aberration equation from the Lorentz transformations and obtain the same result as (1) except for the special relativity factor

$$\frac{1}{\sqrt{1 - v^2/c^2}}$$

but there is no observational evidence for this second order effect. Jackson states that "the departure of the radical from unity is far beyond the realm of observation."

Lunar Aberration

The observed aberration angle for moonlight [Clemence 1952] is $\theta = -0.703$ seconds. The moon's orbital motion and the earth's rotational motion have the same angular direction in the sidereal frame of reference. However, in the earth's rotating frame of reference the moon is orbiting around the earth in the opposite direction. The negative value of lunar aberration is due to this retrograde motion of the moon with respect to the earth's frame of reference.

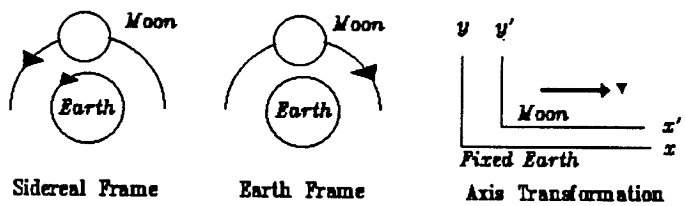

Fig. 2. Relative motion of moon with respect to earth frame.

Fig. 2 illustrates this with the counterclockwise direction for the earth and moon in the sidereal frame, and the moon's clockwise orbital direction with respect to the earth's frame. It also shows the two coordinate systems at time 0 with the moon's x' and y' axes moving with velocity v with respect to the earth's "fixed" x and y axes.

The moon's period of revolution is 27.3 sidereal days compared with the earth's sidereal period of rotation of one day. So the earth rotates 27.3 times as fast as the moon's orbital rate in the sidereal frame of reference. The lunar aberration is still computed from the aberration equation $\theta = v/c$ in which v is negative, the moon's backwards velocity with respect to the telescope's fixed frame of reference, the earth's frame.

The theoretical value of the aberration angle for this moving source will be computed and checked against the measured lunar aberration angle: The frequency is the reciprocal of the moon's period. The sidereal day is 86,164 seconds.

$$f = 1/27.3 \times 86,164 = 4.251 \times 10^{-7}\text{sec}^{-1}$$

The moon's mean orbital radius is 3.84×10^8 meters. Its orbital speed through the earth's ether is $v = -2\pi r f = -1.026 \times 10^3$ meters/sec. The computed aberration angle $\theta = v/c = -3.42 \times 10^{-6}$ radians $= -0.705$ seconds of arc. This provides an excellent check for lunar aberration:

Theoretical aberration angle $= -0.705$ seconds

Measured aberration angle $= -0.703$ seconds.

In the sidereal frame the earth's spin and lunar orbit are in the same direction. In the earth's fixed frame the moon orbits retrograde. The transformation is from earth fixed axes to moon moving axes.

Derivation of Lunar Aberration Equation

The derivation of the equation for lunar aberration differs from the derivation of the equation for stellar aberration. The earth is taken as the fixed frame of reference and the source, the moon, as the moving frame of reference. Instead of the Galilean transformations from fixed source to moving earth, the transformations are from moving source to fixed earth.

Changing from moving to fixed frame the primed quantities are changed to the unprimed and the sign of v is changed. The applicable transforms are

$$x = x' + vt \qquad \text{and} \qquad y = y' \tag{2}$$

Light from the moon is propagating toward the earth as seen in Fig. 3. The ray-trace equations are

$$y' = -ct \qquad \text{and} \qquad x' = 0 \tag{3}$$

where $t = 0$ at $x = x' = 0$ (at the telescope on earth). Substituting (2) in (3) yields these equations in the fixed frame,

$$x = vt \qquad \text{and} \qquad y = -ct.$$

Eliminating t from these simultaneous equations

$$y = -\frac{c}{v}x \tag{4}$$

This light ray is shown in Fig. 3 as a straight line, through the origin, with a slope of $-c/v$. The telescope views the moon back up that line, at the aberration angle

$$\theta = -\frac{v}{c} \tag{5}$$

This theoretical lunar aberration angle is negative. Instead of tilting in the direction of motion v, it tilts backwards from v.

Up to now nothing has been mentioned of the effect of the various ethers through which the light is propagated before reaching the telescope. It will now be shown that when these different ethers are included as crosswinds the result is the same aberration equation.

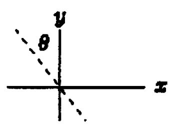

Fig. 3 Lunar aberration angle.

Ether Wind

Unlike atmospheric wind, ether wind is consistent and predictable. Like gravity its motion is tied to the motion of its source, the earth, the moon, etc. Light propagating from the moon to the earth will pass through a relative wind, the earth's ether. This wind is a crosswind. Within the space of interest, it is a uniform wind. A uniform wind never bends a light ray, it only shifts it, regardless of whether it is at a right angle or not.

Hence the direction of light propagated from the moon to the telescope on earth is unaltered by the ether wind. The aberration angle "predicted" by the space medium theory, with its separate ethers, is the same angle as that presented in the previous sections for stellar aberration and for lunar aberration.

In his paper on stellar and lunar aberration [Durie 1983] noted that there is no measurable aberration of light when a telescope is focused on a street light. That is to be expected because the ether wind at the earth due to the relative motion of the moon and other external ether sources, is effectively uniform wind and does not contribute to aberration. The previously referenced Beckmann paper provides a more general treatment which is applicable to this terrestrial optics.

Conclusion

The space medium theory, with its separate ethers, is a Galilean electrodynamic theory that provides a physical explanation of the aberration of light. The absence of aberration in terrestrial sources confirms the several independent ethers, but cannot be reconciled with an absolute, single, all-pervasive ether unless time dilations, space contractions and other Einsteinian or Lorentzian artificies are introduced.

The theoretical values check with the measured values of aberration. The simplifing assumption of a uniform ether-wind in the ether regions of interest appears to be a credible assumption. There is no sharp boundary in the transition region. Nor is there aberration data at present to indicate a speed gradient, which would yield refraction analogous to that in underwater sound.

The failure to observe terrestrial aberration, from street light to telescope, is to be expected. There is no relative motion between the source and receiver. Which way would the aberration angle tilt, since there is no relative motion? The propagation of light in the independent ethers is in accord with Maxwell's electromagnetic theory.

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NOTE

[1] Theory of propagation of electromagnetic waves is developed in the above reference [Barnes 1986]. It employs the Faraday repulsion between adjacent lines of force to provide the asymmetric modulation of opposing components to yield the incident wave vector at the radiating source. Maxwell's field equations govern its propagation in the ether.

A New Analysis of Time Dilation

By J. P. Claybourne
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The special relativity prediction that a clock moving at speed v will run slow by the factor $(1-v^2/c^2)$ has been experimentally verified under a variety of conditions. In all cases the clocks have been subjected to significant accelerations. Clocks will run slow when accelerated according to the equivalence principle of general relativity, which predicts results consistent with those of special relativity and with the observations. An interesting outcome of this alternate explanation is that it is independent of conclusions inherent to special relativity which have only been postulated, never proved. These include reciprocal time dilation, space contraction, relativity of simultaneity and even constancy of the speed of light.

General Relativity Time Dilation

A concise description of general relativity effects on clocks is provided by French [1]. Clocks are slowed in a region of negative gravity potential. If two clocks are separated a vertical distance h in a uniform gravity field g, the difference in gravity potential between the two points is the product gh. The factor f by which two clocks' running rates differ is:

$$f = 1 - \frac{gh}{c^2} \qquad (1)$$

Eq.(1) was verified to an accuracy of 1% by Pound and Snider[2], measured over a height h of only 22.5 meters. The equation has two interpretations. First, it shows that the lower clock runs slower than the upper clock by the amount shown when both are in the gravity field g. The second interpretation of particular interest here is based upon the equivalence principle which states that we can replace the local gravity field g with a general acceleration g which would affect a clock in the same way. We shall apply this approach in the next sections.

Fast Muon Decay

Frisch and Smith[3] observed a time dilation factor of 8.8 for muons first observed at an average speed of $.9952c$ at the top of Mt. Washington, an elevation of 6265 feet (1910 m) and later at sea level at an average speed of $.9889c$. The time dilation factor was calculated on the basis of the fraction of muons surviving to sea level, but it can be seen to correspond to the special relativity time dilation factor for a constant velocity of $.9935c$.

The precise verification of the equivalence principle by Pound and Snider was not available at the time of the muon experiment but Frisch and Smith did make a rough estimate of the deceleration of the muons during their atmospheric descent. They quoted 2×10^16 cm/sec but did not recognize the general relativity implications.

If we consider the time dilation factor of 8.8 as a given condition and use (1) to calculate the acceleration operating over the 1910 meter distance to obtain this amount of time dilation, the result is $g = 4.154 \times 10^15$ cm/sec Considering the uncertainties involved in the experiment and associated calculations, general relativity clearly provides a prediction consistent with the observed results. Although Frisch and Smith did not address the issue, an observer theoretically traveling with the muons would not see any change from their normal half-lives and could account for the results by assuming either that the muons were moving much faster than c or that Mt. Washington contracted to a height of $6265/8.8 = 712$ feet. The general relativity explanation does not require either of these assumptions.

Time Dilation in Orbital Motion

In (1) the product gh was obtained from the gravitational potential Φ as follows. If G is the gravitational constant, M is the mass of the earth and $r$the distance to the center of the earth, then

$$\Phi = \frac{GM}{r} \qquad (2)$$

At height h above r,

$$\Phi_h = \frac{GM}{r+h} \qquad (3)$$

from which

$$\Delta\Phi = \Phi - \Phi_h = \frac{GMh}{r^2} = gh \qquad (4)$$

when $h \ll r$.

Since $g = GM/r^2$, the difference between g at the two locations r and $(r+h)$ is

$$\Delta g = \frac{GM}{r^2} - \frac{GM}{(r+h)^2} = \frac{2GMh}{r^3} \qquad (5)$$

From (4) and (5) we obtain

$$\Delta\Phi = \frac{r(\Delta g)}{2} \qquad (6)$$

If a clock is moving with linear velocity v, the acceleration required to bring the clock into a circular path of radius r is

$$\Delta g = \frac{v^2}{r} \qquad (7)$$

From (6) and (7) we obtain

$$\Delta\Phi = \frac{r(\Delta g)}{2} = \frac{v^2}{2} \qquad (8)$$

From (1), (4) and (8),

$$f = 1 - \frac{\Delta\Phi}{c^2} = 1 - \frac{v^2}{2c^2} \qquad (9)$$

Time Dilation in Linear Acceleration

Referring again to (1), let a clock be accelerated from rest at an acceleration g over the distance h. The velocity v at time t is:

$$v = gt \tag{10}$$

The distance h is related to g and t by:

$$h = \tfrac{1}{2}gt^2 \tag{11}$$

Squaring (10) and solving (10) and (11) for t^2,

$$t^2 = \frac{v^2}{g^2} = \frac{2h}{g}$$

from which

$$gh = \frac{v^2}{2} \tag{12}$$

Inserting (12) into (1) yields

$$f = 1 - \frac{v^2}{2c^2} \tag{13}$$

Discussion

The product gh in (1) is the gravitational potential energy per unit mass and has the dimensions of velocity squared; the term $v^2/2$ in (9) and (13) is the kinetic energy per unit mass. Thus it appears that clocks run slow as a function of their energy per unit mass whether the energy comes from a gravity field or an accelerating force. One interpretation of the Lorentz transformation leads to the prediction of time dilation that is verified by all known experimental data. Other conflicting interpretations appear to arise from the fallacy of treating the transformation equations as though they expressed purely mathematical relationships rather than physical phenomena. Consider the Lorentz equation for time:

$$t' = \gamma(t - vx/c^2) \tag{14}$$

where t and x are the time and space intervals between two events as measured in a stationary frame; t' is the time interval between the events in a frame moving at speed v reference the stationary frame and $\gamma = (1 - v^2/c^2)^{-1/2}$.

If (14) is viewed as a purely mathematical equation then x can assume any arbitrarily assigned value, leading to values of t' that are larger than t, equal to t, smaller than t, equal to zero or negative. Mathematically all of these values are acceptable solutions of (14) but it becomes physically absurd to assume that a moving clock will run faster, slower, stop or run backward depending upon its location in the stationary frame.

It is precisely this interpretation of (14) that yields current views that clocks synchronized in one inertial frame will not be synchronized in any other frame[4] and that events simultaneous in one frame will not be simultaneous in any other frame[5]. In an earlier paper [6] this writer identified experimental data from atomic clocks flown aboard aircraft and spacecraft which refute the concept of the relativity of simultaneity.

If we assume that the parameter x in (14) physically represents the distance moved by any and all clocks in the moving system, then

$$x = vt \tag{15}$$

and

$$t' = \gamma\left(t - \frac{v^2 t}{c^2}\right) = \frac{t}{\gamma} \tag{16}$$

All experimental data to date verify (16) and refute any other interpretations of (14) which lead to different results. In special relativity it is customary to treat the relative velocity between frames with no regard for how the relative velocity was established. Consider two observers A and B initially at rest in the same frame and both equipped with identical clocks and inertial guidance systems. If B is set in motion with acceleration g, when B reaches a distance h, his clock will read slow as shown in (16). B's guidance system will verify g and h while A's guidance system will show no acceleration, no velocity and no displacement. So time dilation is not reciprocal when the origin of the relative velocity is considered.

Eq. (16) can be derived directly from the principle of the constancy of the speed of light or from the Lorentz transformation which derives from that principle. Thus it can be said that experimental data support this special relativity prediction, but *the data do not prove the constancy of the speed of light since an alternate general relativity explanation accounts for the observations without depending upon the constancy of the speed of light.*

Three more observations are offered. First, it was stated in connection with (14) that t, x and t' are time and space intervals between two events. These parameters are actually the coordinates of a second of two events, the first of which had coordinates $x = x' = t = t' = 0$; therefore t, x and t' are numerically equal to the intervals between the events. It might be preferable to use $\Delta t, \Delta x$ and $\Delta t'$ in the notation, but as long as it is understood that t, x and t' represent intervals the notation is acceptable either way.

Second, the general relativity explanation for time dilation shows that the running rate of a clock and the decay rate of a particle are slowed down only by the presence of a gravity field or an acceleration. The companion reference clock not under these influences continues to run at the faster base rate. The special relativity mysticism that time itself is "dilated" is not supported by experimental observation; we know only that time keeping mechanisms are slowed down under certain conditions.

Finally, (13), derived from general relativity for particles under linear acceleration, needs to be reconciled with (16), the special relativity expression which has been repeatedly verified in particle accelerators.

Eq. (13) comes from (10), (11) and (12), all of which express kinematic relations which treat motions without regard for the forces that create the motions. Eq. (13) correctly expresses kinetic energy per unit mass and its contribution to the slowing of clocks. The complete picture requires that we include total energy per unit mass, which takes us from kinematics to dynamics and incorporates mass/energy relationships.

Eq. (16) expressed as a series is

$$t' = t\left(1 - \frac{v^2}{2c^2} - \frac{v^4}{8c^4} - \frac{v^6}{16c^6} - \cdots\right) \tag{17}$$

The total energy is

$$E = mc^2 = m_0c^2\left(1 + \frac{v^2}{2c^2} + \frac{3v^4}{8c^4} + \frac{15v^6}{48c^6} + \cdots\right) \tag{18}$$

For small v, (14) and (17) agree on clock slowing and the total energy in (18) is the rest energy plus the kinetic energy of motion. Consider an example where $v/c = 0.99$. From (13),

$$f = 1 - .49 = .51 \tag{19}$$

From (16)

$$t'/t = .141 = 1/7.1 \tag{20}$$

From (18)

$$E = 7.1 m_0 c^2 \tag{21}$$

In (19) kinetic energy of motion alone would slow a clock to about half speed but the additional terms in (17) represent additional energy stored as mass and slow the clock to 1/7.1 . Note that this slowing (1/7.1) is exactly equal to the reciprocal of the total energy in (21), expressed in rest energy units.

The reciprocal of the total energy provides the total velocity slowing effect. In cases such as clocks in orbit the gravity potential effect must be added; with high speed muons it is insignificant.

Einstein's uncanny intuition led him to make some correct predictions in 1905 although the correct explanation came several years later. The idea that relative velocity could make clocks slow down is nonsense because the reciprocal effect of two clocks running slower than each other is of course impossible. The dynamics of general relatively rescued the kinematic predictions of special relativity from their untenable base.

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The Nature of Space

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The paper shows that the concept of space is bound to matter and its energy, in particular gravitational, electromagnetic, and rotational energy. It follows that the universe must be finite and cannot be steadily expanding.

1. Physical Creation

Every configuration of matter which can exist in the physical sense is given as a solution to the equation

$$\nabla_4^2 = \frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{\partial^2\psi}{\partial w^2} = 0 \qquad (1.1)$$

where x, y and z are rectangular space coordinates and w is related to time. If the substitution

$$w = jc_0t \qquad (1.2)$$

is used, where j us the imaginary symbol, the standard wave equation results. If we use

$$w = jvt \qquad (1.3)$$

the equation becomes the matter equation. Solutions of the two resulting equations yield the configurations of positrons, electrons, protons, neutrons, and atoms as well as photons, neutrinos, and an infinity of unstable particles. The present article is concerned with the philosophy that since space itself is a part of the physical creation, (1.1) must be able to describe its characteristics.

2. The Equation of Space

There are certain observations which can be made. Space is three- dimensional in the visual sense. Astronomical objects such as suns and planets are spherical in nature. In general, these objects rotate with respect to a polar axis. In this case it appears that a transformation to the spherical polar coordinate system is suggested. Then (1.1) becomes

$$\frac{\partial^2\psi}{\partial r^2} + \frac{2}{r}\frac{\partial\psi}{\partial r} + \frac{1}{r^2}\left[\frac{\partial}{\partial\mu}\left((1-\mu^2)\frac{\partial\psi}{\partial\mu}\right) + \frac{1}{1-\mu^2}\frac{\partial^2\psi}{\partial\phi^2}\right] + \frac{\partial^2\psi}{\partial w^2} = 0 \qquad (2.1)$$

where the transformation

$$\mu = \cos\theta \qquad (2.2)$$

has been used. The angle θ is the polar angle and ϕ is measured in the equatorial plane.

In the analysis of space it appears that certain simplifications can be introduced. Functions of the equatorial angle ϕ are rendered constant by symmetry. Also, since space is constant with respect to time, the variable w does not appear. Then equation (2.1) becomes

$$\frac{\partial^2\psi}{\partial r^2} + \frac{2}{r}\frac{\partial\psi}{\partial r} + \frac{1}{r^2}\frac{\partial}{\partial\mu}\left[(1-\mu^2)\frac{\partial\psi}{\partial\mu}\right] = 0 \qquad (2.3)$$

We conclude that all characteristics of space are given by the solutions of (2.3).

3. Space Potentials

The immediate conclusion to be drawn from the equation is that all current theories of space are in error. The Greek geometers' concept of space as an infinite emptiness is a contradiction to itself. The concept of a uniform and infinite ether is a complete impossibility. The space-time continuum of relativity has no meaning, and Berkeley's concept of space determined by "Fixed Stars" does not make sense.

The radius vector $\mathbf{r}$ in (2.3) must be measured with respect to an origin of coordinates. In the case of a mass object, the center of mass is the only point which can be defined as being at rest. Since the equation describes conditions exterior to the surface of the object, the conclusion is that the space of the object is determined by the object itself. Then if the object has a motion of translation imposed upon it, the space of the object translates with the center of mass.

We assume the solution

$$\psi = R\Theta \qquad (3.1)$$

where each factor in the product is a function of the corresponding coordinate only. When (3.1) is used in (2.3) and the resulting equation is divided by the product itself, we find a separation in the form

$$\frac{1}{R}\frac{\partial^2 R}{\partial r^2} + \frac{2}{Rr}\frac{\partial R}{\partial r} + \frac{1}{r^2}\left[\frac{\partial}{\partial\Theta\mu}\left((1-\mu^2)\frac{\partial\Theta}{\partial\mu}\right)\right] = 0 \qquad (3.2)$$

Then we write

$$\frac{d}{d\mu}\left[(1-\mu^2)\frac{d|\Theta|}{d\mu}\right] = K|\Theta| \qquad (3.3)$$

where K is a constant of separation and the ordinary derivative notation has been used since only one variable appears.

Equation (3.3) is to be solved subject to a finite quantization. The we assume a series solution $|\Theta| = a_l\mu^l$, where l is a finite integer value (0, 1, 2, 3, ...). When this series is used in (3.3), the value of K is found to be $K = -l(l+1)$. Hence (3.2) becomes

$$\frac{d^2R}{dr^2} + \frac{2}{r}\frac{dR}{dr} - \frac{l(l-1)}{r^2}R = 0 \qquad (3.4)$$

where the ordinary derivative notation applies.

4. The Potential Functions

In (3.7), it appears that an inverse function in the radius vector r is required. Then we write

$$R = a_n r^{-n} \qquad (4.1)$$

since the potential function must reduce to zero at infinity. When (4.1) is used in the equation we find

$$n(n-1) - l(l-1) = 0 \tag{4.2}$$

This yields the single solution

$$n = 1 + l \tag{4.3}$$

The potential function as applied to space then becomes

$$\psi = \frac{a_l \mu^l}{r^{1+l}} \tag{4.4}$$

Since the only limit on l is that it should be a non-negative finite integer, it appears that more than one potential exists.

5. The Force Functions

Every potential that can be identified has a corresponding force function. The least potential requires $l = 0$. Then we have

$$\psi_0 = \frac{a_0}{r} \tag{5.1}$$

The associated force function is an inverse square given by

$$-\frac{\partial \psi_0}{\partial r} = \frac{a_0}{r^2} \tag{5.2}$$

Examples are given by the gravitational foce form and the forces between electric charges.

There is a potential energy given by $l = 1$. The form required is

$$\psi_1 = \frac{a_0 + a_1 \cos\theta}{r^2} \tag{5.3}$$

where (2.2) has been used. The question of the evaluation of coefficients must be considered. Since the potential must be symmetrical with respect to the equator described by $\theta = 90°$, the value of a_1 must be zero. The corresponding force function is then

$$-\frac{\partial \psi_1}{\partial r} = \frac{2a_0}{r^3} \tag{5.4}$$

This is a force associated with a rotating mass object. As applied to the earth the effect is that of the second order in relation to the static gravitational potential.

The potential associated with $l = 2$ is written

$$\psi_2 = \frac{a_0 + a_1 \cos\theta + a_2 \cos^2\theta}{r^3} \tag{5.5}$$

Evaluation of the coefficients in this case provides $a_1 = 0$, $a2 = a_0$. Then we have

$$\psi_2 = \frac{a_0(1 + \cos^2\theta)}{r^3} \tag{5.6}$$

to provide a force function

$$-\frac{\partial \psi_2}{\partial r} = \frac{3a_0(1 + \cos^2\theta)}{r^4} \tag{5.7}$$

This is the form of the force between two magnetic dipoles, which is extremely small in relation to the other two. The fact that it exists is required by the magnetic field of the earth.

There seems to be no point in carrying the analysis to any greater extreme. In case other potentials exist, they are of such short ramge that they can have no significance in the determonation of the space exterior to any aggregate mass. Since the first potential is that of a static spherical potential, and the remaining potentials are at least of the second order with respect to this one, we are forced to conclude that the earth is a rotating object within a non-rotating space.

The fact that all space potentials are zero at infinity is sufficient to indicate that the energy of space is finite. The gravitational force is that of the inverse square. Since the energy density of such a space is proportional to the square of the gradient, we write

$$\int_{r_0}^{\infty} \frac{K}{r^4} 4\pi r^2 \, dr = \frac{4\pi K}{r_0} = \frac{GM^2}{r_0} \tag{5.7}$$

to represent the gravitational energy stored in the space of the earth. In this case th eenergy density of space falls off inversely as the fourth power of the radius vector.

6. The Philosophy of Reality

The sun is the largest mass object in our own solar system. Aside from the earth itself, it must have greater effect in determining the nature of the space of the earth than the remaining planets of the system. In view of the fact that the effect of the sun is reduced with distance as the inverse fourth power of the radius vector, it is still true that the effect is negligible. We conclude that as far as measurement is concerned, the space of the earth translates with the earth in its orbit as the earth rotates on its axis with respect to its own non-rotating space. Further, as we penetrate the region of interstellar distance away from the mass centerof the solar system, the effect of all remote masses in the universe becomes negligible. Then we must question the meaning of the reality of space. If we define it only on th ebasis of energy density, we must conclude that we can run out of space with elevation just as we can run out of the material atmosphere. In this case, the Newtonian concept of the universe loses all its meaning.

7. Experimental Fact

The Foucault pendulum is a heavy weight mounted on a thin cable at least forty feet in length. Friction is minimized so that when the pendulum is put into motion, it will swing for days. Since it is activated by gravity, the plane of the swing must pass through the mass center of the earth. This must continue to be true in spite of the fact that the earth moves in its orbital path at a rate of about eighteen miles a second. This fact alone is sufficient to indicate that the space of the earth translates with the earth.

The earth rotates about its own axis as it moves on its orbital path. The function of the Foucault pendulum is that of detecting this rotation. The earth rotates through a cycle of 360° with respect to the plane of the pendulum in a period of a day. This fact is sufficient to indicate that the space of the earth does not take part in the earth's rotation. Then we conclude that at least to the limit of second order effects, the space of the earth translates with the earth while the earth rotates with respect to the space.

In long range gunnery at sea in the northern hemisphere there exists a principle known as the "Starboard Correction" (correction for the Coriolis force). Since the earth is rotating, any tangential plane north of the equator rotates to the left.

In this case a long range shell must be aimed in a direction such that the target is to the right of the point of aim to allow for the rotation of the earth.

The shell must describe a partial orbit with respect to the mass center of the earth. This continues to be true as the earth translates in its orbit around the sun. The plane of the shell trajectory maintains its orientation as the earth rotates under it. Again, we have perfect confirmation that the space of the earth translates with the earth, but does not take part in its rotation.

The difficulty is that no scientist worthy of the name is going to be influenced by such simple facts. If the experiment is not exotic and difficult (and expensive) it cannot be used as proof of anything. Therefore we must consider more exotic experiments.

8. The Michelson-Morley Experiment

"In any experiment, dogma determines the results to be observed."

The null result of the Michelson Morley experiment confirms exactly that the space of the earth translates with the earth. However, the scientific dogma at the time was to the eefect that there existed a fixed ether. Since the dogma had to be preserved, a contraction was introduced to show that any motion through the ether could be measured.

The results of the Michelson-Morely experimentcannot be considered separately from the results of a much later experiment by Michelson and Gale. This was concerned with sending beams of light around an evacuated pipe in the form of a rectangle in both directions. When the interference fringes were compared to those of a much smaller calibration rectangle, a definite and consistent fringe shift was established. The rotation of the tangential plane of the earth with respect to space was clearly established. The results of this experiment in conjunction with the null result of the Michelson Morley experiment are in exact agreement with the result obtained from the Foucault pendulum and the long range guns.

9. Concluding Remarks

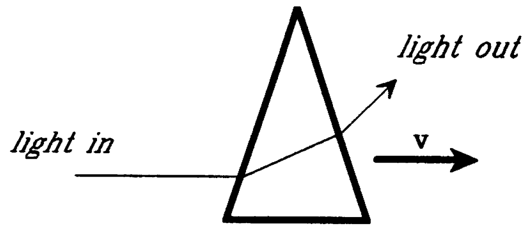
Man and the universe in shades of night,
God said "Let Newton be" — and all was light.
It could not last, the Devil shouting "Ho!
Let Einstein be" — restored the status quo.

The above verse is not accurate in all respects. Newton did not shed light on all universal theory. Neither did Einstein bring a return of the darkness. The beginning of the fiasco can be traced back to the Greeks and their idea of space as an infinity of nothing. The worst offender of the lot was Galileo with his concept of the inertial reference frame and the transformations associated with it. This led Einstein and all of the other investigators into the endless morass of observer-based (Einsteinian) relativity. If there is a conclusion to be drawn it is that there can be no real advance in the understanding of the universe until the observer-based relativity principle in all of its ramifications and convolutions is abandoned.

CORRESPONDENCE

Entrainment by Non-Refractive Media

I believe I have found an error in the derivation of equation (3) in [1]. You use the substitution $t = x/v$ where v is the velocity of the blob. But this x is essentially the position of a point that was at $x = 0$ at $t = 0$, but which is moving at the velocity of the blob. In equation (1) x is a parameter such that substituting a particular value of x will give the corresponding value of y along the line of constant phase. Doing this substitution and setting these two different x's equal has the effect of destroying one degree of freedom. Thus, the equations incorrectly appear to uniquely determine the light path in the blob. This degree of freedom would otherwise have required that the conditions at the boundary of the blob be considered.



Here is my argument that the light should bend at the boundaries: Consider the case where $\alpha = 0$, that is, the light travels horizontally from left to right. Let the blob be a prism. According to the equations, the light should always remain horizontal. But here is what really happens:

With the blob moving at velocity v and the light inside the blob moving at c with respect to the blob, the total velocity for light in the blob is $v + c$.

The lines of constant phase start out vertical. As the light moves to the right the lower part enters the blob first. At this point the lower part will be moving at $v + c$ while the upper part is still just moving at c.

Thus, the lower part will move farther than the upper part and the line of constant phase will no longer be vertical. After the upper part enters the blob both top and bottom parts will move at $v + c$, but the lower part is still ahead of the upper part. As the light exits the blob, the upper part will exit first. Now the upper part is moving at c while the lower part is moving at $v + c$, and the lower part gets even further ahead. By the time the lower part finally exits the blob (and everything is moving at c again) the lower part of the line of constant phase will be way ahead of the upper part. This means the line is way off vertical. And since the light travels perpendicular to the line of constant phase, it is now moving upward at an angle.

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[1] P. Beckmann, "Entrainment by a non-refractive medium," *Galilean Electrodynamics*, vol. 1, no. 3, p. 32, May/June 1990.

AUTHOR'S REPLY

The first objection, unconnected to the second, does not point out an error, but the intended aim of the substitution, amounting to discarding one degree of freedom. From the phase valid at any point of the x, y plane at any time we extract the phase valid along a wave crest, valid at any time, and then follow its progress across the x, y plane. This change from a plane to a line is, of course, a loss of one degree of freedom, but an intended one. The phase value of zero is merely chosen for convenience; any other value will lead to the same result at a small additional cost in algebraic manipulation.

The second objection is, at first sight, more persuasive and would be correct if the medium to the right of the boundary were isotropic, i.e., if waves propagated through the medium with the same phase velocity in all directions (and consequently light traveled perpendicular to the lines of constant phase). But this is not the case: the phase velocity is $c + v$ in the direction of motion, and c in all directions perpendicular to this privileged direction. (Conversely, if we choose the "blob" as the rest frame, the medium to the left side of the boundary is effectively anisotropic with velocity of propagation $c - v$ in one privileged direction only.)

To find the angle of refraction, we must therefore go back to first principles and consider the tangential components of the fields at both sides of the boundary, which is not as trivial as in the isotropic case. Fortunately, this has already been done in crystal optics: this case corresponds to a uniaxial crystal, with the optical axis along the direction in which the phase velocity differs from the (mutually equal) phase velocities in the plane at right angles to it; in our case the optical axis therefore corresponds to the direction of motion. The results may be taken from crystal optics, e.g. [2, 3].

In general, if the ("extraordinary") phase velocity along the optical axis is v_e and the ("ordinary") phase velocity of propagation in the directions normal to it is v_o, then the crystal exhibits double refraction. There are two indices of refraction, each determining the direction of a ray via Snell's Law, and each tied to a "ray velocity" in that direction by the usual definition of an index of refraction

$$n_{1,2} = \frac{c}{v_{1,2}} \tag{1}$$

where the two ray velocities v_1, v_2 are related to the two phase velocities ($v_o = c$, $v_e = c + v$) by [2,3]

$$v_1^2 = v_o^2 \tag{2}$$

$$v_2^2 = v_o^2 \cos^2 \vartheta + v_e^2 \sin^2 \vartheta \tag{3}$$

Here ϑ is the angle made by the direction of propagation with the optical axis — in our case the angle between the refracted wave and the direction of motion. The two directions are thus equal only at normal incidence ($\vartheta = 0$).

The only peculiarity of the present case as compared with crystal optics is that the ordinary ray (2) propagates with ray velocity $v_1 = c$, making $n_1 = 1$, so that all of the energy at any angle of incidence is transmitted. This leaves no energy for the extraordinary ray (which would be absent anyway since $c/(1 + \beta) < 1$, and all angles of incidence lie beyond the critical angle).

Thus the change of direction in the blob *by virtue of refraction* is zero for the ordinary ray, and the extraordinary ray is absent. The only change in direction results from entrainment, i.e., from aberration. Hence the assumption in [1] that there is no *refractive* change of direction at the boundary in a non-refractive medium was correct; however, for a moving medium the point is not trivial, and I am grateful to Mr. White for bringing it up.

The absence of the extraordinary ray is fortunate not only because it counters Mr. White's objection, but because otherwise one could distinguish wich side of the boundary is moving and the Relativity Principle would be violated.

Petr Beckmann
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[1] P. Beckmann, "Entrainment by a non-refractive medium," *Galilean Electrodynamics*, vol. 1, no. 3, p. 32, May/June 1990.

[2] M. Born, E. Wolf, *Principles of Optics*, 3rd ed., Pergamon Press, New York, 1965; Chapter 14, "Crystal Optics."

[3] G.N. Ramachandran, S. Ramaseshan, "Crystal Optics," *Handbook of Physics*, vol. 25, ed. S. Flügge, Springer Verlag, New York 1961.

GALILEAN ELECTRODYNAMICS

Experience, Reason and Simplicity Above Authority

September/October 1990 (Vol. 1, no. 5) **Box 251, Boulder, Colorado 80306**

Contents

Editorial Policy

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it expects to publish papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers will be reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* will generally be limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

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Papers reporting experimental results will be given preference over theoretical papers of equally high standard.

All papers are expected to be in the realm of physics, mathematics, astronomy or engineering; non-mathematical, philosophical considerations will generally not be accepted unless they are fairly short and have something new and outstanding to say.

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Electron Clusters

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A Texas research company has consistently produced electron clusters of some 10^{10} electrons within the space of a few microns, traveling along the boundary of a dielectric at about 0.1 of the velocity of light. The paper gives a possible explanation of the phenomenon, which at first sight seems to contradict Coulomb's Law. It is based on the force of the oscillating Faraday field surrounding a moving electron as previously derived by the author.

1. Electron Clusters

In research carried on since 1984, Kenneth R. Shoulders and coworkers of Jupiter Technologies, Austin, Texas, have been consistently able to produce clusters of electrons of high density (of order 2×10^{23} electrons per cm^3), in a spherical space of about 3 microns, traveling from cathode to anode along (or in the case of gases, through) a dielectric at a velocity of order $0.1c$. The separation between the clusters appears to be of the same order as their diameters.

The discoverer, Kenneth R. Shoulders, has named such a cluster an EV, short for *electrum validum* (powerful electron). Its many applications include submillimeter wave power generation and current-steered computer logic and memory.

Jupiter Technologies is a strongly device-oriented company and results of the EV research have not been published as scientific papers. Reference [1], kindly made available by Mr. Shoulder and unfortunately out of print, is a chronological account of the experiments, and [2] is a pending patent for some of the EV applications. In both cases the essence of the publication deals with the effects of the EVs on the target rather than with their physical structure. The main points will therefore be briefly summarized here.

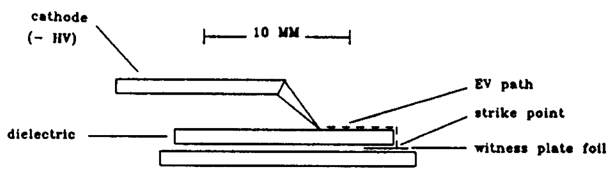

Fig.1. A simple EV source.

The EVs are produced by a variety of sources; an early and simple one is shown in Fig.1. The cathode-anode system is energized with nanosecond pulses of 10 to 500 kV; the path of the arc runs through a vacuum and strikes the "witness plate," which is then examined under a scanning electron microscope. The EVs, which emit light as well as individual electrons, were photographed by a high-speed video camera. A variety of electronic methods were used to calibrate this and other equipment.

The main results are the following:

The EVs are symmetrical with radius of order 1 μm. A 3 μm EV contains a charge of 2×10^{10} electrons, but as many as 3.5×10^{14} electrons have been observed in EVs of diameter 10 μm, so that the charge density lies near 6.6×10^{23} electrons/cm^3.

The individual EVs in the same burst are separated from each other by distances of the order of their radius, i.e., of order 1 μm.

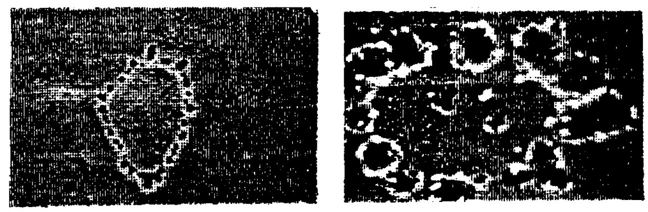

Fig. 2. A series of impacts on the witness plate under the electron microscope, magnified 2,000 and 10,000 times. The elliptic pattern shown is not particularly frequent; however, the distance between the EV's is typical. The patterns correspond to what one would get, in Mr. Shoulder's analogy, by throwing a ball chain, such as used to activate light bulb switches, against a wall, with the trace of the links between the balls not visible. The impact craters are not necessarily made at the same time and may therefore (as in the ball chain example) be quite close together on the impact plate.

That the EVs consist of electrons is borne out by (1) their electron-like behavior in experiments of deflection; (2) by their acceleration in known applied fields, which confirm the electron charge-to-mass ratio; and (3) by the copious release of X-rays when suddenly stopped.

Tests for ion contents of the EVs indicate a presence of not more than 1 ion per 100,000 electrons, so that the presence of ions, if any, is negligible.

2. Existing Explanation

By Coulomb's Law, one would expect the repulsive force of equal charges to be explosive. Using $\Phi = q/4\pi\epsilon_0 r$, it is easily found that the confinement of 10^{10} electrons to a sphere of radius 1 μm represents a potential energy of 9×10^{25} eV or 1.5 megajoules, representing the energy that ought to be released as the individual electrons of a cluster are blasted to infinity. ("Blasted" would appear to be the right word: the energy is equivalent to about 3.5 g of TNT for a *single* such cluster).

Clearly this is an unusual phenomenon, and any explanation must find reasons (1) why Coulomb repulsion does not act on the electrons in the cluster, (2) what makes the clusters coagulate in the first place, and why they form apparently in a fairly regular pattern of separation.

In an endeavor to provide an explanation, Ziolkowski and Tippett [3] treated the problem as one of a plasma in which sudden and shortlived, localized electromagnetic fields arise due to quantum-mechanical effects; these are found as special solutions of the vector potential equation transformed to a Klein-Gordon form.

The clusters are certainly short-lived, since their life over a distance of 1 cm at $0.1c$ lasts only 3.33×10^{-12} sec before it is ended by the impact on to witness plate. However, among several criticisms of the method and explanation, one is particularly important and appears to be fatal: the result does not explain what has been found a necessary condition for the appearance of EVs, namely the presence of an interface with a dielectric. The EVs will not tunnel through a solid dielectric and will arise only when the dielectric offers them a path either along its flat surface or through a *preexisting* tunnel. They will tunnel through a low pressure gas, which one may regard as an interfacing envelope round the electric discharge, but they will not form in free space without matter close to their path.

Also, the Ziolkowski-Tippett solution of the vector potential equation claims only to show the possibility of the existence of such clusters; their form as a packet is assumed, and there is no explanation of either the original formation of the clusters, nor of their quasi-periodic (or at least not altogether random) occurrence along the path.

To the knowledge of this author, no other explanation has been put forward to explain the existence and behavior of EVs.

3. Charge Neutralization by Dielectric Polarization

If Coulomb's Law is not to be violated, the charge of the individual electrons in the discharge must be neutralized, and the most obvious agent of such a neutralization is the immediate neighborhood of a dielectric — a necessary condition for the formation of EVs.

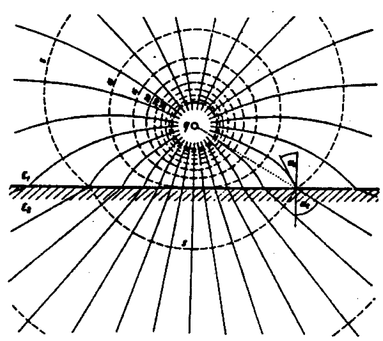

Fig. 3. Macroscopic charge near a plane dielectric interface.

Fig. 3 shows the textbook example of a macroscopic charge in vacuum near the plane interface of a dielectric with the well known refraction of the **E** lines of force at the interface, where a bound surface charge appears as the result of dielectric polarization. What happens physically (in the case of quasielastic dielectric moments) is that the field of the charge causes the electron orbits to be displaced toward or away from the attracting or repelling charge. Thus each atom is polarized without being ionized; the effect cancels in neighboring atoms, leaving a net bound charge only at the surface, which modifies the field as shown in the example of Fig. 3. (If the dielectric has orientational dipoles, displacement is replaced by alignment, but does not affect any of the following.)

If we apply the Divergence Theorem to a box that encloses a section of the interface plus arbitrary volumes to either side of it, we will, of course, get the enclosed bound charge (plus the free source charge, if it was included in the box). However, this is true only for a macroscopic charge, leading to a virtually continuous increase in enclosed charge as the box volume is increased to take in more of the surface. The polarized charge is then always smaller than the source charge until the volume becomes infinite. But if the source charge is a single electron, this procedure would lead to a fraction of an electron charge in the enclosed volume, contradicting the quantization of charge.

We must therefore conclude that an electron can polarize only one atom in its immediate neighborhood at the surface of the dielectric. The two will be attracted to each other and form an electric dipole whose field near the direction along the interface is [4]

$$\mathbf{E}_d = \frac{\mathbf{p}\cos\theta}{4\pi\epsilon_0 r^3} \qquad (1)$$

where $\mathbf{p} = ql$ is the dipole moment, with l the distance between the electron and the polarized atom to which it is attracted, and r the distance from the center point of the dipole. The direction $\theta = 0$ is that $\mathbf{p}$, so that $\theta = \pi/2$ is (any) direction along the interface; the slight difference from a true cosine function due to the differing permittivities has been neglected as irrelevant to the following.

Now let the electron move at a mean velocity v_0 with respect to the dielectric; then as it passes by the atoms in close vicinity, it will polarize them one at a time, always forming a dipole with zero force along the interface. The same will apply to any other electron moving along the interface, and in accordance with (1), two such electrons will exert no force on each other; the only force on them from Coulomb's Law is that exerted by the corresponding polarized atom with which the electron forms a dipole. One might call this a "traveling dipole," as long as it is understood that it is the dipole *state* that travels; the only mass or charge traveling in the direction of $\mathbf{v}_0$ is that of the electron.

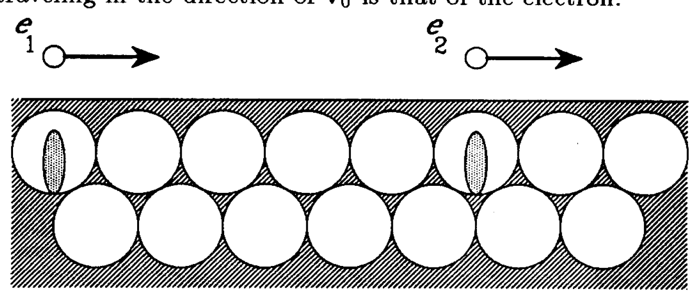

Fig. 4. Dipole state moving along the interface of a dielectric. The shaded part represents the domain that is considered a dielectric when viewed macroscopically. The white circles represent individual atoms, with the polarized atoms forming a dipole with the electron passing over them. The dark ellipses in the polarized atoms represent the electron orbits displaced by the repulsive Coulomb force. The representation is, of course, entirely symbolic, with no attempt to observe scales or individual positions.

Coulomb's Law is therefore not violated by such traveling dipoles; it merely results in zero force, because in the only pertinent direction the charge is effectively neutralized.

4. Clustering by Faraday Field Oscillations

But the dipole mechanism does not explain the actual clustering, for the preceding consideration by itself would only lead to irregular patterns of traveling dipoles. However, the Coulomb field is merely the non-rotational part of the electric field acting on an electron. As shown in detail in [5], and more cursorily in [6], the rotational part of the electric field, the Faraday field

$$\psi = -\frac{\partial \mathbf{A}}{\partial t} \approx \frac{\Phi}{c^2}\frac{dv}{dt} \tag{2}$$

where **A** is the magnetic vector potential, plays a crucial role in the force acting on a moving electron: as the electron accelerates and thus builds up its magnetic field, the induced Faraday field will oppose the acceleration, and similarly, when the electron decelerates and the magnetic field collapses, the induced Faraday field will accelerate it again in a process representing the inductance of a single moving electron. The exchange of energy stored in the magnetic and the Faraday fields of the moving electron is the exact analogy of a tuned circuit, with the frequency of oscillations, as derived in [5], given by the de Broglie relation $h\nu = m\lambda v\nu$, or $\omega = mv_0^2/\hbar$, with m the mass of the electron, h Planck's constant ($\hbar = h/2\pi$), and $\lambda = v_0/\nu$ the de Broglie wavelength.

As shown in [5], the instantaneous velocity of the electron is

$$v = v_0(1 + \beta^2 \sin \omega t) \tag{3}$$

where all velocities are referred to the dominant field, in this case the cathode-anode electric field, i.e., the laboratory.

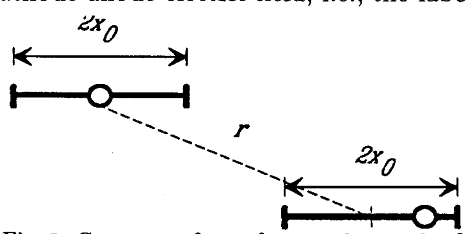

Fig. 5. Geometry of two electrons interacting by the Faraday force. The angle between **v** and **r** is zero for purposes of this paper, but the derivation remains valid for the general angle shown.

The force $\mathbf{F} = q\boldsymbol{\psi}$ acts not only on "its own" electron that engendered the $\boldsymbol{\psi}$ field, but on any other charge q within its domain, such as another electron as shown in Fig. 5. From (2) and (3) this force is

$$\mathbf{F} = q\boldsymbol{\psi} = F_0 \cos \omega t \; x^\circ \tag{4}$$

where $\mathbf{x}^\circ$ is a unit vector in the direction of the force, which for the present application is important only in the direction of the velocity (more generally, it is found from $\nabla \times \mathbf{B}$), and

$$F_0 = \frac{q\Phi v_0 \omega \beta^2}{c^2} = \frac{q\Phi\beta^4 mv}{\hbar} \tag{5}$$

Here $\beta = v_0/c$ and the formula $E = \hbar\omega = mv^2$ (kinetic plus electromagnetic, [5]) has been used.

Let us first compare this force of one electron on another with the Coulomb force Φ/r; the ratio of the Faraday to Coulomb forces is

$$\frac{|\nabla\Phi|}{|\partial\mathbf{A}/\partial t|} = \frac{2\pi\beta^4 r}{\lambda} \tag{6}$$

with $\lambda = h/mv$ the de Broglie wavelength. The appearance of the distance r is due to the fact that the Faraday force falls off more slowly with distance ($1/r$) than the single-charge Coulomb force ($1/r^2$).

It is noteworthy that for $\beta = 0.1$ the ratio (6) at a distance of 1 μm amounts to 8.6. Thus, even if the Coulomb force is not completely neutralized as described in the preceding section, or if the theory given there is inaccurate, the Faraday force at that distance is still much stronger than the full free-space, single-charge Coulomb force.

5. Phase Relations

Consider the force of the Faraday field of an electron acting on another electron. We now change the coordinate system to one traveling at velocity v_0 with respect to the laboratory so that the electron velocity in this frame is $v = v_0\beta^2 \sin \omega t$, and we set the origin at the midpoint of the oscillation cycle of one particular electron, at the point where $v = 0$. The instantaneous position of the electron is then

$$x = x_0 \sin \omega t, \qquad x_0 = \frac{\beta^2 v_0}{\omega} = \frac{\beta^2 \lambda}{2\pi} \tag{7}$$

For $\beta = 0.1$ the amplitude x_0 is of the order 10^{-15}m, which is of the order of a classical electron radius, and utterly negligible compared to 1 μm or any other distance involved in the following.

What is not negligible, however, is the phase of the field at any point where it acts on a second electron, for by (4) this will determine whether the second electron is attracted or repelled. We have conveniently taken the phase of the oscillation as zero in omitting a cosine term in (3); but we are not at liberty to do so for a second electron, which in Fig. 5 is shown displaced from the center or zero phase point of its oscillation cycle. Let this phase shift of the second electron be φ_2; then the Faraday field of the second electron is

$$\boldsymbol{\psi}_2 = A_{22} \sin(\omega t \varphi_2)\, \boldsymbol{\psi}^\circ \tag{8}$$

where the amplitude A_{22}, though obtainable from (5), will be of little interest in the following. On the other hand, the Faraday field due to the first electron in the neighborhood if the second, apart from an unimportant difference in amplitude, will also differ by a phase delay:

$$\boldsymbol{\psi}_1 = A_{21} \sin(\omega t - \mathbf{k}\cdot\mathbf{r} - \varphi_2) \tag{8}$$

where the propagation vector **k** has the direction of the unit vector $\mathbf{r}^\circ = \mathbf{r}/r$ and scalar value $k = 2\pi/\Lambda$, with Λ the free-space wavelength (not to be confused with the de Broglie wavelength $\lambda = \beta\Lambda$).

The next step involves breaking a well-ingrained habit. We are so used to writing the force on a charge in the field of another charge as $\mathbf{F}_{12} = q_2\mathbf{E}_1$ that it is often forgotten that this is merely a shortcut, usually justifiable, which bypasses the full equation for the force on a charge acted on by the total field surrounding it, i.e., $\mathbf{F}_{12} = q_2(\mathbf{E}_1 + \mathbf{E}_2)$. This is justifiable in all cases where $q_2\mathbf{E}_2 = 0$, as is the case in electrostatics (the force on a charge by its own field cancels by symmetry) and in all dynamic cases in which the non-conservative part of **E**, the Faraday field, is negligible compared with the Coulomb field, as it is in most applications. But here we have a Faraday field which, far from being negligible compared with the irrotational component of **E**, is the *only* component of the electric field, and this field induced by the accelerating charge most certainly acts on it in accordance with Lenz's Law. Hence the total force on the second electron in the total field surrounding it is

$$\mathbf{F}_{12} = q(\boldsymbol{\psi}_1 + \boldsymbol{\psi}_2) \tag{9}$$

Whether the two fields reinforce or oppose each other depends entirely on the phase difference between these two Faraday fields $\boldsymbol{\psi}$. That phase difference was originally, at time $t = 0$,

$$\Delta\varphi = -\mathbf{k}\cdot\mathbf{r} - \varphi_2 \tag{10}$$

Now let the two electrons move, by attraction or repulsion, toward or away from each other by a distance $\Delta\mathbf{r} = \mathbf{v}_a\Delta t$, where v_a is some average velocity over this distance. Then the phase difference (10), which is unaffected by the increments $\omega\Delta t$ (the same for both), is given by the changed delay of $\boldsymbol{\psi}_1$ in reaching the second electron, and by the changed position of that electron in the expression for $\boldsymbol{\psi}_2$. But the change in the delay of $\boldsymbol{\psi}_1$ $-\mathbf{k}\cdot\mathbf{r}$ is $\mathbf{k}\cdot\Delta\mathbf{r} = \mathbf{k}\cdot\mathbf{v}_a\Delta t$, which also exactly equals the change in the phase of $\boldsymbol{\psi}_2$ due to the change of position of the second electron.

Hence, regardless of the amplitudes of the two Faraday fields (which will change with time as the two electrons interact), the phase difference (10) between the two fields remains constant as the two electrons attract or repel each other under the force of the Faraday field. The initial phase (10) at time $t = 0$ is determined by the random variables $\mathbf{r}$ and φ, and is therefore itself a random variable, distributed uniformly over an effective interval of length 2π, so that attraction or repulsion are equally likely. However, once the type of interaction, attraction or repulsion, has been set by the initial phase, *it remains the same throughout the path in which the two oscillating electrons are move toward or away from each other.*

If the Faraday field makes two electrons repel each other, they will, of course, fall into the domain of other electrons whose oscillating Faraday fields will attract or repel them. If two electrons are attracted until they are within a volume of dimensions small compared with the distance to other electrons, the process will repeat itself with one of the charges doubled, which means a doubled force to attract single electrons or repel them toward other similar clusters. However, since the process will continue throughout the plasma simultaneously, such a double electron is more likely to interact not with a single electron, but with another double electron, and the resulting quadruple charge with another quadruple charge, and so on. The resulting geometric-series chain reaction will lead to an extremely rapid clustering of electrons whose limits we will now consider.

6. Limiting Values

The clustering process will come to a stop when the lowest of several bounds has been reached. Among the constraints that set such bounds the following appear the most important:

1) The dielectric polarization, whether elastic or orientational, becomes saturated as the orbit displacement or orientation reach their maximum possible values.

2) The supply of electrons in the plasma of the arc is exhausted; i.e., when they have all been absorbed by neighboring clusters, while the clusters themselves have settled at a separation of $(2n+1)\lambda/2$, when the net interaction is zero. This is an unstable equilibrium state, but the clusters have little time (order 10^{-12} sec) to leave it.

3) At a certain separation of electrons, the remnant Coulomb (dipole) field becomes stronger than the Faraday field. Actually the dipole field, proportional to r^{-3}, is derived under the assumption that the separation of the charges or dipole length is small compared with r, but even before this assumption breaks down as r decreases, there is the rapid rise of the dipole field (r^{-3}) compared to the slow rise of the Faraday field (r^{-1}). In our treatment of Sec. 3, the dipole field was set to zero due to the $\sin\theta$ factor in any direction along the surface. However, for very small r even a slight change of direction of the dipole moment (for whatever reason) will quickly bring on an overpowering Coulomb field. If the Coulomb field were that of an isolated charge with a r^{-2} dependence, it would by (6) exceed the Faraday field at distances

$$r < \frac{\hbar}{mv\beta^4} \tag{11}$$

For $\beta = 0.1$ this yields $r < 0.1$ microns. If we repeat the procedure of (6) for the Coulomb field of a dipole with moment $p = ql$ where l is the distance separating the two charges, we find instead of (11)

$$r < \sqrt{\frac{\hbar l}{\beta^4 mv}} \tag{12}$$

but owing to the uncertainty of the value of l it is difficult to say whether this would be closer to the measured order of 1 micron. (The value of l that would give such a result is 10^{-8}m, or about 190 Bohr radii — a not unreasonable value.)

4) Saturation by virtue of the electron density in the cluster becoming so high that its electrons can no longer individually react with the dielectric surface — which would happen when the electron density reaches that in the dielectric, i.e. that of a solid.

From the reported data [1], the electron concentration in an EV is about 6.6×10^{23} electrons/cm^3. This approaches the electron densities in a solid, and therefore the fourth constraint may be the strictest; however, the third constraint may well be of the same order or stricter, and it is probably these two constraints that predominantly set the limit on cluster formation.

7. Conclusions

The existence of high-density electron clusters or EVs can be explained by the formation of dipoles at the interface of the guiding dielectric and by the interaction of the oscillating Faraday fields surrounding each electron.

The phenomenon of EVs appears to confirm the oscillating Faraday field derived from the Maxwell equations in [5]; at present no other viable explanation appears available.

This confirmation has a wider import than the problem of the EV itself, for the existence of the velocity oscillations of an electron, in turn, are totally incompatible with the Relativity Principle in Einstein's observer- based conception.

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Galilei Covariant Electromagnetic Field Equations

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Based on the Galilean relativity principle and the experimental observation that the vacuum behaves like a carrier medium (EM substratum) for EM waves and fields, generalized Galilei covariant Maxwell equations are derived. The generalized Maxwell equations for inertial frames $\Sigma(\mathbf{w})$ with substratum flow contain explicitly the substratum velocity $\mathbf{w}$, and reduce to the usual Maxwell equations when $\mathbf{w} \rightarrow \mathbf{0}$. As illustrations, (i) the field invariants in transformations between inertial frames,and (ii) electric and magnetic induction in reference frames with substratum flow $\mathbf{w}$, are discussed.

Introduction

According to Maxwell, Hertz, Heaviside, Poincaré, Lorentz, Abraham and others, Maxwell's equations hold only in a frame of reference $\Sigma^\circ(\mathbf{r}^\circ, t^\circ, \mathbf{0})$, in which the carrier of the electromagnetic (EM) fields is at rest, $\mathbf{w}^\circ \equiv \mathbf{0}$ [1–7]. A physically more meaningful observation would have been the recognition that it makes no physical sense to expect EM field equations, such as Maxwell's equations, to be covariant against physical space-time transformations of any type, if these field equations hold only in a single inertial frame (Σ°) and their form in arbitrary inertial frames (Σ) is unknown. Furthermore, Maxwell's equations can be shown to be covariant with respect to an infinite number of linear and nonlinear mathematical space-time transformations, with the Lorentz transformations representing a simple linear coordinate substitution [8]. Thus, Maxwell's equations have no unique or physically distinguished transformations [8].

In order to illustrate physical transformation theory (and the strange mathematical developments which lead to Lorentz covariant electrodynamics [9]), let the Galilei covariance of the familiar acoustic wave equation be discussed. In the inertial frame $\Sigma^\circ(\mathbf{r}, t^\circ, \mathbf{0})$ in which the acoustic carrier (e.g. a gas) is at rest, $\mathbf{w}^\circ \equiv \mathbf{0}$, the pressure of sound is described by the ordinary wave equation, $\partial^2 p^\circ/\partial t^{\circ 2} = c_s^{\circ 2}\nabla^{\circ 2} p^{\circ 2}$. This wave equation is not Galilei covariant since it holds only in the carrier rest frame Σ°. By linear gas dynamics, the acoustic wave equation for an arbitrary inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$, in which the acoustic wave carrier (gas) streams with a velocity $\mathbf{w}$, is of different form, namely $(\partial/\partial t + \mathbf{w}\cdot\nabla)^2 p = c_s^2\nabla^2 p$. This wave equation is generally valid in this form, and is Galilei covariant, since the operators $\partial/\partial t + \mathbf{w}\cdot\nabla = \partial/\partial t' + \mathbf{w}'\cdot\nabla'$, $\nabla = \nabla'$, and the pressure $p(\mathbf{r}, t) = p'(\mathbf{r}', t')$ and the velocity of sound $c_s = c_s'$ are invariants in Galilei transformations $\Sigma \leftrightarrow \Sigma'$. On the other hand, the acoustic wave equation $\partial^2 p^\circ \partial t^{\circ 2} = c_s^{\circ 2}\nabla^{\circ 2} p^\circ$ of the carrier (gas) rest frame Σ° is covariant against the Lorentz transformation if in the latter the velocity of light c is replaced by the sound velocity c_s°. Thus the Lorentz transformation is a non-physical space-time coordinate substitution which leaves certain field equations mathematically invariant, even though these are physically not generally valid.

The Maxwell equations were generalized to a form in which they hold for arbitrary inertial frames Σ with ether flow $\mathbf{w}$ in 1984 [10 – 12]. These generalized Maxwell equations contain explicitly the velocity $\mathbf{w}$ of the EM wave carrier (ether), and are Galilei covariant [10 – 12]. According to this theory, light signals propagate anisotropically in inertial frames Σ with ether flow $\mathbf{w}$, and isotropically in the ether rest frame Σ° [10,11]. For example, the velocity of a light signal in vacuum is $c \pm w$, depending on whether it propagates downstream (+) or upstream (−) with respect to the ether flow $\mathbf{w}$.

Considering this anisotropy of light propagation, the time difference of light signals propagating parallel (||) and perpendicular (⊥) to the ether flow $\mathbf{w}$ in the Michelson Morley experiment is $\Delta t = (2/c_0)[L^{\|}(1 - w^2/c^2)^{-1} - L^{\perp}(1 - w^2/c^2)^{-1/2}]$. The observed fringe shift $\phi \propto \Delta t = 0$ vanishes exactly since the longitudinal mirror distance $L^{\|} = L_0(1 - w^2/c^2)^{1/2}$ is Lorentz contracted, whereas the transverse mirror distance $L^{\perp} = L_0$ is not. The physical (nonkinematic) effect of Lorentz contraction of bodies traversed by the ether flow $\mathbf{w}$ follows (i) experimentally from the observed $\Delta t = 0$ and (ii) theoretically from the deformation of the spherical equipotential surfaces of the Coulomb fields of the electrons and nuclei of bodies into oblate spheroidal equipotential surfaces by the ether flow $\mathbf{w}$. Accordingly, the assertion of the special theory of relativity (STR) that light signals propagate isotropically with velocity c on the earth is a trivial misinterpretation of the M-M experiments, and contradicts the electrodynamics of charged particles of bodies in motion. The associated generalization (observer-based "relativity principle"), according to which one and the same light signal propagates isotropically with velocity c in all possible inertial frames, is geometrically and physically untenable.

In this paper a derivation of the generalized Galilei covariant (i) wave equations of the EM potentials and (ii) Maxwell equations of the EM fields is given for arbitrary inertial frames with ether flow $\mathbf{w}$, with applications to electric and magnetic induction phenomena. In follow-up investigations, anisotropy of light propagation, length contraction, and time dilation in inertial frames with ether flow $\mathbf{w}$ will be deduced from these fundamental equations, and a physical interpretation of the MM- and Sagnac type experiments will be given based on first principles.

Galilei covariant electromagnetic equations

In general, wave phenomena, e.g. acoustic, shear or spin waves, exist only in a carrier medium, such as gases, liquids, and solids. Gravitational and electromagnetic waves appear to represent exceptions, since they propagate also in "free space" or "vacuum" (space without "ordinary" matter). However, an EM signal advances in vacuum with a wave front velocity which is independent of the velocity of the emitting source [1]. Thus, the vacuum behaves like a carrier medium for EM waves, in a similar sense as gases, liquids and solids serve as carrier media for ordinary waves. Equally remarkable is the fact that a vacuum has (nonvanishing) physical properties, namely a permittivity $\epsilon_0 = 10^{-9}/36\pi$ [As/Vm] and a permeability $\mu_0 = 4\pi \times 10^{-7}$ [Vs/Am], as well as derived physical properties, such as an EM wave resistance $Z_0 = (\mu_0/\epsilon_0)^{1/2} = 120\pi$ [Ω], and a characteristic EM phase velocity $c = (\mu_0\epsilon_0)^{-1/2} = 3 \times 10^8$ [m/s] [1].

The Galilei transformations of the EM field have found wide use in applied science (e.g. in the analysis of electric induction generators and motors) [13]. On the other hand, the STR is usually avoided because of the contradictions and paradoxes it generates in applications [14]. The Lorentz transformation is only one of the infinite number of possible space-time coordinate substitutions which provide form-invariance, i.e., they are not unique transformations of the Maxwell equations [8].

Furthermore, it is now known that the EM forces between moving charges and/or moving magnetic dipoles do not depend on their *relative* velocities (as postulated by the STR), but on their absolute velocities [16, 17]. Therefore the Galilean relativity principle holds and that of the STR fails [16,17].

For the understanding of the following considerations, it is essential to be aware that they are based exclusively on the Galilean relativity principle. In any inertial frame of reference $\Sigma(\mathbf{r}, t, \mathbf{w})$, which moves with absolute velocity $\mathbf{U}$ relative to the ether frame Σ°, the velocity $\mathbf{v}$ of any material particle or object has absolute meaning. The relative velocity of two particles or systems (1,2) is always given by the linear Galilean relation $\mathbf{u}_G = \mathbf{v}_1 - \mathbf{v}_2$.

The preferred reference frame $\Sigma^\circ(\mathbf{r}^\circ, t^\circ, 0)$ in which the EM carrier (ether) is at rest ($\mathbf{w}^\circ = \mathbf{0}$) is that inertial frame, in which experiments show isotropic propagation of vacuum light signals with the characteristic speed $c = (\mu_0\epsilon_0)^{-1/2}$ [2,11 - 13]. According to Maxwell, Heaviside, Hertz, Poincaré, Lorentz, and Abraham, the usual Maxwell equations hold in Σ°. The EM vacuum fields $\mathbf{E}^\circ(\mathbf{r}^\circ, t^\circ)$ and $\mathbf{H}^\circ(\mathbf{r}^\circ, t^\circ)$ in Σ° are derivable from vector $\mathbf{A}^\circ(\mathbf{r}^\circ, t^\circ)$ and scalar $\Phi^\circ(\mathbf{r}^\circ, t^\circ)$ potentials by [1]

$$\mathbf{E}^\circ = -\nabla^\circ\Phi^\circ - \frac{\partial \mathbf{A}^\circ}{\partial t^\circ}, \qquad \mathbf{H}^\circ = \frac{1}{\mu_0}\nabla^\circ \times \mathbf{A}^\circ \tag{1}$$

Since (1) determines only the curl of $\mathbf{A}^\circ$, the divergence of $\mathbf{A}^\circ$ is subjected to the Lorentz gauge [1],

$$\nabla \cdot \mathbf{A}^\circ = -\mu_0\epsilon_0 \frac{\partial \Phi^\circ}{\partial t^\circ} \tag{2}$$

in order to specify the vector field $\mathbf{A}^\circ(\mathbf{r}^\circ, t^\circ)$ completely. By means of (1) and (2), the Maxwell equations for the vacuum (μ_o, ϵ_0) can be separated into inhomogeneous wave equations for the EM potentials [1]:

$$\mu_0\epsilon_0 \frac{\partial^2 \mathbf{A}^\circ}{\partial t^{\circ 2}} - \nabla^{\circ 2}\mathbf{A}^\circ = \mu_0 \mathbf{j}^\circ \tag{3}$$

$$\mu_0\epsilon_0 \frac{\partial^2 \mathbf{\Phi}^\circ}{\partial t^{\circ 2}} - \nabla^{\circ 2}\mathbf{\Phi}^\circ = \frac{\rho^\circ}{\epsilon_0} \tag{4}$$

The EM vacuum potentials have their sources in the space charge $\rho^\circ(\mathbf{r}^\circ, t^\circ)$ and current density $\mathbf{j}^\circ(\mathbf{r}, t^\circ)$ fields of individual charges e moving with a velocity field $\mathbf{v}^\circ(\mathbf{r}^\circ, t^\circ)$, where $\mathbf{j}^\circ = \rho^\circ\mathbf{v}^\circ$.

The EM wave equations (3) and (4) are not generally valid, since they are only applicable in the inertial frame $\Sigma^\circ(\mathbf{r}^\circ, t^\circ, \mathbf{0})$, in which the wave carrier is at rest, $\mathbf{w}^\circ = \mathbf{0}$ [3]. For this reason, it is physically not meaningful to investigate their covariance properties in space-time transformations (e.g., the Lorentz transformations). [11 - 13].

Accordingly, the wave equations (3) and (4) are first transformed from the ether rest frame Σ° to an arbitrary inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ which moves with an arbitrary constant velocity $\mathbf{U}$ relative to Σ°. In Σ, the ether streams with the velocity $\mathbf{w} = -\mathbf{U}$. This transformation cannot be accomplished by means of the Lorentz transformations, since they do not lead to different wave equations.

Let (3) and (4) be transformed by means of the Galilean transformation $\Sigma^\circ \to \Sigma$ to the inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ with ether flow $\mathbf{w}$. Thus, different wave equations are obtained for the EM vacuum potentials $\mathbf{A}(\mathbf{r}, t)$ and $\Phi(\mathbf{r}, t)$ in the inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$, that moves with arbitrary constant velocity $\mathbf{U} = -\mathbf{w}$ relative to Σ° [11,12]:

$$\left[\mu_0\epsilon_0\left(\frac{\partial}{\partial t} + \mathbf{w}\cdot\nabla\right)^2 - \nabla^2\right]\mathbf{A} = \mu_0(\mathbf{j} - \rho\mathbf{w}) \tag{5}$$

$$\left[\mu_0\epsilon_0\left(\frac{\partial}{\partial t} + \mathbf{w}\cdot\nabla\right)^2 - \nabla^2\right](\Phi - \mathbf{w}\cdot\mathbf{A}) = \frac{\rho}{\epsilon_0} \tag{6}$$

In this Galilei transformation, the vacuum properties have been assumed to be invariant, $\mu = \mu_0,\ \epsilon = \epsilon_0$ [24,25]. Note that the wave equation of the inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ explicitly contain the ether velocity $\mathbf{w}$. Furthermore, $\mathbf{j} = \rho\mathbf{v}$.

From the simultaneous solutions $\mathbf{A}(\mathbf{r}, t)$ and $\Phi(\mathbf{r}, t)$ of (5) and (6), the EM fields follow via the covariant relations [11,12]

$$\mathbf{E} = -\nabla\Phi - \frac{\partial \mathbf{A}}{\partial t}, \qquad \mathbf{H} = \frac{1}{\mu_0}\nabla \times \mathbf{A} \tag{7}$$

In the inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ with ether flow $\mathbf{w}$, the EM potentials satisfy the generalized Lorentz gauge [11,12]

$$\nabla\cdot\mathbf{A} = -\mu_0\epsilon_0\left(\frac{\partial}{\partial t} + \mathbf{w}\cdot\nabla\right)^2 (\Phi - \mathbf{w}\cdot\mathbf{a}) \tag{8}$$

The wave equations of the form (5) and (6) are valid in an any inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ if they are covariant in Galilei space-time transformations from the inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ to an arbitrary other inertial frame $\Sigma'(\mathbf{r}', t', \mathbf{w}')$:

$$\mathbf{r}' = \mathbf{r} - \mathbf{u}t, \qquad t' = t \tag{9}$$

with

$$\frac{\partial}{\partial t} = \frac{\partial}{\partial t'} - \mathbf{u}\cdot\nabla', \qquad \nabla = \nabla' \tag{10}$$

where Σ' moves relative to Σ with the arbitrary constant velocity $\mathbf{u}$. (The origins 0 of Σ and 0′ of Σ' are assumed to coincide for $t = t' = 0$). In Σ', the ether streams with the velocity $\mathbf{w}' = \mathbf{w} - \mathbf{u}$. Since $\mathbf{u} = \mathbf{w} - \mathbf{w}'$, (10) implies the covariant operators

$$\frac{\partial}{\partial t} + \mathbf{w}\cdot\nabla = \frac{\partial}{\partial t'} + \mathbf{w}'\cdot\nabla', \qquad \nabla = \nabla' \tag{11}$$

In the Galilei transformation $\Sigma \to \Sigma'$, the EM potentials $\mathbf{A}, \Phi$ and the source fields $\rho, \mathbf{j}$ exhibit the invariance properties

$$\mathbf{A} = \mathbf{A}', \qquad \rho = \rho' \tag{12}$$

$$\Phi - \mathbf{w} \cdot \mathbf{A} = \Phi' - \mathbf{w}' \cdot \mathbf{A}' \tag{13}$$

$$\mathbf{j} - \rho\mathbf{w} = \mathbf{j}' - \rho'\mathbf{w}' \tag{14}$$

In view of the Galilei invariants (12) – (14), and the covariant operators in (11), it is easily recognized that the wave equations are of the same form for $\mathbf{A}'(\mathbf{r}', t')$ and $\Phi'(\mathbf{r}', t')$ of Σ', as the wave equations (5) and (6) of Σ, if the vacuum properties are invariant:

$$\mu_0 = \mu_0', \qquad \epsilon_0 = \epsilon_0' \tag{15}$$

Accordingly, the wave equations (5) and (6) are Galilei covariant, i.e., they are applicable in an arbitrary inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ with ether flow $\mathbf{w}$. The assumed invariance (15) of the vacuum properties μ_0, ϵ_0 in Galilei transformations is obvious and agrees with known experiments. The invariants (11) – (15) with $\Sigma' \equiv \Sigma^\circ, \mathbf{w}' \equiv \mathbf{w}^\circ = \mathbf{0}$, can also be used to transform the wave equations (5), (6) into the wave equations (3),(4) of the ether frame Σ°. This constitutes the ***a posteriori*** derivation of equations (5) and (6). Since $\mathbf{u} = \mathbf{w} - \mathbf{w}' = \mathbf{v} - \mathbf{v}'$ in the Galilei transformations $\Sigma \to \Sigma'$, (11), (13) and (14) imply the Galilei invariants

$$\frac{\partial}{\partial t} + \mathbf{v} \cdot \nabla = \frac{\partial}{\partial t'} + \mathbf{v}' \cdot \nabla' \tag{16}$$

$$\Phi - \mathbf{v} \cdot \mathbf{A} = \Phi' - \mathbf{v}' \cdot \mathbf{A}' \tag{17}$$

$$\mathbf{j} - \rho\mathbf{v} = \mathbf{j}' - \rho'\mathbf{v}' \tag{18}$$

Application of (7) to the Galilei invariants (12), (13) and (17) yields, in view of (15), the EM field invariants in Galilei transformations $\Sigma \to \Sigma'$:

$$\mathbf{E} + \mu_0 \mathbf{w} \times \mathbf{H} = \mathbf{E}' + \mu_0 \mathbf{w}' \times \mathbf{H}' \tag{19}$$

$$\mathbf{E} + \mu_0 \mathbf{v} \times \mathbf{H} = \mathbf{E}' + \mu_0 \mathbf{v}' \times \mathbf{H}' \tag{20}$$

$$\mathbf{H} = \mathbf{H}' \tag{21}$$

where

$$\mathbf{w} - \mathbf{w}' = \mathbf{v} - \mathbf{v}' = \mathbf{u} \tag{22}$$

Equation (20) indicates that the Lorentz force $\mathbf{F} = e(\mathbf{E} + \mu_0 \mathbf{v} \times \mathbf{H})$ acting on a charged particle e is Galilei invariant (e is a Galilei invariant). More remarkable is (21), which shows that the magnetic field $\mathbf{H} = \mathbf{H}'$ is an exact Galilei invariant.

The corresponding Galilei covariant generalized Maxwell equations for the EM vacuum (μ_0, ϵ_0) fields $\mathbf{E}(\mathbf{r}, t)$, $\mathbf{H}(\mathbf{r}, t)$ in an arbitrary inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ with ether flow $\mathbf{w}$ are given by

$$\nabla \times (\mathbf{E} + \mu_0 \mathbf{w} \times \mathbf{H}) = -\left(\frac{\partial}{\partial t} + \mathbf{w} \cdot \nabla\right) \mu_0 \mathbf{H} \tag{23}$$

$$\nabla \cdot \epsilon_0 (\mathbf{E} + \mu_0 \mathbf{w} \times \mathbf{H}) = \rho \tag{24}$$

$$\nabla \times \mathbf{H} = \left(\frac{\partial}{\partial t} + \mathbf{w} \cdot \nabla\right) \epsilon_0 (\mathbf{E} + \mu_0 \mathbf{w} \times \mathbf{H}) + \mathbf{j} - \rho\mathbf{w} \tag{25}$$

$$\nabla \cdot \mu_0 \mathbf{H} = 0 \tag{26}$$

These EM field equations reveal the fundamental asymmetry of the time-dependent EM field, caused by the existence of electric charges and the nonexistence of magnetic charges.

The Galilei covariance of (23) to (26) follows from the Galilei invariants (11), (14), 15), (19), and (21). For $\mathbf{w} = \mathbf{0}$, the generalize Maxwell equations (23) to (26) reduce to the ordinary Maxwell equations, which hold only in the ether frame Σ°. Similarly, application of the invariants (11), (14), (15), (19), and (21) to the Galilei transformation $\Sigma \to \Sigma^\circ(\mathbf{w} \equiv \mathbf{w}^\circ = \mathbf{0})$ transforms (23) to (26) to the Maxwell equations of the ether frame Σ°. This constitutes the proof that (23) to (26) are the generalized, Galilei covariant Maxwell equations for an arbitrary inertial frame Σ with substratum flow $\mathbf{w}$.

The corresponding electromagnetic field equations for dielectric and conducting media have been given in earlier publications [10, 11, 12].

Discussion

We have shown that electrodynamic phenomena can be understood by means of Galilei covariant EM field equations [wave equations (5) to (6) or generalized Maxwell equations (23 to (26)], in which the velocity of the EM wave carrier $\mathbf{w}$ appears explicitly. The derivation of the Galilei covariant EM equations is based on the experimental fact that the vacuum behaves like an EM wave carrier (the velocity of EM signals is independent of the velocity of the emitter) [1 – 4, 9, 11 – 13] and the assumption that the usual Maxwell equations hold in the ether frame $\Sigma^\circ(\mathbf{w} = \mathbf{0})$ [1 – 11]. The concept of the EM substratum is experimentally supported by cosmic microwave background of $2.7^\circ K$, which represents a thermal excitation of the ether [15].

Major applications of the Galilei covariant EM equations will be given in follow-up investigations. Here, only the phenomena of electric and magnetic induction are discussed.

Electric induction. In the curl equation (23) for the electric field, the expression $\nabla \times (\mathbf{w} \times \mathbf{H}) = -\mathbf{w} \cdot \nabla\mathbf{H}$ by (26), can be eliminated. Thus, the Galilei covariant induction equation (23) is brought into the form of the usual induction equation,

$$\nabla \times \mathbf{E} = -\mu_0 \frac{\partial \mathbf{H}}{\partial t} \tag{27}$$

The derivation yields (23) in a form in which its Galilei covariance is obvious, whereas the Galilei covariance of (27) is not so apparent. Accordingly, Faraday's induction law,

$$\oint_C \mathbf{E} \cdot d\mathbf{r} = -\int_A \mu_0 \frac{\partial \mathbf{H}}{\partial t} \cdot d\mathbf{A} \tag{28}$$

holds in Galilean electrodynamics for any inertial frame $\Sigma(\mathbf{r}, t, \mathbf{w})$ (even though the ether velocity $\mathbf{w}$ does not occur explicitly in (27) to (28). The transformation invariants yield

$$\mathbf{E}' = \mathbf{E} + \mu_0 \mathbf{u} \times \mathbf{H} \tag{29}$$

for the electric field in Σ', which moves with velocity $\mathbf{u} = \mathbf{v} - \mathbf{v}'$ relative to Σ. Equation (29) describes electric induction in the Σ' system: $\mathbf{E}'$ of Σ' differs from $\mathbf{E}$ of Σ by the induced electric field $\mu_0 \mathbf{u} \times \mathbf{H}$.

Magnetic Induction. The curl equation (25) of the magnetic field does not permit a similar simplification, since magnetic induction is due to charge motion relative to the ether. For the elementary case of a charge e moving with uniform velocity $\mathbf{v}$ in an inertial frame $\Sigma(\mathbf{w})$, equations (23) to (26) are readily integrated, with the result

$$\mathbf{H} = K\epsilon_0(\mathbf{v}-\mathbf{w})\times\mathbf{E}, \quad K = \frac{1}{1+\mathbf{w}\cdot(\mathbf{v}-\mathbf{w})/c^2} \tag{30}$$

for the relation between $\mathbf{E}$ and $\mathbf{H}$ of the moving charge. Accordingly, the electric field $\mathbf{E}(\mathbf{r},t)$ of a moving charge induces a magnetic field $\mathbf{H}(\mathbf{r},t)$ only if it moves relative to the ether, $\mathbf{v}-\mathbf{w}\neq\mathbf{0}$. Hence magnetic fields are excitations of the ether produced by motion between charge and ether. The "general" STR relation $\mathbf{H}=\epsilon_0\mathbf{v}\times\mathbf{E}$ holds exactly only in the ether frame $\Sigma^\circ(\mathbf{w}=\mathbf{0})$ or approximately in other inertial frames $\Sigma(\mathbf{w})$ if $|\mathbf{w}|\ll|\mathbf{v}|$.

In contrast to the induced electric fields, the induced magnetic fields are small, of order $(v/c_0)^2$. As an elementary illustration, the interesting field invariance $\mathbf{H}=\mathbf{H}'$ will be derived. In (25), the operator is $\partial/\partial t+\mathbf{w}\cdot\nabla = \text{inv} = \partial/\partial t' + \mathbf{w}'\cdot\nabla'$ for a uniformly moving ($\mathbf{v}$) charge. By (14) and (19), we find from (25) $\nabla\times\mathbf{H}=\nabla'\times\mathbf{H}'$, and since $\nabla\cdot\mathbf{H}=\nabla'\cdot\mathbf{H}'$, the fundamental transformation invariance $\mathbf{H}=\mathbf{H}'$ follows.

The existence of a substratum or ether has significant physical implications. The motion of the ether past an electric charge distribution ρ results in a current density $\rho\mathbf{w}$ in (25). Length contractions and time dilations are no longer kinematic illusions (STR) of a (moving) observer, but are absolute physical effects, which are interrelated (a clock can be realized by a light signal reflected back and forth between two mirrors held apart by a rod) [18]. A rod has its longest length L° when at rest in the ether frame $\Sigma^\circ(\mathbf{w}=\mathbf{0})$ and a shorter length $L=L^\circ(1-w^2/c^2)^{1/2}$ when at rest in an inertial frame $\Sigma(\mathbf{w})$ with ether flows $\mathbf{w}$. A clock has its fastest rate ν° when at rest in the ether frame $\Sigma^\circ(\mathbf{w}=\mathbf{0})$, and a slower rate $\nu=\nu^\circ(1-w^2/c^2)^{1/2}$ when at rest in the inertial frame $\Sigma(\mathbf{w})$ with ether flow $\mathbf{w}$. Thus all illusions and contradictions based on the relativity of an observer's velocity are eliminated [18].

In subsequent communications, more elaborate applications of Galilean electrodynamics (anisotropic light propagation in ether flow, physical explanations of the Michelson-Morley and Sagnac experiments, shock waves and radiation in vacuum). One can also show that some interesting effects of order w/c should be observable in the compression of magnetic flux or microwaves in inertial frames with ether flow [11, 19, 20]. Furthermore, the experiments of Wilson and Roentgen-Eichwald can be explained by means of Galilean electrodynamics of dielectric media [11]. As to microscopic ether theory, it is referred to Winterberg [21].

APPENDIX

Galilei Covariance of Relations Between Fields and Potentials

In (7), the EM field $\mathbf{E},\mathbf{H}$ is related to the potentials $\mathbf{A},\Phi$. Although $\mathbf{H}=\nabla\times\mathbf{A}/\mu_0=\nabla'\times\mathbf{A}'/\mu_0'=\mathbf{H}'$, is evident, the Galilei covariance of

$$\mathbf{E} = -\nabla\Phi - \frac{\partial\mathbf{A}}{\partial t} \tag{A1}$$

is not so obvious [this is similar to the hidden Galilei covariance of the induction equation (27)]. To prove the Galilei covariance of (A1), $\mathbf{E},\nabla\Phi$, and $\partial\mathbf{A}/\partial t$ in (A1) are transformed from Σ to Σ' by means of the invariants in (10), (12), (13), (19), (21), and (22):

$$\mathbf{E}'-\mu_0\mathbf{u}\times\mathbf{H}' = -\nabla'[\Phi'+\mathbf{u}\cdot\mathbf{A}'] - \left(\frac{\partial}{\partial t'}-\mathbf{u}\cdot\nabla'\right)\mathbf{A}' \tag{A2}$$

Substitution of

$$\begin{aligned}\nabla'(\mathbf{u}\cdot\mathbf{A}') &= \mathbf{u}\times\nabla'\times\mathbf{A}'+\mathbf{u}\cdot\nabla'\mathbf{A}'\\ &= \mu_0\mathbf{u}\times\mathbf{H}'+\mathbf{u}\cdot\nabla'\mathbf{A}'\end{aligned} \tag{A3}$$

into (A2) reduces (A2) to the form of (A1),

$$\mathbf{E}' = -\nabla'\Phi' - \frac{\partial\mathbf{A}'}{\partial t'} \tag{A4}$$

Accordingly, (A1) is of the same form in all inertial frames Σ' (Galilei covariance).

Equation (A1) is also presentable in a form in which its Galilei covariance is obvious [see invariants (19), (13), (11)], namely

$$\mathbf{E}+\mu_0\mathbf{w}\times\mathbf{H} = -\nabla[\Phi-\mathbf{w}\cdot\mathbf{A}] - \left(\frac{\partial}{\partial t}+\mathbf{w}\cdot\nabla\right)\mathbf{A} \tag{A5}$$

However, (A5) is mathematically undesirable since it contains three terms which cancel, and thus it reduces to (A1).

Note that the Galilei covariance of the relations in (7) holds for dielectric media with substratum flow $\mathbf{w}$, too [11].

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Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment

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Summary: A uniformly charged spinning ring is proposed as a model for the electron. Four parameters, the radius of the ring R, the half-thickness r, the total charge e, and the tangential velocity c are chosen to yield the four electron characteristics, the mass m, the charge e, the spin $\hbar/2$, and the magnetic moment μ_e. The model is completely stable under electromagnetic forces alone. The twice classical value for the gyromagnetic ratio is explained. The size of the electron equals the rationalized Compton wavelength, and the frequency of rotation equals the Compton frequency. The model yields to a higher order approximation the anomalous magnetic moment in agreement with observation.

Introduction

Ever since discovery of the electron in the nineteenth century, a major goal of physics has been to find an electron model that accounts for the physical properties observed and measured with ever increasing precision. Early models proposed by Abraham [1] and Lorentz [2] provided a physical picture of the electron but could not satisfactorily account for some electrical properties. Later models such as the Dirac point model [3] and the quantum mechanical model have been conformed to experimental data; yet, these mathematical models have only tenuous links to a mechanical and physical structure that is the persuit of physics (the study of the *physical* nature and properties of the universe). The need for a better electron model is stated by Ivan Sellin who wrote in 1982 that

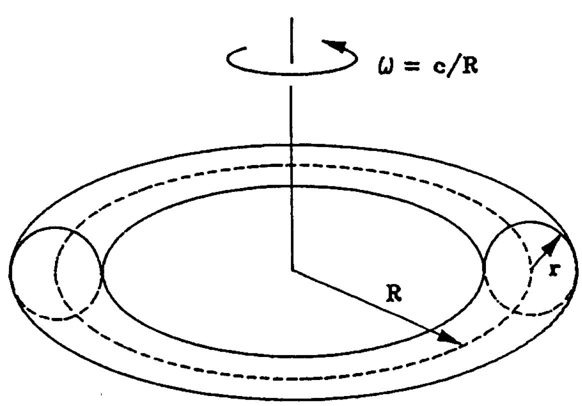

Fig. 1. The Spinning Ring Model of the Electron.

"...a good theory of electron structure still is lacking.... There is still no generally accepted explanation for why electrons do not explode under the tremendous Coulomb repulsion forces in an object of small size. Estimates of the amount of energy required to 'assemble' an electron are very large indeed. Electron structure is an unsolved mystery, but so is the structure of most other elemtary objects in nature, such as protons [and] neutrons..." [4].

Early models of the electron [1,2] were not realistic, primarily because they did not take into account the spin and magnetic moment of the electron. All of the models proposed so far have had to assume ad hoc non-electromagnetic forces to hold the model together. The model proposed here is the first model ever proposed that is completely stable under electromagnetic forces alone; the model does not radiate.

The Model and Some of its Consequences

An electron is assumed to be a uniform surface charge density σ that forms a ring of radius R and half-thickness r spinning about the axis of symmetry with the angular velocity $\omega = c/R$, as shown in Figure 1. The uniform surface charge density over the ring σ must be chosen to yield the total charge e; thus,

$$e = A\sigma = 4\pi^2\sigma rR \tag{1}$$

where $A = (2\pi r)(2\pi R)$ is the surface area when $r \ll R$.

The mass of the electron is obtained from the classical electromagnetic energy of the charged spinning ring and mass-energy equivalence. The total electromagnetic energy of the spinning ring E_t, is given by the electrostatic energy,

$$E_e = \frac{e^2}{2C} \tag{2}$$

where C is the capacitance of the spinning ring, plus the magnetostatic energy,

$$E_m = \frac{LI^2}{2} \tag{3}$$

where L is the self inductance of the spinning ring, and the current I is

$$I = \frac{e\omega}{2\pi} = \frac{ec}{2\pi R} \tag{4}$$

For the thin ring where $r \ll R$, it may be shown [5,6,7] that the capacitance and inductance have the values

$$C = \frac{4\pi^2 \epsilon_o R}{\ln(8R/r)} \qquad (5)$$

$$L = \mu_o R[\ln(8R/r) - 2] \approx \mu_o R[\ln(8R/r)] \qquad (6)$$

Equations (2) through (6) yield equipartition of electric and magnetic energies such that

$$mc^2/2 = E_t/2 \approx E_m \approx E_e = \frac{e^2}{8\pi^2\epsilon_o R}\ln(8R/r) \qquad (7)$$

The model does not radiate as the sources, the surface charge density σ and the surface current density $\sigma c/2\pi R$, are constant and do not change with time. When "charges occupy the entire circle continuously, then ... the total radiation field will vanish ...; this implies that a continuous ring current will not radiate ..."[8].

The tangential speed c of the spinning ring does not violate any principle. The ring is *not* a material ring, so no matter or mass is traveling with the speed c. Actually the velocity may be regarded as necessarily c, because the model may be viewed as consisting of electric and magnetic fields only; and electromagnetic fields necessarily propagate with the velocity c in a vacuum.

Stability of the Model as a Function of the Half-thickness of the Ring

The essential weakness of prior models of the electron has been that forces of unknown origin have to be postulated ad hoc to hold the electron together against electrostatic repulsion. In contrast, the present model is completely stable under the action of classical electromagnetic forces alone, and no forces of unknown origin have to be postulated.

The magnetic force on the thickness of the ring produces an inward directed pressure P_m, or "pinch" force, $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$; thus,

$$P_m = -\sigma v B \qquad (8)$$

where B is the magnetic field at the surface of the thickness due to the spinning of the charged ring. Here the surface charge σ moves with the velocity $v = c$, so the pinch pressure becomes

$$P_m = -\sigma c B \qquad (9)$$

Integrating the line integral of $\mathbf{B}$ around the thickness yields, according to the inappropriately named "Ampere integral law,"

$$2\pi r B = \mu_o I \qquad (1)0$$

Using equation (4), the magnetic field at the thickness becomes

$$B = \frac{e}{4\pi^2\epsilon_o c r R} \qquad (1)1$$

From equations (1), (9), and (11) the magnetostatic pressure on the thickness is then given by

$$P_m = -\frac{e^2}{16\pi^4\epsilon_o r^2 R^2} = -\frac{B^2}{\mu_o} \qquad (1)2$$

The latter result, varying as B^2/μ_o, is the well known inward directed magnetostatic stress of the field.

The electrostatic repulsive force $\mathbf{F} = q\mathbf{E}$ on the thickness of the ring produces an outward pressure or tension P_e given by

$$P_e = +\sigma E \qquad (13)$$

where E is the electric field at the surface of the thickness. From Gauss's law and equation (1), the electric field at the surface of the thickness is

$$E = \frac{\sigma}{\epsilon_o} = \frac{e}{4\pi^2\epsilon_o r R} \qquad (14)$$

Combining equations (13) and (14), the electrostatic outward directed tension or pressure becomes

$$P_e = \frac{e^2}{16\pi^4\epsilon_o r^2 R^2} = \epsilon_o E^2 \qquad (15)$$

The latter result, varying as $\epsilon_o E^2$, is the well known electrostatic stress or tension of the field.

Comparing equations (12) and (15), it is seen that the outward electrostatic repulsive pressure is balanced exactly by the inward magnostatic pressure or pinch; thus,

$$P_e = -P_m \qquad (16)$$

The thickness of the ring thus holds itself together in equilibrium under classical electrical and magnetic forces alone.

Stability of the Model as a Function of the Radius of the Ring

In addition to the stability of the thickness involving r, the ring as a closed current loop of radius R is also stable under classical electric and magnetic forces alone. To discuss the stability of the ring as a function of R, it is necessary to use the fundamental Weber [9] electrodynamics as generalized by Wesley [10], which (unlike the Maxwell theory) prescribes the force between two moving charges from the outset. In particular, the force between two charges q at $\mathbf{s}$ and q' at $\mathbf{s}'$, separated by the distance $\mathbf{S} = \mathbf{s} - \mathbf{s}'$ with relative velocity $\mathbf{V} = \mathbf{v} - \mathbf{v}'$ is

$$4\pi\epsilon_o c^2 \mathbf{F} = (qq'\mathbf{S}/S^3) \times \left[c^2 + V^2 - \frac{3(\mathbf{V}\cdot\mathbf{S})^2}{2S^2} + \mathbf{S}\cdot\frac{d\mathbf{V}}{dt}\right] \qquad (17)$$

The outward force f_e per unit length of the ring $Rd\phi$ due to electrostatic repulsion (the first term in the bracket on the right of equation (17)) may be obtained by considering the change in electrostatic energy when the ring is enlarged from R to $R + dR$. From equations (2) and (7), this electrostatic repulsion per unit length becomes

$$f_e = \frac{\partial[q^2/2C]}{\partial R} \approx \left(\frac{e^2}{8\pi^2\epsilon_o}\right)\frac{\ln(8R/r)}{R^2} \qquad (18)$$

Similarly the force f_m per unit length of the ring of radius R due to magnetostatic forces may be obtained by considering the change in magnetostatic energy for an expansion of the ring from R to $R + dR$. From equations (3) and (7) this magnetostatic repulsive force per unit length becomes

$$f_m = \frac{\partial(LI^2/2)}{\partial R} \approx \left(\frac{e^2}{8\pi^2\epsilon_o}\right)\frac{\ln(8R/r)}{R^2} = f_e \qquad (19)$$

The fact that the force f_m is outward may be seen from the fact that the pinch force on the thickness is slightly greater on the inside of the thickness than on the outside of the thickness, the magnetic field being slightly stronger inside then outside. From equations (18) and (19), the net outward force on the ring per unit length due to the electrostatic and magnetostatic effects is

$$f = f_e + f_m \approx \frac{e^2 \ln(8R/r)}{4\pi^2 \epsilon_o R^2} \tag{20}$$

These forces arise from the first, second and third terms in the bracket on the right side of equation (17).

The effect of the last term in the bracket on the right of equation (17) may be obtained by noting that for $r = 0$ (an approximation that is justified, as $r \ll R$) the model gives

$$\mathbf{S} \cdot d\mathbf{V}/dt = (\mathbf{s} - \mathbf{s}') \cdot \left(\frac{d\mathbf{v}}{dt} - \frac{d\mathbf{v}'}{dt} \right)$$

$$= -2R^2\omega^2[1 - \cos(\phi - \phi')] \tag{21}$$

where ϕ is the angular position of q and ϕ' is the angular position of q' and both charges are fixed at the same radial distance R with the same angular velocity $\omega = \dot{\phi} = \dot{\phi}'$. The situation is symmetric about the axis of symmetry of the ring, so averaging the angle $(\phi - \phi')$ over the ring yields zero for the cosine part of equation (21); and

$$\langle \mathbf{S} \cdot d\mathbf{V}/dt \rangle_\phi = -2R^2\omega^2 = -2c^2 \tag{22}$$

Substituting this result (22) into equation (17) shows that the effect of the acceleration term is just twice that of the electrostatic force and is in the opposite direction. Thus the acceleration force per unit length f_a is directed inward and is given by

$$f_a = -2f_e \tag{23}$$

From the equality of the electrostatic and magnetostatic forces, it may be seen that the total force of electromagnetic origin on the ring from equations (20) and (23) is zero; thus,

$$f_a + f_e + f_m = 0 \tag{24}$$

The ring is, thus, in equilibrium under classical electromagnetic forces alone, for the ring dimension R, as well as for the thickness dimension r. The spinning ring is completely stable because the forces upon it are in equilibrium, and its charge and current distributions do not vary with time. According to Maxwell theory, no radiation is possible; and without any means of losing energy, the ring retains its electromagnetic energy and shape.

The Natural Frequency and Size of the Ring

Still another way to see that the speed of the ring c is actually merely the velocity of an electromagnetic field is to consider the spinning ring as an LC-circuit. The resonant frequency of an LC-circuit with a standing electromagnetic field of velocity c is

$$\omega_{LC} = \frac{2\pi}{\sqrt{LC}} \tag{25}$$

From equations (5) and (6) this gives

$$\omega_{LC} = \frac{2\pi c}{\sqrt{4\pi^2 R^2}} = \frac{c}{R} \tag{26}$$

The Compton frequency is often associated with an electron. It is given by the Planck frequency condition where the energy is taken as the rest energy of the electron; thus,

$$\omega_C = \frac{mc^2}{\hbar} \tag{27}$$

Equating the natural resonant LC-frequency of the model ω_{LC}, equation (26), with the Compton frequency ω_C, equation (27), yields

$$\omega_{LC} = \omega_C \qquad R = \tfrac{\hbar}{mc} \tag{28}$$

The radius R of the ring equals the rationalized Compton wavelength, 3.86×10^{-13} meters. Previous estimates of the electron size have been both larger and smaller. Quantum theory is generally assumed to specify a large smeared out distribution of mass and charge which can be on the order of atomic dimensions—about 10^{-10} meters. A vastly smaller estimate of $\sim 10^{-22}$ meters was recently published [11]; this is even smaller than the size of a proton. Yet the electron's magnetic moment is known to exceed the proton's, and equation (29) requires a larger electron size for reasonable estimates of charge rotations. Modern atomic models assign small protons to the nucleus and larger electrons to the volume surrounding the nucleus.

The Magnetic Moment of the Electron

The magnetic moment of the model to the first approximation, using equation (4) is given by

$$\mu_e \equiv A'I = \frac{\pi R^2 e\omega}{2\pi} = \frac{ceR}{2} \tag{29}$$

where A' is the area of the current loop $A' = \pi R^2$. From equation (28) for R as the Compton wavelength, the model yields the magnetic moment to the first approximation as

$$\mu_e = \frac{\hbar e}{2m} \equiv \mu_B \tag{30}$$

where μ_B is the Bohr magneton. This fits the observed value to about 3 or 4 places. A closer approximation that includes the so-called anomalous magnetic moment is derived below.

Electron Spin

Evans states [12] "Empirically, it was necessary to assume that each electron possesses an intrinsic angular momentum, in addition to its usual orbital angular momentum, as though it were a spinning rigid body. The observable magnitude of this spin angular momentum is $\hbar/2$." This magnitude of the angular momentum of spin

$$p_s = \frac{\hbar}{2} \tag{31}$$

should be identified with the *free* electron and should not be confused with the spin of an electron bound in an atom and coupled to other atomic particles.

The angular momentum of a free electron depends upon its magnetostatic energy only and not upon its electrostatic energy, since only *moving* charge will produce momentum. A charged non-spinning ring would have electrostatic energy, but no angular momentum. The spinning ring has the tangential velocity c, so that the spin angular momentum is

$$p_s = m_m cR \tag{32}$$

where

$$m_m = \frac{E_m}{c^2} \approx \frac{E_t}{2c^2} \approx \frac{m}{2} \quad (33)$$

is the mass equivalent of the magnetostatic energy, as given by equations (3) and (7).

The fact that only magnetostatic mass m_m is involved and the magnetostatic mass is one-half the total mass of the electron means that the angular momentum of the electron p_s, as given by equation (32), is only one-half the amount that would be associated with an ordinary spinning macroscopic body. This spinning ring model then explains why the electron has a gyromagnetic ratio μ_e/p_s twice as large as the classical ratio $e/2m$, or from equations (30) and (31)

$$\frac{\mu_e}{p_s} = 2\frac{e}{2m} \quad (34)$$

From equations (7), (28), (32), and (33), the spin of the electron according to the proposed model becomes

$$p_s = \frac{e^2}{8\pi^2\epsilon_o c}\ln(8R/r) = \frac{\hbar}{2} \quad (35)$$

If $R = \hbar/mc$ is the Compton wavelength, then the half-thickness r is to be chosen such that

$$\ln(8R/r) = \pi/\alpha \quad (36)$$

where $\alpha = e^2/4\pi\epsilon_o c\hbar$ is the fine structure constant, and

$$r = 8R\exp(-\pi/\alpha) \approx 0 \quad (37)$$

The value of r is so small that it can be ignored except where a singularity might otherwise arise.

Anomalous Magnetic Moment

To the first approximation, the spinning ring model of the electron yields one Bohr magneton for the magnetic moment of the electron, equation (30), in agreement with observations to 3 or 4 places. A more accurate expression is obtained by using a better value for the self inductance L' of the spinning ring. Instead of the second of equations (6), a more accurate expression for the self inductance is

$$L' = \mu_o R'[\ln(8R'/r') - 2] \approx \mu_o R'\ln(8R'/r')(1 - 2\alpha/\pi) \quad (38)$$

where the approximation involves setting $\ln(8R'/r') = \pi/\alpha$, as given by equation (36) and $\alpha = e^2/4\pi\epsilon_o c\hbar \approx 1/137$, and where the radius of the ring R' and the half-thickness r' are to be determined anew.

The more accurate expression (38) reveals that the magnetostatic energy is slightly less than the electrostatic energy, leading to more accurate ring parameters. The relevant relations that must be satisfied by appropriate choices of the parameters R', r', and ω' are:

angular frequency: $$\omega' = c'/R' \quad (39)$$

current: $$I' = e\omega'/2\pi = ec'/2\pi R' \quad (40)$$

magnetostatic energy: $$E'_m = L'I'^2/2 = (e^2/8\pi^2\epsilon_o R')(c'/c)^2\ln(8R'/r')(1 - 2\alpha/\pi) \quad (41)$$

electrostatic energy: $$E'_e = (e^2/8\pi^2\epsilon_o R')\ln(8R'/r') \quad (42)$$

angular momentum: $$p'_s = m'_m c'R' = E'_m c'R'/c^2 = \hbar/2 \quad (43)$$

total energy: $$E_t = E'_e + E'_m = mc^2 \quad (44)$$

magnetic moment: $$\mu' = \pi R'^2 I' = (ceR'/2)(c'/c) \quad (45)$$

From Lenz' law, it may be assumed that the physical system will adjust so that changes in the parameters from the first approximation will be as small as possible. It may be assumed that the magnitude of the change in magnetostatic energy will equal the magnitude of the change in the electrostatic energy from symmetry; thus,

$$|E'_e - E_e| = |E'_m - E_m| \quad (46)$$

Using these conditions, the radius of the spinning ring R need not be changed from the first approximation; thus,

$$R' = R = \frac{\hbar}{mc} \quad (47)$$

Only the angular frequency ω' and the half-thickness r' need to be chosen anew such that

$$\omega' = \omega(1 + \alpha/2\pi) = (mc^2/\hbar)(1 + \alpha/2\pi)$$

$$\ln(8R/r') = \ln(8R/r)(1 + \alpha/2\pi) = \pi/\alpha + 1/2 \quad (48)$$

The new half-thickness r' then becomes

$$r' = \frac{8\hbar}{mc}\exp\left(\frac{-\pi}{\alpha} - \frac{1}{2}\right) \approx 0 \quad (49)$$

From equation (39), the new tangential velocity of the ring c' becomes greater than the former rim velocity c; thus,

$$c' = c(1 + \alpha/2\pi) \quad (50)$$

The new tangential velocity of the ring is *exactly* equal to the speed of light which may be shown by calculating the condition for dimensional stability of the ring using the exact equation for inductance. Equation (50) indicates that the first approximation of tangential velocity (labeled c) is actually slightly less than the speed of light. Substituting equations (47), (48) and (50) into (41) and (42), the new magnetostatic and electrostatic energies become

$$E'_m = E_m(1 - \alpha/2\pi) \qquad E'_e = E_e(1 + \alpha/2\pi) \quad (51)$$

which are seen to conserve energy from equations (7) and (44) and also the symmetry condition (46). Susbstituting the first of equations (51) and (47) into (43), it is seen that the angular momentum of spin p_s is conserved as $\hbar/2$. Substituting equations (47) and (50) into (45), the more exact magnetic moment becomes

$$\mu'_e = \mu_e(1 + \alpha/2\pi) = (e\hbar/2m)(1 + \alpha/2\pi) \quad (52)$$

The anomalous magnetic moment is then given by

$$\mu'_e/\mu_e - 1 = \alpha/2\pi = 0.0011613\cdots \quad (53)$$

which agrees with the observations to 6 or 7 places. Considering the gyromagnetic ratio μ'_e/p'_s from equations (43) and (52), it is seen to possess the same anomaly $\alpha/2\pi$ as the magnetic moment.

Higher order approximations for the magnetic moment of the electron can be obtained by considering still more accurate expressions for the capacitance and self inductance of the spinning ring.

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EDITOR'S NOTE

The authors and the reviewer of this paper failed to resolve the following issue, which is left to the reader:

The reviewer objected to the claim of stability, which is not merely a zero net force, but means the ability to return to the original state after a perturbing force first changes it and is then withdrawn. The reviewer required a proof of the claim, such as a minimum of energy in the state claimed to be stable.

The authors, on the other hand, felt that unstable or neutral equilibrium situations actually occur rarely in real situations in physics, and that it is not worth disussing the question in terms of the Bergman model. For the *asymptotic* solutions considered the equilibrium is clearly neutral, f(electrostatic) $= -f(\text{Weber}) \propto 1/R^2$, for all R. But, claim the authors, the exact expressions for the inductance L and the capacitance C will certainly show a *stable* equilibrium value for R, which yields the observed mass of the electron as the electrostatic plus the magnetostatic energy.

CORRESPONDENCE

Lunar Aberration

It would appear that Barnes and Slusher [1] have described two different phenomena with the same term. Aberration of starlight is measured as the *difference* in apparent direction of a star when observed at different times during the year. It is explained by the change in the relative velocity of the earth's orbit with respect to the star during different times of the year. What Barnes and Slusher refer to as lunar aberration is apparently the difference in the instantaneous direction of the moon compared to the direction from which the light is obtained. It is equivalent to the angle through which the earth rotates during the transit time of the light. Using this definition of aberration on starlight would result in more than 131 million degrees of aberration for a star 1000 light years away.

I have two other problems with the Barnes and Slusher paper. First, to assume that the ether in the vicinity of the earth rotates with the earth is to ignore the lesson of the Michelson-Gale experiment. Second, the argument that an ether wind does not bend a light ray but only shifts it, is to misapply the Beckmann paper which was referenced. The direction of energy flow is in a different direction while it is inside the gravitational field. What Beckmann showed was that after it emerged again the direction was unchanged.

Finally, I would like to voice my appreciation for *Galilean Electrodynamics.* While I often disagree with some of the positions taken, I do find it stimulating. Also, it has brought to my attention experiments which would otherwise have escaped my notice.

Ron Hatch
1142 Lakme Ave.
Wilmington, CA 90744

[1] Barnes, Thomas G. and Harold S. Slusher, "Space Medium Theory Applied to Lunar and Stellar Aberration," *Galilean Electrodynamics*, Vol. 1, No. 4, July/August 1990.

AUTHORS' REPLY

We must differ with Mr. Hatch in his definition of aberration of starlight. According to Russell, Dugan, and Stewart' s *Astronomy* [1], "Aberration is the apparent displacement of a heavenly body, due to the combination of the orbital velocity of the earth with the velocity of light." Quantitatively the aberration angle is the arctangent of the ratio of the transverse velocity v to the velocity of light c. This equation for aberration holds for lunar aberration, where v is the moon' s orbital velocity with respect to the earth's "fixed" frame, as shown in Fig. 2 of the paper.

Hatch's first objection is not valid. Our lunar aberration angle is not, as he states, "equivalent to the angle through which the earth rotates during the transit time of the light." The authors' theoretical solution for lunar aberration checks very well with the astronomical evaluation in the referenced "Aberration in the Lunar Ephemeris" [2].

The second objection is not valid. The space medium theory with its separate ethers provides a physical explanation for the positive result in the Michelson-Gale experiment. That provides confirmation of rotation of the earth with respect to the composite-ether, the second "level" of ether in the earth space.

The third objection is not valid. To show this, let the earth's frame be the "fixed" reference frame. The only ether wind involved is the lunar wind, motion of lunar ether with respect to the earth's "fixed" frame. Due to the fact that the same face of the moon is always toward the earth, the light ray "aimed" at the earth enters the lunar-ether "entrainment" normally. In accordance with the Beckmann entrainment [3], the light ray exits the lunar ether entrainment at the same angle.

Thomas G. Barnes and *Harold S. Slusher*
2115 N. Kansas, El Paso, TX 79902

[1] H. N. Russell, R. S. Dugan, J. Q. Stewart, *Astronomy*, Revised Ed. Ginn & Co., 1945. vol.1, p.139.
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A Message from Bunker Hill College

I want to inform you guys that there is no such thing as Galilean Electrodynamics. You learn that in any sophomore level electromagnetism course. Maxwell's equations have relativistic (not Galilean) covariance. Surely you must have heard of the Lorentz gauge (explicitly relativistically covariant) formulation of these equations!

There is nothing in physics on a more solid experimental foundation than Maxwell's E& M (of course GM must considered also). You guys probably started this bogus journal as a joke to divert papers that are a waste of time from the regular journals (and save their precious referees the trouble of reading them). Well, I think that would be extremely cynical if you actually did do it. Shame on you.

Joel Maker
Physics Department
Bunker Hill Community College
Boston, Mass.

DISSIDENT NEWS

In Memoriam: Prof. R. A. Waldron

We greatly regret to inform readers that Prof. Richard A. Waldron, M.A., Sc.D., F. Inst. P., F.I.R.E., F.I.M.A., Professor of Mathematics at the University of Ulster, U.K., died suddenly on 24 May 1990. He is survived by his wife and two children,

A graduate of Cambridge University, Waldron became an international authority on the propagation of guided electromagnetic waves and worked for 20 years in the telecommunication industry in Britain and the USA. Since 1973 he was at the Univesrity of Ulster, continuing to work as a consultant to industry on both sides of the Atlantic. He published over 70 papers and six books, including *The Theory of Guided Electromagnetic Waves.*

His intimate knowledge of electromagnetic wave propagation put him in conflict with the Einstein theory, and he became the most articulate contemporary supporter of the ballistic theory of light, by which he sought to explain all available optical and other evidence. He published his results in *The Wave and Ballistic Theories of Light* (Frederic Muller, London) in 1977. His was probably a minority point of view among contemporary dissidents, but he worked on undeterred, welcoming the establishment of this journal and expecting to contribute to it; his last letter (on the subject of Michelson's 1913 experiment) was received here in January of this year.

He will always be remembered as one who rejected fashionable authority in physics, and asked for logic and simplicity instead. *P.B.*

GALILEAN ELECTRODYNAMICS

Experience, Reason and Simplicity Above Authority

November/December 1990 (Vol. 1, no. 6) **Box 251, Boulder, Colorado 80306**

Contents

EDITORIAL POLICY

Galilean Electrodynamics aims to publish high-quality scientific papers that are based on experimental evidence even if their interpretation of it runs counter to the conventional orthodoxy. In particular, it publishes papers supporting the position that Einstein's interpretation of the (undisputed) Relativity Principle is unnecessarily complicated, has been confirmed only in a narrow sector of physics, leads to logical contradictions, and is unable to derive results that must be postulated, though they are derivable by classical methods.

Though the main purpose of the journal will be publication of logically correct and experimentally supported theories contradicting the Einstein theory, it will, should the occasion arise, publish related, or even unrelated physical topics that rest on logically and experimentally firm ground in challenging other theories cherished by physics orthodoxy.

Where there is more than one theory contradicting accepted opinion and interpretation, but all of them meet the criteria of faultless logic, greater simplicity, and absence of experimental contradiction, none of them shall be favored, except when Occam's razor yields an overwhelming verdict.

All papers are reviewed by qualified physicists, astronomers, mathematicians or engineers. Rejection on the *sole* grounds that a submitted paper contradicts accepted opinion and interpretation will be ignored. *Galilean Electrodynamics* are generally limited to papers challenging established orthodoxy *or defending it* against such direct or indirect challenges.

No paper contradicting experiment will be accepted; however, papers making a case why the current interpretation of observed effects may be erroneous will be considered for publication.

All papers are expected to be in the realm of physics, mathematics, astronomy or engineering; non-mathematical, philosophical considerations will generally not be accepted unless they are fairly short and have something new and outstanding to say. Papers reporting experimental results will be given preference over theoretical papers of equally high standard.

Shorter papers will be preferred over long papers of comparable quality; and papers easily grasped at the level of keen seniors and graduate students will be given emphatic preference over esoteric analyses accessible only to a limited number of specialists.

However, none of these restrictions (other than length and subject area) apply to book reviews, news items, and readers' letters; these are solicited and encouraged to be vividly interesting.

Authors do not have to pay any page charges; but once an author's paper has been accepted (after being submitted in 3 copies in any well readable form), it should be submitted on a diskette (see Instruction to Authors overleaf). Papers submitted in TeX are welcome, but not obligatory.

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Letter from the publisher

At the end of the first year

Touch wood, but it looks like we've made it.

There were sufficient papers to publish the journal on a strictly bimonthly schedule, and we end the volume with a small backlog of favorably reviewed papers ready to be printed.

There has been no compromise on quality. About as many papers were rejected in the reviewing process as have been published.

Contacts have been made with dissidents in other countries, and we hope to publish some of their papers in 1991. This includes some high ranking scientists in the USSR, some of whom are now coming out in the open under glasnost – although, as in the West, prejudice still stands in the way where repression has gone. One Soviet scientist wrote us, "In our country we are now free to criticize Marx, Engels and Lenin, but not Einstein."

In broadening our international standing, we are particularly pleased to welcome a new member of the Editorial Board: Prof. Pavel Fyedorovich Parshin, head of the Physics Department of the Academy of Aviation in Leningrad, who is among the foremost Soviet physics dissidents. He was mentioned in Bryan Wallace's report on the 1989 Leningrad Space-Time Conference in our March/April issue (p. 24). His joining was approved unanimously by the old Editorial Board.

That was also the case with our second addition to the Board, Prof. Horst E. Wilhelm, a physicist at the Materials Science Department of the University of Utah. Prof. Wilhelm has held a number of tenured positions as professor at US and overseas universities. He is familiar to readers as the author of the paper on Galilei-covariant field equations in the Sept./Oct. issue.

On the other hand, Prof. Jan Mycielski resigned from the Board, feeling that as a mathematician he was too far out of his field.

For the coming year, an advertising campaign is being launched. A four-page flyer will be sent to some 11,000 prospects: Buyers of books on electromagnetic theory, EE faculty teaching courses on fields waves, and antennas, and the IEEE Prof. Group on Antennas and Propagation. The return is expected to be small, most unlikely to pay off *financially*, but we have to make do with the best available, and money is not the primary object of publishing this journal.

We shall be most happy to send reasonable numbers of these promotional flyers to readers who can distribute them in their neighborhoods or organizations.

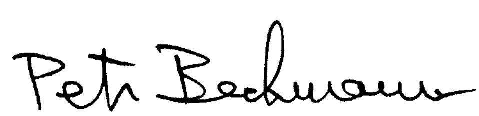
Also aimed at prospective new subscribers is Volume 1 bound as a book (soft cover). Any reader who subscribed to Volume 1 and would like to have it in addition to his individual issues may order it at 10% discount off its list price of $25.

Let me share one more prosaic publisher's problem. The flow of submitted papers has encouraged us to apply for Second Class Mail privileges (where rigorous periodicity is required), so that we can increase the paper weight and possibly even the number of pages at a substantial saving in postage.

We are very much hoping that our present readers – the charter subscribers – will give us a vote of confidence by renewing their subscriptions.

We could never have made it without the support of our readers. This editorial is above all to thank them very sincerely.

But also to tell them that we continue to need them very much.



If Sagnac and Michelson-Gale, Why Not Michelson-Morley?

By Howard C. Hayden
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Anisotropy in the speed of light due to coordinate frame rotation has been amply demonstrated throughout the present century. The original experiment by Sagnac used a rotating table in a laboratory setting. The first of several subsequent experiments using instead the diurnal rotation of the earth was performed by Michelson and Gale. Predating both of these early rotation-sensing experiments was the famous Michelson-Morley experiment, whose null result is often cited as experimental proof for the constancy of light speed otherwise *assumed* in special relativity theory. But since it was conducted on the surface of the earth, the Michelson-Morley experiment was *also* conducted in a rotating frame. Although not sensitive enough to pick up diurnal rotation, the experiment should have seen the orbital motion of the earth rotating around the sun. How exactly did the null result then come about?

The Sagnac Effect

In 1913, Sagnac performed his brilliant experiment with light circulating clockwise and counterclockwise around a rotating table. The result was a *non-zero* fringe shift

$$\Delta = \frac{4A\omega}{c\lambda} \tag{1}$$

where A is the area enclosed by the light path, ω is the angular velocity, c the speed of light, and λ the wavelength (Fig. 1).

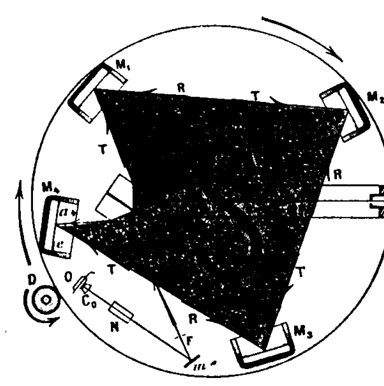

Fig. 1. The Sagnac apparatus

From the standpoint of the laboratory frame, light traveling in the same direction as the mirrors spends extra time catching up to the mirrors, while light traveling in the opposite direction spends less time because the mirrors catch up to the light. A phase shift results.

From the standpoint of the moving mirrors, we note that the distance from one mirror to the one ahead or behind does not change; therefore the measured fringe shift must be attributed to non-isotropic velocity in that reference frame. (Relativists often refer to "coordinate velocity" to distinguish it from the other kind.)

The existence of the Sagnac effect is today quite well verified. Indeed, it is the basis of a fairly mature technology for rotation sensing, in the form of ring-laser gyroscopes and fiber-optic gyroscopes. The effect is also the subject of continuing scientific investigation, discussed next.

Explanations in the Literature

Almost without exception, textbooks assert that the speed of light is constant *only*in an inertial frame. That is, in SRT one does not *expect*the speed of light to be constant in a non-inertial frame. What happens in a rotating frame?

To use Einstein theory, one may either deal with a sequence of infinitesimally different inertial coordinate frames in the manner of Goldstein [1980] or Post [1967], resort to *general* relativity theory (GRT) in the manner of Schleich and Skully [1982] or Tonnelat [1959], or else retreat to a non-rotating, *inertial* frame of reference.

For the present purposes, it is sufficient to note that in the rotating frame of the Sagnac experiment, Einstein theory predicts that the speed of light along the direction of rotation is $c - V$ and in the opposite direction it is $c + V$. [See Post, 1967, Eq.14 for example.]

Michelson-Gale and Other Large Scale Sagnac Experiments

The original Sagnac experiment was of only table-top size, and it was bettered by several powers of 10 when Michelson and Gale [1925] performed a truly grandiose area-enclosing experiment. They used a rectangular path of approximately 340 meters by 610 meters, with sides enclosed in 30 cm diameter water pipe evacuated to prevent aberrations due to air currents, and with corners bounded by mirrors adjusted by helpers coordinated via a telephone system (Fig. 2).

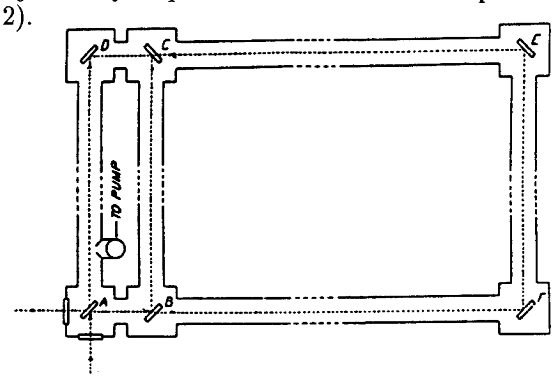

Fig. 2. The Michelson-Gale apparatus at Clearing, Illinois: The large rectangle is approximately 340 by 610 meters. Light traveling counterclockwise around the loop lags behind the light traveling clockwise by an amount sufficient to result in a shift of about 0.3 fringes.

The Michelson-Gale experiment succeeded in measuring a shift of about 0.3 fringes. If the speed of light had been constant with respect to the Michelson-Gale "laboratory" frame, light would have taken the same time to go around the rectangle in opposite directions, and there would have been no fringe shift. The presence of the fringe shift implies some anisotropy to the speed of light in this frame. A Gallilean form of anisotropy had been assumed at the time of the Michelson-Morley experiment [1887]; namely, that the speed of light c' is $c - V$ in the direction of travel, and $c + V$ in the opposite direction. Assuming that V arises from some rotational motion with angular rate ω, the fringe shift can be estimated to first order as in (1). Inserting the earth's diurnal rotation rate and the area projection A normal to its vector direction then accounts for the 0.3 fringe shift.

Michelson wrote that the experimental result was "also consistent with relativity theory." but did not elaborate.

In a frame positioned at the North Pole and free of diurnal rotation, the rectangle has the angular velocity ω of the earth's diurnal rotation. The Michelson-Gale experiment is then viewed as an enormous Sagnac experiment. Unlike the original, it has its center of rotation far removed from the enclosed area. But this makes no difference, as (1) makes no reference to the center of rotation, and correctly predicts the result anyway.

More so than the original Sagnac experiment, the subsequent Michelson-Gale demonstration of the Sagnac effect is curiously neglected in the literature. R. D. Sard [1970] comments only that the Michelson-Gale experiment determined the earth's angular velocity to within 2.5%. L. S. Swenson [1987] recently devoted only 22 words to the experiment, calling it "an attempt at a large field in Clearing, Illinois, to measure the effect of the Earth's rotation on the velocity of light." In 55 references, E. L. Hill [1967] does not list the Michelson-Gale experiment. In a list of some 1600 references, C. W. Misner, K. S. Thorne, and J. A .Wheeler [1970] make no mention of Michelson-Gale. E. T. Whittaker [1987] is similarly mute. Moreover, the Michelson-Gale paper is not mentioned in *any* of the famous papers which claim to measure the velocity of light, or to compare light speeds in various directions.

Nevertheless, the Sagnac effect due to the earth's diurnal rotation that Michelson and Gale demonstrated has been reconfirmed several times over by even more grandiose modern experiments. Imagine a path encircling the entire earth at, say, the equator. One expects that there will be the usual Sagnac phase shift (1) around this path. The phase shift will be equivalent to a time difference for transit one way as compared to the other:

$$\Delta t = \frac{4A\omega}{c^2} \tag{2}$$

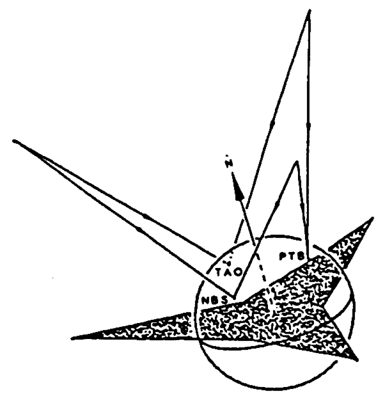

Fig. 3. The around-the-world Sagnac experiment of Allan, Weiss, and Ashby: Several ground stations and several geosynchronous satellites are used to transmit radio signals in both directions around the globe. The signal traveling east lags behind the west-bound signal by the amount in (2). The actual time delay is measured, because the lag is much greater than a single wavelength.

This east-west asymmetry of (2) was confirmed recently on a planetary scale by the microwave propagation experiment of Allan et al. [1985] using satellites and several ground stations (Fig. 3), where (2) was used to calculate the "Sagnac correction" between remote sites. Only by making such corrections is it possible to synchronize clocks at various positions around the globe. Moreover, the Sagnac correction is not applied just to signals traveling entirely around the globe, but going part-way. Indeed, it was applied in a one-way sense [Allan et al., 1985].:

> The Sagnac correction from NBS Boulder, CO, to Paris, France, varies from 71 to 112 ns and from Boulder to Washington, DC, varies from 11 to 13 ns, depending upon satellite position.

Further east-west asymmetry has been confirmed in the "time dilation" experiment of Hafele and Keating [Hafele 1972], who used aircraft to transport clocks around the globe. East-bound clocks slowed, but west-bound clocks sped up.

Logical Extensions

A quick look at the numbers should convince the reader that the usual "explanation" for any of the above experiments, which states that the effects are due to coordinate system acceleration, is subject to serious question. At 40° latitude, the centripetal acceleration due to diurnal rotation is 0.02 m/s^2. Meanwhile, the centripetal acceleration at the North pole due to earth orbital motion about the sun is 0.006 m/s^2. This is fully 30% of the acceleration which supposedly renders the earth-surface system non-inertial. Considering the range of all possible accelerations, it would be surprising if a dividing line between "inertial" and "non-inertial" frames occurred between 0.006 and 0.02 m/s^2.

Therefore, let us extrapolate the logic of the Sagnac experiment to even larger scale in a *gedanken* experiment. Consider an array of mirrors orbiting the sun along with the earth at its solar orbit radius (Fig. 4). It is reasonable to expect that equations (1) and (2) should still hold; that is, such a Sagnac experiment should show the fringe shift or the time delay between light beams in the direction of the velocity and against it, like any other Sagnac experiment.

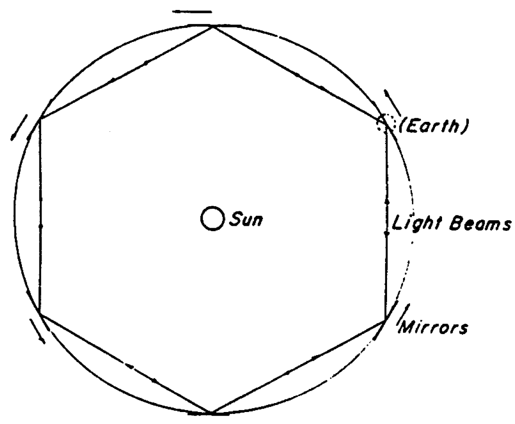

Fig. 4. A hypothetical around-the sun experiment: The mirrors are in earth's orbit, 1.5×10^{11} m from the sun, and travel at earth's velocity, 30 km/s. This differs from the other Sagnac experiments only in scale, and should yield the same results, *viz*, a time delay given by (2). From the standpoint of any given mirror, the signal should be seen to move at a different rate along the velocity than against it.

In fact, it seems difficult in principle to argue for any particular dividing line between inertial and non-inertial frames. Therefore, consider a more extreme extrapolation, with a reference point which is vastly further away. Along with the sun, the earth orbits around the Milky Way Galaxy. Imagine an array of mirrors deployed at the galactic orbit radius. Again, the Sagnac fringe-shift/time-delay must ensue. In fact, there is nothing in the existing theory of the Sagnac effect to prevent one extrapolating even further. *Any* velocity, no matter how close to linear it may be, can be thought of as a limiting case of rotation about an extremely distant center.

How can we begin to think about such extreme but logical extensions? In (1) and (2), A is the projected area enclosed by the light path. In the case of Michelson-Gale this area is $lw\cos(\theta)$, the product of the rectangle length, width, and projection. In the case of Allan et. al., A is the projected area of an irregular star shaped figure formed by paths between satellites and ground stations. In both these cases, and in the the logical extension cases, we can at least imagine a redesign of the experiment to replace the mirrors with an optical fiber and simplify the area to a circle in the plane normal to the rotation-rate vector.

The fringe shift around a circular path is given by

$$\Delta = \frac{4\pi r^2\omega}{c\lambda} \tag{3}$$

Recognizing $r\omega/c$ as V/c or β, we have

$$\Delta = \frac{4\pi r\beta}{\lambda} \tag{4}$$

Then recognizing 2π as the radian measure of the closed circular path, we are led to enquire after an arbitrary arc of the path. Logic dictates that all parts of the path contribute equally, so for an arc with arbitrary radian measure θ we have

$$\Delta(\theta) = \frac{2r\theta\beta}{\lambda} \tag{5}$$

For an incremental θ that is small enough, $r\theta$ is simply a linear dimension l. Then we have

$$\Delta(l) = \frac{2l\beta}{\lambda} \tag{6}$$

This result means that any rotation must produce an incremental Sagnac effect in any laboratory scale experiment. The meaning implied here is that light leaving a hypothetical point on the circle in phase but going opposite directions would, on arrival at points located at $\pm l/2$ along the orbit be out of phase by the amount given in (3), or equivalently as a fractional time difference 2β due to a velocity difference $2v$.

The effect is not subtle; $\Delta(l)$ is first order in β. Depending on l and λ, it can be quite large. Note that for diurnal rotation, V is of the order of 300 m/s, so β is of the order of 10^{-6}. For the solar orbit, V is about 30 km/s, so β is about 10^{-4}. For the galactic orbit, V is about 300 km/s, and β is about 10^{-3}. Given a laboratory scale path and a visible wavelength, the galactic β, and the orbital β are both large enough to make Δ quite macroscopic.

The logical existence of the incremental Sagnac effect implies that either it must be possible to devise *some* optical technique to detect, not only the earth's diurnal rotation as has been amply demonstrated, but also solar orbit motion, and especially galactic orbit motion, or that there is some compelling physical reason why the effect cannot be observed at the surface of the earth. It was in fact the orbital velocity that was sought in the much earlier Michelson-Morley experiment, discussed next.

Michelson-Morley and Other Round-Trip Experiments

The Gallilean assumption ($\mathbf{c}' = \mathbf{c} + \mathbf{V}$) means that a round trip on a path of length L aligned with $\mathbf{V}$ requires time

$$t = \frac{L}{c+V} + \frac{L}{c-V} \tag{7}$$

The average light velocity in this orientation is therefore

$$c_{\text{parallel}} = \frac{2L}{t} = c(1-\beta^2) \tag{8}$$

By contrast, if the path is perpendicular to $\mathbf{V}$, then the component of light propagation velocity along L in either direction is $c_{\text{perp}} = c\sqrt{1-\beta^2}$ [Michelson 1887].

Assuming that the relevant velocity is the orbital velocity 30 km/s, one has the *difference* between the two velocities as 1.5 m/s. For the 11 m path length L in the Michelson-Morley apparatus, light in the parallel arm would have lagged light in the other by 110 nm, about 1/5 of a wavelength. With a 90° rotation, there would be the same lag, but of the opposite sign, for a total effect of $\Delta = 0.4$ fringes.

Yet the orbital velocity was not witnessed; nor was any cosmic velocity, which ought, in principle, to have been that much easier to detect.

Modern experiments of the round-trip type [Joos 1930, Jaseja *et al.* 1964, Brillet and Hall 1979] have been even more sensitive than the original Michelson-Morley experiment, and all of them have claimed to detect no anisotropy at all in the speed of light. The Brillet-Hall experiment measures a frequency shift [see Hayden, 1990 for derivation]

$$\frac{\Delta f}{f} = \frac{\beta^2}{4}\cos 2(\theta - \theta_0) \tag{9}$$

The authors *claim* that their results show no anisotropy down to $\Delta f/f = 2.5 \times 10^{-15}$, corresponding to a velocity of 30 m/s (see below). This is a factor of ten below even earth's diurnal rotation speed, and so, if the claim is valid, it is in clear contradiction to the Michelson-Gale result.

Current Situation

The existence of the highly reproducible Sagnac effect and its logical extensions is apparently incompatible with the equally reproducible Michelson-Morley result and its modern variations. In short then: If Sagnac and Michelson-Gale, why not Michelson-Morley?

Post [1967] argues:

> To avoid possible confusion, it may be remarked that the beam path in the more well-known Michelson-Morley (1886) interferometer which *was* mounted on a turntable, does not enclose a finite surface area; therefore no fringe shift can be expected as a result of uniform rotation of the latter.

Arguably, this statement is correct, if Post meant that no *additional* fringe shift should result from rotation of the apparatus. If on the other hand he meant, or readers take the statement to mean, that the absence of a non-zero enclosed area implies that no fringe shift should result at all, then the statement is incorrect. In the Sagnac experiment, light beams traveling CW and CCW around *the same loop* are compared, whereas in Michelson-Morley, there are two *different* loops.

We hold that until something new is brought to the table, this question simply cannot be resolved. No currently accepted theory reveals why, like a Cheshire cat, the Sagnac effect shows itself in one kind of experiment but not in another.

Let us consider several possibilities, focusing our attention on a *gedanken* experiment around-the-sun or cosmic Sagnac experiment:

1. The speed of light is actually constant with respect to any *point* in a rotating system, and the asymmetries in "closed-loop" experiments (Sagnac, Hafele-Keating) might still have some reasonable explanation.
2. The speed of light is actually *variable* in a rotating system, in which case there must be some reason for its not being detected:
   a. Such cosmic asymmetries are evident in some modern round-trip experiments, but simply have not been properly recognized, or
   b. Cosmic velocities are in principle detectable, but not by round-trip light velocity measurements, or
   c. Cosmic velocities are not detectable at the surface of the earth, because the medium of transmission co-moves with the earth.
   d. Others

Constant speed hypothesis

For alternative (1), one might adopt the analogy of a wheel, where the point of contact with the road has no velocity, but the opposite side moves at $2V$. This view would explain how the linear Michelson-Morley experiment could get a null result while the rotating Sagnac and Michelson-Gale experiments would not. (But see Beckmann [1987, pp. 15-16].) Adopting this point of view, incidentally, would be to imply that Post [1967] and others are incorrect in calculating times in the rotating frame by using $t = 2\pi r/(c \pm R\omega)$.

Variable speed hypotheses

Data present but not recognized? For completeness, we include the notion that data in experiments already performed might actually contain data which show cosmic asymmetries, but which have somehow not been noticed. Though we offer none, we note below that some published experimental data have been processed in such a way as to remove any indication of earth's rotational velocity.

Round-trip experiments can't show effect? Consider the possibility that a speed of light measurement in a *rotating* coordinate frame is determined, not by vector addition of two contributors, but rather by scalar addition of multiple contributors; namely, a power series of corrections in β', the projection of β parallel to the propagation. With this hypothesis, the measured light speed is $c' = c/(1-\beta')$.

This hypothesis is fully consistent with the Sagnac result being linear in β, and also with the Michelson-Morley result being zero. All round-trip experiments sampling at a single point produce an exact cancellation that explains their null results. Where samples at separated points are compared, small signals can be generated by the point-to-point differences in diurnal β. This could explain the anisotropy in the raw data from the Brillet-Hall experiment (see below). In the case of orbital and galactic rotations, laboratory-scale point-to-point differences are too small to detect by any conventional configuration, whether path reversing *or* area enclosing. Something new is needed for those.

Not detectable at the surface of the earth? If one assumes [Beckmann 1987] that the speed of light is constant with respect to the locally-dominant, non-rotating gravitational field, then the following conclusions ensue: the speed of light with respect to an observer on the earth's surface is $\mathbf{c} - \mathbf{V}_{\mathbf{rot}}$, where $\mathbf{V}_{\mathbf{rot}}$ is the velocity due to diurnal rotation, regardless of the source; in orbit about the sun, but on something of negligible mass (such as a Sagnac mirror) the velocity is $\mathbf{c} - \mathbf{V}_{\mathbf{orb}}$, where $\mathbf{V}_{\mathbf{orb}}$ is the orbital velocity rather than the circumferential velocity. This model is fully consistent with Michelson-Morley and all Sagnac experiments.

Upon careful examination of the Brillet-Hall paper [1979], one finds that the data are isotropic in sidereal coordinates, but *not in diurnally-rotating lab coordinates.* The lab-based data are very clearly anisotropic, and have exactly the type of signature expected from a $c \pm V$ model, where V is the velocity due to rotation at that latitude. Brillet and Hall describe the asymmetry as "spurious," and subtract the noon values from the midnight values to obtain the low degree of anisotropy quoted.

Summary and Future Prospects

We have discussed how various hypotheses react to the conflict between the Sagnac and Michelson-Morley experiments. SRT and GRT really offer nothing. Assuming that asymmetries in rotating reference frames arise remotely, that is, always on the other side of the loop where mirrors move at $2V$, would allow local linear measurements of the speed of light to remain constant. If light velocity is determined by the dominant gravitational field, then the large orbital and larger cosmic velocities have no effect on the speed of light at or near the surface of the earth. If measurable light velocity parallel and antiparallel to rotation velocity is $c' = c/(1 \pm \beta)$, then Michelson-Morley type measurements would not be able to detect even huge cosmic velocities, because effects would cancel out exactly in the round-trip measurement.

We believe the opportunities presented by space travel should be exploited to resolve some of the pending issues. In low earth orbit, the velocity of a satellite is about 20 times the surface velocity due to rotation, and sensitivity to V^2 effects is 400 times as great. A Brillet-Hall experiment done so as to detect, rather than ignore, this velocity would have an overabundance of sensitivity.

New laboratory experiments designed to seek first-order effects due to velocity may also be of help. We know of only one experiment on record that has attempted to avoid dependence on path reversing and/or area enclosing geometries, and focus instead on the incremental Sagnac effect over an incremental open path [Silvertooth 1987]. One of us [Whitney 1990] has pointed out that the result reported there is numerically consistent with the galactic orbit velocity. Further investigation of this possibility seems needed.

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Reinterpreting Planck's constant

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Planck's constant h (or better $h/2\pi$) is reinterpreted as a quantum of angular momentum instead of a quantum of action. The photon with its quantum of angular momentum $\hbar$ is shown to be the mediator of low energy quantum physics. Action is identified as angular momentum and the principle of least action is construed to be the conservation of angular momentum.*

It is generally accepted that there is no physical mechanism responsible for quantum physics. It was previously proposed that the photon, through its creation and annihilation in which it transfers energy, linear momentum, and a quantum of angular momentum $\pm\hbar$ $(h/2\pi)$, is the specific physical mechanism responsible for low energy quantum physics [1],[2]. It is argued that the elusive concept of action is, in fact, angular momentum and the mysterious principle of least action is, in reality, an alternate description of the conservation of angular momentum. Further, it is concluded that Planck's constant h (or better $\hbar$) should be identified as a quantum of angular momentum rather than a quantum of action as it currently usually is. As a quantum of action h (and $\hbar$) has been treated as a *non-conserved* scalar; as a quantum of angular momentum $\hbar$ would be treated as a *conserved* axial vector that always occurs in a chiral state + or -, corresponding to left-handed rotation or right-handed rotation.

In 1900 Planck [3] discovered a new constant which he called h, now universally recognized as Planck's constant, and quantum physics was born. Because h has the dimensions of action, Planck [4] christened h a quantum of action and there it remains to this day. The constant h also has the dimensions of angular momentum. Had Planck identified h (or better $\hbar$) as a quantum of angular momentum, quantum physics would be vastly different from what it is today.

Action, and more importantly the principle of least action, have long and colorful histories spanning centuries [5]-[10], and are associated with Maupertuis, Leibniz, Lagrange, Euler, Jacobi, Hamilton, Boltzmann, Clausius, Helmholtz, Larmor, Schwarzschild, Einstein, Minkowski, Planck, Schrödinger, Heisenberg, and Feynman, among many others.

It is curious that an acceptable physical basis for the principle of least action has not yet been elucidated.

Despite this lacuna Planck [11] contended in 1910

> The chief law of physics, the pinnacle of the whole system is, in my opinion, the principle of least action, which involves the four universal co-ordiates in a perfectly symmetrical form.

and in 1915 further noted[12]

> Among the more or less general laws, the discovery of which characterize the development of physical science during the last century, the principle of Least Action is at present certainly one which, by its form and comprehensiveness, may be said to have approached most closely to the ideal aim of theoretical inquiry ...
>
> "This central position attained by the principle of least action is, however, not even to-day quite undisputed; for a long time the principle of the conservation of energy had been a keen competitor.

That there is more than a trace of mysticism still associated with the principle of least action is clear from Planck's further comments [13]

> In this connection mention may certainly be made of Leibniz's theorem, which sets forth fundamentally that of all the worlds that may be created, the actual world is that which contains, besides the unavoidable evil, the maximum good. This theorem is none other than a variations principle, and is, indeed, of the same form as the later principle of least action. The unavoidable combination of good and evil corresponds to ...

In stark contrast, from time to time one can find violent polemics against the principle of least action. See Heaviside [14] as an example.

Action is usually interpreted as in [15]:

"Hamilton's principle can be stated as *The motion of the system from time t_1 to time t_2 is such that the line integral*

$$I = \int_{t_1}^{t_2} L\, dt \ , \tag{2.1}$$

where $L = T - V$, has a stationary value for the correct path of the motion. [Footnote:] The quantity I is referred to as the *action* or *action integral.*"

In the above L is the Lagrangian, T is the kinetic energy, and V is the potential energy.

For a friction free nondissipative system the principle of least action states in effect that I does not change as the system progresses from t_1 to t_2. It is curious to observe that the literal meaning of the principle of least action is a misnomer. The action is not at the smallest possible value. Rather

$$\frac{dI}{dt} = 0 \tag{1}$$

as the system progresses from t_1 to t_2. Examples, where (1) would be expected to be valid, are in the vicinities of minima, maxima, and extrema or zero-slope tangents in general. These examples are discussed in detail in [9] and [10].

If action does not change as t changes then it is constant as time passes. An equivalent statement would be action is conserved as time passes. Thus, a better description of the phenomenon usually identified as the principle of least action would simply be the conservation of action.

Action and angular momentum are dimensionally equivalent, $[M][L]^2[T]^{-1}$. Therefore, the statements conservation of angular momentum and conservation of action are physically equivalent in one sense. When considered in this light, both action and the principle of least action lose most of the mystery surrounding them.

The principle of least action played a key role in the original formulation of quantum mechanics, by Schrödinger [16], and Heisenberg [17], and its subsequent development by Feynman and Hibbs [18].

Ubiquitous in the physics literature [19] is the contention "at the classical limit h (or $\hbar$) $\to 0$." Similarly, atomic systems are characterized by "at the classical limit $N\hbar \to \infty$."

It is 90 years since the quantum of action h was postulated. Curiously, there has been no experimental conformation that action is quantized in units of h, and yet no one has seriously questioned the existence of the quantum of action.

In 1927 Ruark and Urey [20] proposed that the photon possesses a quantum of angular momentum $\pm\hbar$. In 1936 Beth [21] experimentally demonstrated that the photon does possess an angular momentum of $\pm\hbar$. This has been repeatedly confirmed [22].

Planck in his original work of 1900 was studying the frequency distribution spectra as a function of temperature of black body radiation — the photons emitted by a black body cavity. We now know that each of these photons possessed an angular momentum of $\pm\hbar$. For lack of any clear physical model for the source of the black-body radiation, Planck introduced a hypothetical quantized linear harmonic oscillator. The sole justification for its use was that it gave the proper frequency distribution. This hypothetical quantized linear harmonic oscillator is still widely used [23]. If h is considered to be a quantum of action, there is no obvious conflict with the linear oscillator. When $\hbar$ is recognized to be a quantum of angular momentum, a linear oscillator is certainly not the simple obvious choice if angular momentum is going to be conserved in the creation and annihilation of photons. A linear harmonic oscillator does not possess any angular momentum!

If $\hbar$ is a quantum of angular momentum and not a quantum of action, then $\hbar$ is an axial vector [24] which always occurs as either a right-handed or left-handed form and must always conform with the law of conservation of angular momentum. Thus the wide spread contentions [25] that "at the classical limit $\hbar \to 0$" and for atomic systems "at the classical limit $N\hbar \to \infty$" are clearly physically untenable.

Edmonds [26] in his book *Angular Momentum and Quantum Mechanics* points out the fundamental role that the conservation of angular momentum plays in quantum mechanics and notes

> THE INTRODUCTION OF QUANTIZATION. The historic paper of Bohr (1913) on the spectrum of the hydrogen atom introduced for the first time the postulate that the angular momentum of a system was quantized, i.e. that it could only take values which were interger multiples of the quantum of action h times $1/2\pi$.

Curiously, no further mention of action, the quantum of action, or the relationship between action and angular momentum is included. Further, despite a very extensive bibliography, the work of neither Ruark and Urey[20] nor Beth[21] is included.

In the Heisenberg Uncertainty Principle [27]

$$\Delta x \, \Delta p_x \geq h \tag{2}$$

there is a major conceptual problem if h is angular momentum and is going to be exactly conserved. All of the arguments proposed to justify the Uncertainty Principle by physical intuition now point to its non-validity. Clearly the whole physical model has to be restructured. Others have already noted that p is linear momentum, a conserved quantity, and must be accounted for exactly.

How could this state of affairs have developed?

Wigner [28] recently noted

> Most books on mechanics, written around the turn of the century and even later, do not mention the general theorem of the conservation of angular momentum.[2] It must have been known quite generally because those dealing with the three-body problem, where it is useful, write it down as a matter of course. However, people did not pay very much attention to it ... As far as the conservation laws are concerned, their significance became evident when, as a result of the interest in Bohr's atomic model, the angular momentum conservation theorem became all-important. Having lived in those days, I know that there was universal confidence in that law as well as in the other conservation laws.

[2] Cajori's *History of Physics* (New York: Macmillan Company, 1929) [reprint of a 1898 edition] gives exactly half a line to it (p. 108).

Despite the contention by Wigner, I conclude from what follows below, that from the time of Bohr's original paper in 1913, angular momentum has been largely overlooked as a key controlling factor in atomic systems.

Thus, Bohr[29] wrote

> Let us now, however, take the effect of the energy radiation into account, calculated in the ordinary way from the acceleration of the electron. In this case the electron will no longer describe stationary orbits. W [potential energy] will continuously increase, and the electron will approach the nucleus describing orbits of smaller and smaller dimensions, and with greater and greater frequency; the electron on the average gaining in kinetic energy at the same time as the whole system loses energy. This process will go on until the dimensions of the orbit are of the same order of magnitude as the dimensions of the electron or those of the nucleus. A simple calculation shows that the energy radiated out during the process considered will be enormously great compared with that radiated out by ordinary molecular processes.

This particular section of Bohr's paper is interesting in several respects:

1. It depicts in very clear terms the contention that his proposed model of the hydrogen atom is not expected to be stable by the then accepted concepts of "classical" physics.
2. Bohr's analysis leads to the conclusion that the "classical" concepts of physics must be put aside and some new concepts introduced to provide for the stability of the hydrogen atom.
3. This particular well recognized, and widely discussed, defect in the Bohr model of the hydrogen atom was a major reason for the switch to quantum mechanics circa 1926.
4. Since 1913 this same argument has been repeated innumerable times and is considered valid today.

As an exercise in their text, French and Taylor [30] use

> 14-1. *Catastrophe for the planetary atom (Rutherford without Bohr).* According to classical physics, the planetary (Rutherford) atom will collapse spontaneously — and in a very short time! The logic is (classically) inescapable: an accelerated charge radiates electromagnetic energy; an orbiting electron in an atom must radiate, since it experiences centripetal acceleration; the radiated energy must come from the electron nucleus system; a steadily decreasing system energy corresponds to orbits of smaller and smaller radius; therefore the electron must finally spiral into the nucleus.

as an introduction to five specific problems for the student to calculate the processes by which the hydrogen atom can be expected to collapse. Numerical answers to the problems are provided.

Quite similar contentions, though usually not as detailed, can be found throughout the physics literature [31]-[33]. On occasion a drawing of the proposed spiraling, radiating electron is provided [34].

Neither in Bohr's original analysis of the hydrogen atom, quoted above, nor most of the subsequent literature, a few of which are cited here, has the conservation of angular momentum been considered. The orbital angular momentum of the electron cannot just evaporate like the morning dew!

Without some specific mechanism by which the change in orbital angular momentum of the hydrogen atom is accounted for, one should conclude that the hydrogen atom in its ground state [35] is just as stable as the earth in its orbit around the sun for lo these billions of years!

Heisenberg, in discussing the classical conservation laws in relation to quantum mechanics [36], enumerates the conservation of charge, conservation of momentum [linear], and the conservation of energy. The conservation of angular momentum is not mentioned. However, on the following pages equations very similar to that found in the principle of least action are included.

Similarly, in the transitions between the various stationary states in the hydrogen atom, in both the original Bohr model [37] and the later quantum mechanical model developed by Schrödinger [38], the conservation of angular momentum was not included. The stable states in both of these models are characterized by angular momenta of $n\hbar$. When transitions between orbits n and $(n+1)$ took place, the energy was properly identified in terms of the wavelength of the radiation. Absolutely no consideration was given to the physical mechanism by which the angular momentum of the system would change! A set of ad hoc selection rules were developed which led to the proper spectra.

Before the advent of quantum mechanics Sommerfeld [39] clearly identified the proper problem when he emphasized, in italics,

> *Thus every change of the azimuthal quantum number* n *denotes a change in the moment of momentum. This amount of moment of momentum cannot be lost but must be transferred from the atom to the ether, if both systems are coupled together during the process of emission.*

In recent times, the angular momentum of the photon $\pm\hbar$ is asserted to be a consequence of the electric dipole transition in the atom of just $\pm\hbar$ [40]:

> Thus the fact that l necessarily changes by one unit in an electric dipole transition is tantamount to a requirement that the emitted photon must carry angular momentum with it. If, in particular, we consider a transition between states with $l=1$ and $l=0$, it becomes plain that in such a transition the photon must carry away one unit of quantized angular momentum if the total angular momentum is to be conserved.

Readers will have to decide for themselves which model they prefer. I perceive that the cause and effect are exactly transposed in the above quote. This is immediately clear to me from a consideration of the formation (and dissociation) of a hydrogen atom from (and to) a free electron and a free proton [41]. A free electron and proton possess no dipole moment; therefore, they cannot control the angular momentum of the photon!

In retrospect, it is clear how Heisenberg [42] was led astray when he discussed the problems with the hydrogen atom in 1930:

> These results, which have certainly been amply confirmed by experiment, are entirely characteristic of the quantum theory and can be deduced from no classical theory, either of the wave or particle representation, since even the existence of discrete energy values can never be explained by the classical theory.

He did not include in his analysis either the angular momentum of the system or the angular momentum of the photon which had already been proposed in 1927 by Ruark and Urey [43].

Low energy quantum physics is created by the transfer of a quantum of angular momentum $\pm\hbar$ (along with energy and linear momentum) to and from atomic and molecular systems by the creation and annihilation of the photon.

There is extensive theoretical and experimental justification to identify Planck's constant h $(\pm\hbar)$ as a quantum of angular momentum and none to justify it as a quantum of action.

Action and the principle of least action should be reinterpreted as angular momentum and the conservation of angular momentum respectively.

NOTE

* This paper was presented at the Fifth Interdisciplinary Laser Science Conference, Stanford, Calif., 27-31 August 1989; abstract in *Bull. Am. Phys. Soc.* vol. 34, 1664 (1989).

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EDITOR'S NOTE

The following issues could not be resolved between author and reviewer, and are left to the reader with the following positions of both sides:

REVIEWER'S OBJECTION:

The reviewer finds the paper interesting and illuminating on historical grounds, but thinks in the end that conservation of angular momentum cannot suffice to provide a fully classical explanation for the stability of the hydrogen atom. A classical explanation cannot invoke the quantum properties of photons, nor can it ignore the classical Larmor radiation due to charge acceleration. With classical radiation, there is radiation reaction and continuous loss of energy, and without photons, there is no prohibition on continuous loss of angular momentum as well. Like the energy, it reappears in the fields.

This is not to say that a classical explanation is really impossible, as most of the world seems to believe. It just says that a classical explanation needs some additional ingredient besides what Deutsch has so far offered. One possibility has been discussed in the series of papers by C. K. Whitney, "A new perspective on the hydrogen atom," "Harmonics in the hydrogen atom," and "Multiple states in the hydrogen atom," *Physics Essays*, vol. 1, pp. 52, 56, and 6 (1988).

AUTHOR'S REPLY:

Curiously, there is no general agreement on what constitutes "classical physics." What is a "classical" hydrogen atom? The electron and proton in this "classical" hydrogen atom each possess a quantized mass, a quantized charge, and a quantized angular momentum. Further, the hydrogen atom is the quantum of hydrogen. At one time matter was treated as a continuum. Apparently, angular momentum has not been used properly in the classical description of the hydrogen atom from Bohr's classical paper of 1913 on ([29], [2], and [30]). The term "neoclassical physics" better describes the classical Newtonian (neglecting special theory of relativity effects) mechanics where the conservation laws of energy, linear momentum and angular momentum act on the quantized particles. The photon [2] was found to be the physical agent responsible for low energy quantum physics. A photon, through its creation and annihilation physically transfers a quantum of angular momentum $\pm\hbar$ between systems.

Position Error in Satellite Navigation Systems

By E.W. Silvertooth, Ph.D.
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The paper discusses the position error caused in satellite navigation systems when the contribution of the Sagnac effect is ignored. A numerical example shows the discrepancies to bve expected.

Attention has been called to the residual range error of satellite navigation systems from ionospheric effects [1]. An error of a different sort which has not been taken into account either there or more recently in [4] (see also letter on p. 82 of this issue) may be of interest.

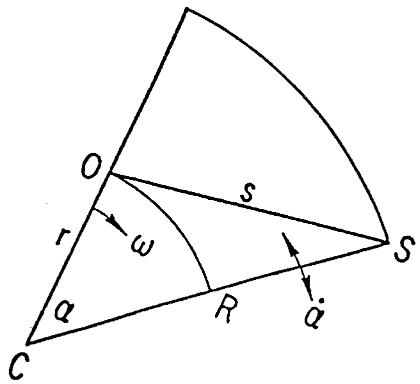

Fig. 1.
O observer, S satellite, C center of earth.

As an example, consider the case, in Fig. 1, of an observer O at the equator and a satellite S in a circular equatorial orbit (0° inclination). From the figure it is seen that

$$s^2 = R^2 + r^2 - 2Rr\cos\alpha$$

and

$$\dot{s} = \frac{Rr\dot{\alpha}\sin\alpha}{\sqrt{R^2 + r^2 - 2Rr\cos\alpha}}$$

Hence the Doppler shift is

$$\Delta f_D = \frac{\nu\dot{s}}{c} = \frac{\nu\dot{\alpha}}{c}\frac{Rr\sin\alpha}{\sqrt{R^2 + r^2 - 2Rr\cos\alpha}}$$

However, the earth is rotating at an agular velocity ω, which introduces a phase shift δ along the path s where

$$\delta = \frac{2\omega\nu A}{c^2} = \frac{\omega\nu}{c^2} R\sin\alpha$$

with $A = Rr/2$ the area of the triangle OCS, as experimentally shown by Sagnac [2].

The time rate of change of δ, a frequency, is then proportional to the rate of change of A or

$$\dot{\delta} = \Delta f_s = \frac{\omega\nu Rr\dot{\alpha}\cos\alpha}{c^2}$$

The actual frequency shift seen by O is then

$$\Delta f = \Delta f_D + \Delta f_s = \frac{\nu\dot{\alpha}Rr}{c}\left[\frac{\sin\alpha}{\sqrt{R^2 + r^2 - 2Rr\cos\alpha}} + \frac{\omega}{c}\cos\alpha\right]$$

For a non-equatorial orbit the added frequency becomes $\Delta f_s\cos\phi$, where ϕ is the orbit inclination.

Appendix

Numerical example for GPS

An observer at O sees $\Delta f = \Delta f_D + \Delta f_s$. To see the assumed Δf_D he must be at O', where $OO' = \epsilon$, the ground position error.

We have

$$\Delta f = a\left[\frac{sin\alpha}{\sqrt{b - d\cos\alpha}} + e\cos\alpha\right]$$

where $a = \nu\dot{\alpha}/c$,

$$\frac{\delta\Delta f}{\delta\alpha} = a\left[\frac{b\cos\alpha - d(1+\cos^2\alpha)/2}{b - (d\cos\alpha)^{3/2}} - e\sin\alpha\right] = ag$$

$$\delta\Delta f = \Delta f_s = ae\cos\alpha$$

$$\Delta\alpha = \frac{e}{g}\cos\alpha; \epsilon = r\cos\phi\,\delta\alpha$$

Substituting the constants $R = 2.66\times10^7$ m, $r = 6.36\times10^6$ m, $b = R^2 + r^2 = 7.48\times10^{14}\,\text{m}^2$, $c = 3\times10^8$ m/s, $d = 2Rr = 3.38\times10^{14}\,\text{m}^2$, $e = \omega/c = 2.45\times10^{-13}\,\text{m}^{-1}$, $\phi = 6.34°$, the errors ϵ resulting for geocentric angles α are found in the table below.

α (degrees)	ϵ (meters)
0	14.15
10	14.4
20	15.25
30	16.7
40	19.0
50	22.7
60	29.9
70	56.7
78.182 (horizon)	∞
80	−49.7
90	0

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CORRESPONDENCE

Electron Clusters

Petr Beckmann draws attention to a most unusual electrical phenomenon in referring to the discovery of electron clusters [1]. The stable confinement of sufficient electrons in micron sized spheres to produce a ball of energy measured in megajoules is something that cannot be explained by accepted physics.

The explanation offered by Beckmann in terms of Faraday field oscillations is certainly interesting and must be given the fullest consideration. This author does not, however, offer specific comment on the Beckmann theory, because there are aspects of the electron cluster phenomenon which seem to have bearing on the author's own theoretical research dating back to the 1950s. What is contested is the Beckmann statement that: "At present no other viable explanation appears available."

The point of interest is that the apparatus used by Kenneth R. Shoulders and his coworkers at Austin, Texas, to demonstrate the electron cluster phenomenon resembles the Klydonograph by which Lichtenberg figures were produced on film to evidence overvoltage surges on electrical power lines produced by lightning. The Klyodonograph, as used by this author in 1947, had a point electrode in contact with an unexposed 35mm film supported by a dielectric layer resting on a base plate forming the other electrode. In a sense, one could say that a miniature lightning discharge contained by corona effects caused the forked patterns which appeared on the developed film and which were used to estimate the strength of the surge effect of real lightning upon the power line.

What is so fascinating about the Shoulders technique is that an electrical current discharge in such a system, by which a miniature lightning current flows around the dielectric onto what is termed a "witness plate foil" produces what this author sees as miniature ball lightning. It was in the 1950s that the author recognized that Maxwell's charge displacement could occur in a radial sense in a sphere of the vacuum medium if that sphere could be caused to rotate about a central axis. To produce rotation one needed a radial electric field such as might be set up by pinch action of an electron current in a powerful axial discharge. A convenient reference to this is one dated 1983 [2], but the earliest printed reference dates from 1960 [3]. The latter reference included the showing in equation (30) on p. 32 that the charge density within the sphere was a function of spin axis inclination of the sphere relative to a local vacuum spin axis providing a reference governing the Heisenberg jitter motion which underlies quantum phenomena. The expression gave a maximum for parallel alignment of these axes of 4.781 esu/cc = 1.5947×10^{-9} C/cm^3 for each unit of angular spin speed measured in rad/s. This is 10^{10} electrons per cm^3 per rad/s of spin.

It may then be noted that this vacuum spin condition is electrically stable, so long as the vacuum medium spins. It follows that, whether electrons take up positions in the core of the sphere or at the boundary surface, depending upon the spin direction which determines polarity, then since the induced Maxwell charge displacement is a canceling action, those electrons will form a stable cluster. The effective charge of the cluster, as seen from a distance, will be a negative charge represented either by a displaced vacuum charge at the boundary surface of the sphere or by a residual vacuum charge in the core of the sphere. This charge will, however, not be able to escape by Coulomb repulsion because it is seated in the relative displacement of vacuum charges which are locked in position in a vacuum structure.

The net effect, however, is that the electron cluster is stable and we know from the above expression the size of sphere applicable to the maximum electron density and spin rate. The maximum rate of spin is *c/r* , *where c* is the speed of light and *r* is the radius of the sphere. For a 10 micron diameter sphere this means that the maximum electron density is 6×10^{23}. This corresponds rather closely with the maximum concentration reported to have been observed: ". . . the charge density lies near 6.6×10^{23} electrons/cm^3."

Note, however, that if the radius of the sphere is 1 micron and the peripheral speed is that of electrons leaving the cathode at their Fermi velocity, the spin speed is of the order of 10^{11} to 10^{12} rad/s. This implies, by the author's 1960 theory, an electron density of 10^{21} to 10^{22} per cm^3, corresponding to 4×10^9 to 4×10^{10} electrons in a single spherical cluster.

This fits well with the Shoulders data.

As to the derivation of the charge density of the spinning vacuum sphere presented above, this is derived from first-priciple analysis of the vacuum structure linked with a theory for the photon. However, an interesting empirical route to the same quantity is that afforded by realizing that the earth itself is enveloped in a coextensive vacuum sphere spinning with the earth. This explains why the earth exhibits a magnetic field, yet appears to have no measurable electric charge commensurate with induction of that field. In the case of the earth, however, the spin direction is opposite to that of the electron clusters and the earth with its vacuum spin presents an electrically neutral field as measured in outer space. This is because electrons are displaced to the ionospheric boundaries to cancel the positive vacuum displacement charge at the boundary, leaving positively charged ionic matter in the earth's core to cancel the vacuum core charge. The vacuum charge does not develop a magnetic effect canceling that of the rotating earth charge because the vacuum charge involved in this process is part of a structured lattice system which actually determines the local electromagnetic reference frame. Magnetic effects arise owing to charge motion through that frame from lattice site to lattice site, because the vacuum charge sites in the lattice are the seat of actions involved in the electron-positron creation processes which feature in electrodynamic actions. The calculation of the geomagnetic moment based on this theory is presented in references [4, 5, 6].

This magnetic action is probably the reason why the electron cluster spheres adhere to one another rather than repel. The reason is the very powerful magnetic moment that each such sphere possesses owing to its very high rate of spin and the fact that alternate spheres will spin in opposite directions and so develop a line of magnets each lying transverse to the line in which north and south poles form an adjacent sequence. It is also noted that by virtue of the powerful magnetic pairing of adjacent spherical electron clusters, the influence of the geomagnetic field in determining the energy density of the single thunderball as discussed in reference [2] is not applicable. Thunderball energy densities are of the order of a few kilojoules per cm^3, whereas these electron clusters contain energy which is one million times more concentrated.

The circumstance of having adjacent vacuum spheres rotating in opposite directions actually means, however, that the displacement of vacuum charge to set up the core charge can be from one sphere to an adjacent sphere, meaning that the boundary vacuum charges on adjacent spheres can, at least partially, neutralize one another. In the absence of electrons it can be seen that this will set up powerful mutually attractive Coulomb forces as between the adjacent spheres. The presence of electrons in the clusters can then be admitted up to a level where much of the positive vacuum sphere charges are neutralized and yet the line formation of spherical charge clusters remains stable.

It is, of course, of special concern whether the charge the electron cluster, being confined to such a small spherical form, is a true electrical energy state. Indeed, if it were then there would be breach of energy conservation principles in that, as Beckmann notes, this amount of energy is greater than the energy stored in the capacitor initiating the discharge. This has regard to the statement that as many as 3.5×10^{14} electrons have been observed in groups of electron clusters within a diameter of 10 microns, a figure which leads to that very high electron density quoted above and which also implies megajoule energy for such a 10 micron sized object.

However, this author now faces a perplexing problem in that it was part of the basic theory of references [3, 4, 5] that the electrostatic energy involved in the notional sphere of charge was actually only half of the total energy, there being equipartition with the kinetic energy of a vacuum spin state. Indeed, it was this electrical energy of the discharge that was seen as powering the energy eventually released by thunderball when it decays. Given that the spheres of charge formed in the electron cluster experiments are produced by actions not fully powered by the generating circuit, this suggests that the synchronizing constraints in the vacuum which account for the charge induction in spin provide the kinetic energy of the spin motion [6]. In this case there is here the glimpse of an action which might draw on the zero-point field energy of the vacuum itself and which might indirectly account for certain anomalies [6] reported to have been found by USSR researchers on plasma discharges and which are deemed to draw on that zero-point field energy source.

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AUTHOR'S REPLY

I was unaware of Prof. Aspden's work in this area, which represents an alternative explanation of the electron cluster phenomenon, and on which I have no comment.

I am, however, very indebted to Prof. Aspden for pointing out, in a companion personal letter, a numerical error in my paper. The energy of an electron cluster given in the first paragraph of Sec. 2 on p. 55 is not 1.5 MJ, but a mere 0.023 J, which is not equivalent to 3.5 g of TNT and can easily be stored in a capacitor. This has no effect on the rest of the paper, but is noted here with my apologies.

That electron clusters with 10^{14} electrons in a sphere of 10 microns diameter, mentioned later in my paper and in Prof. Aspden's letter, have been observed and do have this order of energy is sheer luck and does not excuse my numerical carelessness.

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A seamy episode

As Balzac described the Seamy Side of History, so, reluctantly, we call attention to a recent episode in the seamy side of science.

A seven author paper sponsored by NASA, IPL, and Cal Tech titled "Test of the isotropy of the oneway speed of light using hydrogen-maser frequency standards" has been published under the Aegis of the American Physical Society [1].

The NASA-JPL-Cal Tech paper is identical in principle to one published by Cialdea [2] in 1972. The conclusion of of that paper was correctly refuted by Tyapkin [3] in 1973. The JPL paper was careful not to cite those and some other references such as that of Torr and Kolen at the University of Utah. Torr and Kolen later admitted that the Tyapkin argument proved their experiment to be ill-conceived and that it had to yield a null if correctly executed.

These and other experiments of a similar nature published in establishment journals suffer by employing two sources and produce null results because of differential time dilation between the two sources. Since time dilation is inherent in relativity, all the authors and journal editors and referees involved are denying the theory they hold sacred. In contrast, an experiment which avoids that difficulty by employing a single source has been refused publication in those same establishment journals.

The issue is not merely one of physics, but involves large errors in the navigational systems of missiles.

Was JPL advised early on of the Tyapkin paper? Yes, JPL was so notified. It is sad that a USAF general and Cal Tech may have put ego before national security. Sad, and unfortunate, since not all nations are so poorly informed.

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DISSIDENT NEWS

Space-Time Conference in Leningrad: Call for papers

The Technical University of Leningrad, the Academy of Civil Aviation (also in Leningrad), and the Geographical Society of the Academy of Sciences of the USSR are sponsoring an International Conference "Problems of Space and Time in Natural Science."

The conference is to be devoted to the following issues on successive days:

- Coordinates and time in astrometry, celestial mechanics and mathematics;
- Coordinates and time in physics, astrophysics, and cosmology;
- (2 days) Coordinates and time in physics, geophysics, and geology; critical analysis of 20th century theories; experimental test;
- general discussion; scientific ethics.

Historians of science and philosophers interested in these topics are also welcome.

Prospective speakers should submit a summary in English or Russian to the

Local Organizing Committee
Intl. Space-Time Conference 1991
P.O. Box 16
Leningrad 198097, USSR

The Local Organizing Committee is chaired by Prof. P.F. Parshin, head of the Physics Department of the Academy of Aviation in Leningrad. Other Soviet organizers include physicist Prof. B.I. Peshchevitsky (Novosibirsk) and astronomer Dr. S.A. Tolchelnikova (Leningrad); all of these have published papers critical of modern physics. At press time, an International Scientific Organizing Committee was also being set up.

Please watch this column for further details as they emerge. Scientists wishing to participate, and especially prospective speakers should not delay preparations, as communications with the USSR are still extremely slow — in our experience, about one month for an air mail letter to be delivered.

The Alleged Conundrum

In a page-long article "Stefan Marinov's seasonal puzzle," in *Nature* (12 July 1990), the editor of that journal John Maddox reports on what he considers a conundrum: (essentially) a magnet rotating about the axis of symmetry of its field with a conductor in that field stationary in the lab, as against the case when the magnet is stationary and the conductor rotating. In the present case, dissident physicist Stefan Marinov has chosen the configuration so cleverly that he need only ask whether a voltage will be induced. Both "yes" and "no" will contradict Einstein.

Maddox correctly comments that [Einstein's] relativity theory predicts no difference, but then says "What is the truth? Nobody is quite sure, for nobody has done the experiment — not even Marinov." But unless he refers to that particular configuration of the general setup for unipolar induction, this is quite incorrect.

Though Maddox is by training a physicist, he can hardly be blamed for not knowing about F. Müller's unipolar induction experiments, described in the May/June issue of this journal, and probably the most complete series on the subject. But he does not know about Faraday's experiments on unipolar induction in 1831, either. Familiarity with either would quickly tell him what is going on and what the answer to the "conundrum" is. All he need have done was to ask whether the field rotates with the magnet when the latter rotates about its axis of symmetry.

Faraday's 1831 experiment, is not all that well known, either, but the unipolar induction effect in general is common knowledge, and when a physicist who is editor of one of the world's major scientific journals writes an editorial on the subject, one would expect him to use its considerable advisory resources.

Even more embarrassing, perhaps, is the fact that Maddox has fallen victim to the baseless dogma that Einstein's observer-based relativity and absolute space are the only possible alternatives. Here I do not refer to any particular contemporary dissident theory, but to the fact that for unaccelerated frames the Principle of Relativity was known to Galileo, was quantitatively formulated by Newton in the *Principia* (Book 1, Corollary 5), and was never doubted by any classical physicist, whether he believed in absolute space or not. (A rotating magnet is not an unaccelerated frame — though Müller has shown the effect for uniform motion also; but Maddox invokes the Relativity Principle anyway.)

It is remarkable to what extent this fundamental principle of physics has been replaced by the Einstein-or-absolute-space dichotomy in the consciousness of physicists in general, many of them working much closer to the subject than an editor. But then, it is remarkable to what extent experimental evidence by such classics as Faraday or Michelson (I refer to the 1924 Michelson-Gale experiment) has simply disappeared from basic (and often even specialized) textbooks when it refutes the dogmas of orthodoxy.

P.B.

Contents

Galilean Electrodynamics