ABSTRACT

Three of the great foundation stones of modern physics are examined in detail from standpoints of both technical content and historical derivation:

A. *Mass-energy interconversion* $E = mc^2$

B. *Relativistic mass* $m = m_o(1-v^2/c^2)^{-\frac{1}{2}}$

C. *Time dilation in elementary-particle decay* $N = N_o e^{-t'/\gamma\tau_o}$

Contrary to the modern consensus, all three prove to be intrinsically independent of the Special Theory of Relativity; and in points of actual historical derivation as well as epistemology, both $E = mc^2$ *and* $m = m_o(1-v^2/c^2)^{-\frac{1}{2}}$ *can be shown to have arisen, not out of the Special Theory and Lorentz transformation as so commonly supposed, but instead from conservation laws of classical physics in conjunction with the momentum relationships and field constant of Maxwellian electromagnetics. Elementary-particle decay similarly proves not to require either the assumption of time dilation or the Lorentz transformation, since alternative explanations are available.*

As for Einstein's two postulates: These prove to be loose statements containing at least six "postulates" without proper distinctions. The most important part of the first is now rephrased as a First Principle of Physics: *All laws of the natural order are equally valid and applicable throughout the physical creation. But his original concept of frame reciprocity and relative-motion-only - - properly called the Principle of Relativity instead of its modern distortions, is discarded because the now known absoluteness of space invalidates it. In fact, discoveries in geophysics regarding planetary and stellar magnetospheres invalidate not only the Principle of Relativity, but the whole historic interpretation of the Michelson-Morley null datum which led to the transformation equations. In fine, Einstein's model of an inertial reference frame should be relegated to mechanics, then corrected and enlarged for purposes of electrodynamics by including the associated Maxwellian field.*

Einstein's Second Postulate is rejected because (a) the definition of c as both a constant and a limiting field value independent of the source of the disturbance is inherent within the field equations and therefore needs no restatement, and (b) the frequently assumed corollary of velocity independence on the part of the observer - - which is not stated in his Postulate but is commonly read into it - - becomes negated by the same considerations repudiating the Principle of Relativity.

This study then shows (1) that every instrument in the long history of experimental physics, which attempted to detect the planetary velocity through space by electromagnetic means, has been situated stationary relative to the geocentric rest coordinates of the embedding Maxwellian field of the magnetosphere; (2) that the uniformly reported null datum must therefore be properly understood as an attestation of these rest coordinates; and (3) that the transformation equations of Larmor, Lorentz, Poincaré, and Einstein, which are based upon the improper model of a state of motion instead of a state of rest, must therefore be improper in turn.

From such considerations there results a new space-time model having these general features: (1) In matters of electrodynamics, an M-Space obtains, structured from the Maxwellian fields of magnetospheres which interlock with, or embed within, one another, each with its own rest coordinates centered in whatever mass generates the field, bounded by its magnetosheath and magnetopause, and exerting autonomy over all laws of electromagnetics within its confines; (2) in matters of mechanics, a G-Space obtains, similarly structured from locally generated fields but of gravitational sort, each again with its own reference frame but of inertial rather than electromagnetic definition, bounded by gravitational equipotentials, and exerting autonomy over all laws of inertial mechanics within its confines; and (3) both types of field-structured space are spatially absolute, whether Euclidean or non-Euclidean, because the individual fields themselves are both locally absolute and contiguous with one another; and they are chronometrically absolute because spatially absolute.

Table of Contents

Introduction

Among physicists, to say nothing of the general scientific community, there is an overwhelming consensus that the mass-energy equivalence principle $E = mc^2$ arose and arises solely and specifically out of Einstein's Special Theory of Relativity, the two so inseparably identified that an experiment demonstrating $E = mc^2$ automatically stands as experimental verification of the Special Theory. A typical textbook quote over the past four decades is that of Pollard and Davidson[279], namely that the unquestionable experimental verification of this principle is "one of the greatest triumphs of the theory of relativity". Kivel[189] within the past year writes of "...the special relativity relation $E = mc^2$", while Helliwell[258] opens his Chapter IX with this statement:

> The most widely known and spectacular prediction of special relativity is that mass is a form of energy.

Directly related and involved, of course, is the concept of relativistic mass: $m = m_o (1 - v^2/c^2)^{-\frac{1}{2}}$; and no question is ever raised today over the assumption that this is both a parameter and a function of the Einstein-Lorentz transformation equations. As for the indisputable elementary-particle decay relationship $\tau = \tau_o (1 - v^2/c^2)^{-\frac{1}{2}}$, nuclear physicists have established its validity, and relativists handle it in an unquestioning manner with the same transformation equations.

However, the first position is demonstrably in error; the second may be; and the third presents some very interesting matters for discussion. For the famed mass-energy equivalence principle was anticipated by others before Einstein's discussion; his own derivation from the point of view of the Special Theory was both incomplete and mathematically incorrect; and the relationship $E = mc^2$ arises just as readily from Maxwellian field theory and the momentum conservation law - - as Einstein himself admitted in a generally overlooked essay written during his later years[105].

Physicists should not permit themselves either to become forgetful or to remain unaware of these things; and particularly should teachers take care to sketch proper backgrounds and balanced viewpoints when presenting such great concepts of physics to those who will become the physicists of future generations. Furthermore, the situation may have some special importance attached to it at this particular time. For the long-smoldering resistance[26A 56 71 325] to Einstein's Special Theory of Relativity has in recent years blossomed into book-length displays[10 62 80 112 180 181 152 201 233 261 305A 305B 314 363], to say nothing of innumerable lesser works proposing alternative models[69 168 234 343 364]; and at its very best the Special Theory has retrograded to some kind of absolute-space model akin to the pre-Einstein ether model of Lorentz[46 83 170 297]. It is not the present purpose to discuss these matters, but rather to draw some clear and necessary distinctions as to what is, and what is not, at stake in relativistic physics when such arguments arise over the Special Theory.

Specifically, the aim is to show that these three great principles of mass-energy equivalence, velocity-dependent mass, and velocity-dependent decay life are immune to any possible weaknesses of the Special theory. They are here to stay, whatever modifications or demolishment the Special Theory might suffer; their backgrounds have roots elsewhere than in the Special Theory, and more firmly; and therefore none of the three should be claimed as exclusively supporting the Special Theory, neither viewed with alarm should the Special Theory fall.

Some Remarks on Background

Coming events do cast their shadows before, and it will be helpful in adjusting one's perspective to glance back upon some of the principal landmarks on the long road to modern physics. We shall confine attention to these four emerging concepts: (1) The corpuscular aspect of radiation, (2) the inertia of radiation, (3) mass-energy interconvertibility, and (4) relative motion.

Newtonian Physics

Since Newton laid the foundation of physics, it is not surprising to find him expostulating upon every one of our four targets of inquiry. His First Law, for example, merely gave statement to a long-held opinion - - notably espoused by the Paris School of Natural Philosophy under Oresme[242] and Buridan some several centuries earlier - - that uniform motion, like the state of rest, needs no cause. Newton wrote:

> The motions of bodies included in a given space are the same among themselves, whether that space is at rest or moving uniformly forward in a right line, without any circular motion.

Since this leads directly to the concept of an inertial observer, there follows what might be called Newton's *Principle of Relativity*[286]:

> All inertial observers are equivalent so far as dynamical experiments are concerned.

This immediately validated the so-called Galilean transformation for mechanical (inertial) physics

$$x' = x - vt$$

$$y', z' = y, z$$

$$t' = t$$

here expressed for in-line-of-motion translation between inertial frames moving at velocities $v \ll c$.

When Newton published his famous Opticks[258], he advanced these three profound remarks under heads of *Queries*:

Query 29: (Rays of light comprise) very small bodies emitted from shining substances ...

Query 30: Gross bodies and light (are) convertible into one another ... The changing of bodies into light and light into bodies is very conformable to the course of nature, which seems delighted with transmutations.

Query 31: All bodies seem to be composed of hard particles ... even the rays of light.

In his Tract Numb. 80[256], published in 1672, he specifically raised the question of whether

> ... the rays of light should possibly be globular bodies?

Unfortunately for Newton, modern knowledge of $h\nu$ was not in his hands to validate this quite astonishing precognition. So he carefully stated that his position was *not* to make a "fundamental supposition of the Corporeity of Light"[257], but rather to look upon it as one of several possible "Mechanical Hypotheses" which might throw a light upon the observations he was seeking to explain.

Support for the corpuscular model came from several sources. First, Kepler in 1619 had called attention to the radial position relative to solar coordinates always adopted by the tails of comets. Here was the origin of the "radiation pressure" concept which both invites and requires a particle/inertial model, and which would consummate three centuries later in the work of Nichols and Hull[259]. Second, Newton was directly troubled with the singular nature of refraction in Iceland or dogtooth spar. Since he could solve it with a corpuscular model, and because Huygens was unable to show wherein he erred, Newton remained with it. However, his first three hypotheses on optics were stated in terms of (I) an aetheral medium, (II) light being capable of exciting vibrations in this medium, and (III) color as a function of wavelength.

Interestingly enough, Newton even laid the foundations for relativistic mass, possibly expressing his deep doubt as to whether matter and light were really not just two forms of one substance. For his definition of force was first given in terms of the rate of change of momentum:

$$F = d(mv)/dt$$

and we shall shortly show that this, in combination with Maxwell-Hertz field theory and the experimental demonstration of m as a function of v

$$m = f(v) = m_0(1 - v^2/c^2)^{-\frac{1}{2}}$$

suffices to establish both relativistic mass and relativistic physics. But in his day velocities fell far short of those causing relativistic mass increase; and shortly classical mechanics came under such as Lagrange and Laplace who, satisfied that the rest mass is constant within experimental errors of measurement at this time, concluded that

$$m_0 \equiv m$$

whereupon they altered Newton's equation to read

$$F = m\, dv/dt = m \frac{d^2s}{dt^2} = ma$$

From this in turn classical mechanics inherited a kinetic energy

$$E_k = \tfrac{1}{2} mv^2$$

which fails to display the matching rest-mass energy now known to be

$$E_0 = m_0c^2$$

such that as $v \rightarrow c$, the total energy becomes

$$E = m_0c^2\ (1 - v^2/c^2)^{-\frac{1}{2}} = mc^2$$

For the kinetic energy is properly

$$E_k = m_0c^2 \left[1/(1 - \beta^2)^{\frac{1}{2}} - 1\right]$$

$$= (m - m_0)c^2$$

$$= m_0c^2\ (\gamma - 1)$$

where

$$\beta = v/c$$

$$\gamma = (1 - v^2/c^2)^{-\frac{1}{2}}$$

Common in textbook presentations[108] is the claim that Newton not only failed to recognize the limiting velocity c, but also the time factor in transmission of force, resulting in the unrealistic "absolute simultaneity" and instantaneous "action at a distance". But Newton was working in the field of mechanics, not electrodynamics - - the macroscopic and megascopic as contrasted with the submicroscopic. Nor were what we today call relativistic velocities of any more concern to his mechanics than they are yet to our own. And as just pointed out, Newton did allow for relativistic mass, whether knowingly or not, in his

$$F = d\ (mv)/dt$$

As for the question of finite *vs.* infinite velocity of light, this was only coming to clarification during the very days of his writing. In fact, he was one of the first to accept Roemer's results - - a matter we shall shortly discuss.

In fine, what Newton accomplished was the launching of low-velocity physics, leaving its high-velocity counterpart to workers with electromagnetics and elementary-particle physics in later generations. Specifically, he took these four positions which became subject to later correction or refinement:

Low-velocity Physics	High-velocity Physics
1. Matter can be represented by discrete points of constant and velocity-independent mass m.	1. Mass is velocity-dependent.
2. The kinetic energy of matter in motion increases with v until becoming infinite at $v = \infty$.	2. Kinetic energy becomes infinite as $v \rightarrow c$.
3. Transmission of force occurs instantaneously as "action at a distance".	3. Transmission of force in forms of either inertial mass or energy is limited to the velocity of c.
4. Transmission of force occurs by in-line (longitudinal) compression.	4. Transmission of electromagnetic force occurs by transverse vibration

Still a third development of the latter 17th Century gave possible strength to Newton's corpuscular model, though it was not so recognized at the time. For while those debates in the field of optics were at their height, the Danish astronomer Ole Roemer[141], working in the Paris Observatory, confirmed a suspicion voiced by the mathematician Pierre Fermat in 1657, namely that the transmission of light has a finite velocity. There was a rapidly rising opinion in those days, and one which would last for a couple centuries, that "action at a distance" was the *modus operandi* of nature, also that the velocity of light was infinite. Roemer checked it out in 1675 with eclipse timings of Jupiter's Galilean satellites gauged against the annual pair of to-fro orbital motions of the Earth relative to the other planet. At the September 1676 meeting of the French Academy of Science, he announced that the predicted eclipse of the innermost satellite on 9 November would be 10 minutes late due to the finite velocity of light and the current fro-motion of the Earth relative to Jupiter. On 21 November he presented another paper calculating the travel time for light across the diameter of the Earth's heliocentric orbit to be 22 minutes - - only off by ∿5.5 mins. from the actual, depending upon how one measures the eclipse.

Although this work of Roemer's stands like a beacon in the history of physics, it received little attention at the time. A half-century later, the Rev. James Bradley, "Savilian Professor of Astronomy" at Oxford, was boating on the Thames while pondering a recent fine compilation of the German astronomer Struve on stellar aberration. Suddenly struck by the peculiarity of the weathercocks on passing boats, which shifted relative to the boat whenever the vessel made a turn, Bradley wrote a brief communication on his "new discovered Motion of the Fix'd Stars" for the Royal Society of London[38]. This culminated the concept begun by Roemer, combining the to-fro orbital motion with the finite velocity of light; and to this day Bradley's explanation of aberration remains uncontested, while his velocity vector

$$\beta = v/c$$

stands as a cornerstone of relativistic physics. The significance for Newton's corpuscular theory was that the trigonometric relation $\beta = v/c$ is as common an experience as holding one's umbrella at an off-vertical angle $\theta = \tan^{-1} v/c$ where v is the pedestrian rate, and c the hydrodynamic; or shooting a duck with the gun sighted at an angle $\theta = \sin^{-1} v/c$ ahead of the bird, where the two velocities now refer respectively to bird and bullet. Not until the following Century did wave theory become adapted to aberration.

Mass-Energy Equivalence: E=mc²

From such a background as briefly sketched here, there arose three main highways of inquiry which would ultimately culminate in relativistic physics: (I) Radiative energy itself as a carrier of inertia, (II) velocity-dependence of the mass of a charged particle, and (III) kinematics of light propagation as affected by the dynamics of mechanical motion.

While all three played their parts in a somewhat conjoined manner toward the development of the Lorentz transformation, and Einstein's Special Relativity, only the third brought about the seeming requirements of the Lorentz transformation and the Special Theory. The principal purpose of this monograph is to treat each of these three routes independently to show that all three of our subject relationships

$$E = mc^2 \quad \ldots \quad \text{Equation A}$$

$$m = m_0(1 - \beta^2)^{-\frac{1}{2}} \quad \ldots \quad \text{Equation B}$$

$$N = N_0 e^{-t'/\gamma\tau_0} \quad \ldots \quad \text{Equation C}$$

stand on their own derivation, independent of either the Lorentz transformation or Special Theory. Therefore *their* consideration, and the consideration of *their proper transformation equations*, should be carefully compartmented as two quite distinctive matters. In fact, we shall not give more than passing attention to this matter of choice of transformation equations, nor will our derivations of these three fundamental equations in any way call upon the machinery of the Special Theory.

Radiation Pressure

Following the observation of comet tails by Kepler in the early 17th Century, some such as Hartsoeker, Hamberg, DeMairan, and DuFay in the early 18th Century attempted to test the pressure exerted by light[73]; but disturbing environmental influences always obscured the results. In 1792 the Rev. A. Bennett[24] made a particularly notable attempt, using a fine gold wire suspended by a spider thread:

> ... light was admitted through a small hole ... with the intention of observing whether it would be moved by the impulse of light ...

But again interfering thermal and gaseous effects prevented a successful observation.

On 12 November 1801 Thomas Young[353] made his remarkable presentation before the Royal Society in London, covering his experiments announced the preceding year[352], and reestablishing the wave theory of light. Young also spoke of the possible inertia of the light beam, and even its gravitational deflection upon passing celestial bodies - - a matter taken up by J. G. von Soldner earlier that same year[146]. This lecture still makes good reading today. Two decades later Oersted unified electricity with magnetism; in 1825 Fresnel[130 131] believed he witnessed certain forces in radiation experiments which were neither electrical nor magnetic; and then in the 1830's Faraday[113] began publishing his concepts of "lines of force" and "contiguous particles", establishing

> ... a true, direct relation and dependence between light and the magnetic and electric forces ...

This probably marks the union of light with mechanical force in a potentially predictive sense.

In 1854 W. Thomson - - the later First Baron, Lord Kelvin - - acted upon this predictive aspect and published a most remarkable paper "on the mechanical value of a cubic mile of sunlight"[334]. Aside from the work of Joule in thermodynamics, this then probably stands as the first clear-cut example of expressly reducing radiation to mechanical force, at least in theory. Thomson's two tools were Joule's recently announced hypothesis of the mechanical equivalent of heat, and a fine set of data on solar radiation just published by Pouillet. Thomson came up with a value of 12,050ft-lbs equivalent to 1 h.p. operating ∿20 sec.

In those days Weber[344 345 346] in Germany was the dominating figure in electrodynamics; and Weber believed that he had witnessed an inertial effect in electricity during opening and closing circuits. But of course this was merely a yet-unrecognized induction effect. Helmholtz with his customary incisive perception suggested testing for it with a doubly-wound spiral, which should then disclose any true effect as an "extra current" traveling in opposite directions. Hertz acted upon his suggestion, and promptly won the first, or one of the first, of his numerous prizes.

Meantime one of W. Thomson's protégés, James Clerk Maxwell[236], took the incomparable body of experimental data left by Faraday, and worked it into the now well-known field equations which, in modern shorthand and for the vacuum condition can be written:

$$(\text{div } D =)\ \nabla \cdot D = 4\pi\rho \qquad (= \nabla \cdot E)$$

$$(\text{div } B =)\ \nabla \cdot B = 0 \qquad (= \nabla \cdot H)$$

$$(\text{curl } E =)\ \nabla \times D = -\left(\frac{1}{c}\right)\left(\frac{\partial B}{\partial t}\right) \qquad (= \nabla \times E)$$

$$(\text{curl } H =)\ \nabla \times B = \left(\frac{4\pi}{c}\right) j + \left(\frac{1}{c}\right)\frac{\partial E}{\partial t} \qquad (= \nabla \times H)$$

where the two field quantities D and B represent respectively the electric displacement and magnetic induction; the magnetic field strength H in the presence of matter becoming related to B as

$$B = \mu H$$

where μ is the permeability; and the electric field strength E becoming related to D as

$$D = E + 4\pi P = (1 + 4\pi\varepsilon)\ P \doteq \kappa P$$

where P is polarization expressed as dipole moment density, κ is the dielectric constant, j the current density, and c a universal constant which shall shortly engage our full attention. The factor 4π of course represents the area of a spherical charge.

However, to retain our analysis within the context of the times in question, let us look at certain of Maxwell's statements concerning his understanding of the meaning of the field relationships[236]. First on the matter of energy:

> In speaking of the energy of the field ... I wish to be understood literally: All energy is the same as mechanical energy, whether it exists in the form of motion or in that of electricity, or in any other form. *The energy in electromagnetic phenomena is mechanical energy.*

We italicize this closing line because four decades later Kaufmann[186], performing the key experiment in the history of relativistic mass along our Route II, would write:

> *Die Masse der Elektronen ist rein elektromagnetischer Natur.*

In that case the italics were his.

On radiation pressure, Maxwell said:

> There is a pressure in the direction normal to the waves and numerically equal to the energy in unit volume.

From the field equations, and considering the historic "radiation pressure" Route I in terms of radiation energy E impinging upon some target at the rate dE/dt, Maxwell calculated the force to be

$$F = \frac{1}{c} \frac{dE}{dt}$$

In 1876 Bartoli[17 18] corroborated this relationship *on purely thermodynamic grounds*, as did Boltzmann[32 33] in Germany and G. F. FitzGerald[118] in Dublin in 1884, next by Lebedew[204] and Galitzine[135] on the Continent in 1892, also by Oliver Heaviside[155] in England, again by Guillaume[142] in France in 1894, and Goldhammer[140] in Germany in 1901. The climax to Route I then occurred in 1901-03 with the definitive study of E. F. Nichols and G. F. Hull[259]. The sum and substance of their work is contained in the closing sentence of their 1903 paper:

> The Maxwell-Bartoli theory is thus quantitatively confirmed.

Derivation I

But if

$$F = \frac{1}{c} \frac{dE}{dt}$$

in electrodynamics, while in mechanics

$$F = ma = dp/dt$$

then the theoretically predicted and experimentally demonstrated interrelationships of mechanical and electromagnetic energy lead to

$$F = dp/dt = \frac{1}{c} dE/dt$$

whereupon

$$dE/dp = c$$

and the beam is seen to carry momentum in the ratio 1/c relative to energy:

$$E/p = c$$

$$p = E/c$$

But momentum is a function of mass

$$p = mv$$

which is here specifically

$$p = mc$$

whereupon

$$dp = cdm$$

$$dm = dp/c$$

and by substituting p = E/c

$$dm = dE/c^2$$

and

$$E = mc^2 \qquad \text{(Equation A)}$$

on the logical assumption that a body losing part of its mass upon losing part of its energy, and in such precise relationship, loses all of its mass when losing all of its energy.

We should add that this approach appears first to have been formulated by the noted thermodynamicist Gilbert N. Lewis about the turn of the present Century, though not published[213] until 1908 when the rapidly rising commotion over mass-energy equivalance made it seem sufficiently important to do so. The following year Lewis published another paper on the subject with the similarly noted Tolman[214]; and both of these papers have been regrettably overlooked, not only by historians of physics, but by those writing its textbooks. We shall later find Lewis's "non-Newtonian mechanics", as he called it, in a position as remarkable technically as it is historically. And certainly his discussion in 1908 on the likelihood of non-Euclidean geometry eventually replacing Euclidean at both far extremes of interstellar space and subatomic structure is arresting. Einstein was still a half-decade away from considerations of non-Euclidean space[107].

Derivation II

Despite the authoritative position of Lewis and Tolman, let us examine this rather rapid classical arrival at the historic Equation A in more detail, from other standpoints, and by additional authorities. Consider a completely isolated tube of mass M and length L, with a luminous substance at one of the two closed ends. Energy in the form of corpuscular light (photons) leaves this one end; and since it is now known from Maxwell's equations and the experiments of Nichols and Hull that light carries a momentum

$$p = E/c$$

the conservation law requires the tube to acquire a momentum

$$p = -E/c$$

such that its recoil velocity becomes

$$v = -E/Mc$$

After an interval Δt the radiation strikes the opposite end of the tube and transfers an identical measure of momentum, but in the opposite direction:

$$p = E/c$$

which, of course, precisely counteracts the first impulse to give

$$v = E/Mc - E/Mc = 0$$

Meantime the tube should have experienced a displacement

$$\Delta x = v\Delta t = -E/Mc\ (L/c)$$
$$= -EL/Mc^2$$

But since it is unreasonable to suppose that the center of mass of an isolated system has actually moved, one can only conclude that the momentum carried by the beam similarly carried an increment mass m according to

$$p = mv$$

such that

$$mL + M\Delta x = 0$$

Whereupon substituting for Δx gives us

$$mL + M\ (\frac{-EL}{Mc^2}) = mL - EL/c^2 = 0$$

and

$$E = mc^2 \qquad \text{(Equation A)}$$

Once again, in no way has any part of either the Lorentz transformation or the machinery of Einstein's Special Theory been applied in this derivation. From whence did such an example arise? It was published in 1906[88] by the same person who published the Special Theory in 1905 - - Albert Einstein.

Derivation III

Now let us try an approach utilizing nothing but the conservation laws and the aberration factor $\beta = v/c$, all of which were a part of established physics before Einstein was born. We shall introduce a pair of observers in uniform motion relative to one another, reminiscent of the models of the Special Theory; but none of the transformation mathematics will enter whatever.

Consider a mass m suspended freely in space and at rest relative to observer A. Two complexes of radiation, each with an energy E/2, arrive simultaneously from respective directions -x and +x. Because of the symmetry, the body remains at rest, while increasing its energy by E.

But now consider this same occurrence from the standpoint of observer B in downward motion along the Z-axis. To B, the mass m is in upward motion at velocity v; and the paired energy packets E/2 have struck it at the aberration angle

$$\theta = \sin^{-1} \beta$$
$$= \sin^{-1} (v/c)$$

However, the consideration from A's standpoint, within his own stationary system, proved that no motion was contributed to m by the symmetrically paired impacts. Let us then analyse the situation from standpoints of total momentum before and after the impact as viewed by B.

According to what Einstein himself calls the "well known conclusion of Maxwell's theory"[105], each beam carried a momentum E/c. The z-component of the momentum Δp for each beam then became

$$\Delta p_z = \sin\theta \left(\frac{E}{2c}\right) \simeq \frac{v}{c}\left(\frac{E}{2c}\right) = vE/2c^2$$

except for quantities of the second order or greater magnitude. The total momentum of the system before impact was therefore

$$\Sigma p = p + \Delta p$$
$$= mv + \left(\frac{E}{c^2}\right) v$$
$$= v \left(m + \frac{E}{c^2}\right)$$

On the basis of the proposition that the mass m might have been altered by the E absorption - - under consideration at least since 1881 by J. J. Thomson[330], and conclusively demonstrated by Kaufmann[186] several years prior to the Special Theory - - let us write

$$p' = m'v$$

whereupon

$$m'v = mv + \left(\frac{E}{c^2}\right) v$$

$$m' - m = E/c^2$$

and the mass increment

$$\Delta m = \Delta E/c^2$$

which defines mass-energy equivalence

$$E = mc^2 \qquad \text{(Equation A)}$$

Again a question naturally arises as to the background and authority for this nonrelativistic and strictly Galilean derivation of Equation A, by Route I, using nothing but conservation laws and the aberration ratio; and again it is quite thought provoking to point to Albert Einstein as the author, and pp.116-119 of his book Out of My Later Years[105] as the place of publication.

Einstein's Relativistic Derivation

Still further nonrelativistic derivations of Equation A can be found in the literature - - such as Brown's[40] approach through the forces on interacting charged particles

$$E = \frac{qq'}{r^2}\left(1 - \tfrac{1}{2}\frac{v^2}{c^2} - \frac{rf}{c^2}\right)$$

and

$$F = \frac{Gmm'}{r^2}$$

also Aspden's[11] answer for avoiding runaway solutions to the Abraham-Lorentz particle which moves as it radiates

$$F_{ext}(t) = m\ddot{x} - \frac{2}{3}\frac{e^2}{c^3}\dddot{x} = m(\ddot{x} - \tau\dddot{x})$$

Later we shall have reason to make an entry on Poincaré's 1904 derivation as interpreted by Pauli some years later[264 265], also Langevin's[196] quantum-Dopplerian approach of 1913, recently resurrected by Fox[126]:

$$\Sigma p = h\nu(1 + \beta)/c - h\nu(1 - \beta)/c$$
$$= 2h\nu\beta/c = E\nu/c^2$$

Then there are the even more powerful experimental demonstrations along the relativistic-mass Route II which we have yet to discuss, and which in themselves still carry no dependence upon either the Special Theory or the choice of transformation equations.

However, we shall close the present discussion with Einstein's own historic analysis of 1905[85], and for these five reasons: First, it should already be clear that there was nothing so singular in Einstein's findings on mass-energy equivalence as to require a renovation of physics as it stood at the close of the 19th Century. Newtonian mechanics merely lacked electromagnetics to constitute a complete physics - - at least so far as Euclidean space is concerned; and this was supplied by such as Faraday[113], Neumann[252], Weber[345 346], W. Thomson[335 138], Maxwell[236], Helmholtz[159 160], FitzGerald[117], Cohn[54], Boltzmann[34], Hertz[163 164], Heaviside[142 154 155], and so on - - all before Einstein. Second, and as the discussion of Route II will shortly show, the discovery of relativistic mass far antedated Einstein; it was in experimental demonstration before his writings began; and in no way does its explanation require either a FitzGerald-Lorentz contraction, time dilation, or the Special Theory. Instead, the whole force of the Einstein-Lorentz derivation of relativistic mass lies in the fortuitous circumstance that the Einstein-Lorentz transformation equations employ the same cosine factor

$$\cos \sin^{-1} \beta = \left(\frac{c^2 - v^2}{c^2}\right)^{\frac{1}{2}} = (1 - v^2/c^2)^{\frac{1}{2}}$$

for space and time which also defines *the asymptotic relationship* for a moving mass *m* as its velocity $v \to c$. The asymptote is one of the most common features of the natural order.

Third, when Einstein began developing his argument, he committed an epistemological error in not relating his mathematical components to the appropriate inertial frame; and Planck called him on this, thence proceeded to develop what is probably the true historical "first" for correctly deriving $E = mc^2$ through the machinery of the Special Theory[268 269].

Fourth, at the climactic part of his derivation, Einstein made a serious mathematical error, as was also pointed out by Planck at that time, and more particularly by Ives[71] much later. And fifth, when he completed his presentation, he had done no better than to arrive at the same kind of first-order approximation exampled in Derivation III above - - *contra* the exact formulation of Derivation I using the Newtonian-Maxwellian approach, and as pointed out by Lewis in 1908[213].

Certainly the informed physicist's brow must lift when reading Einstein's postcard[82] of 17 February 1908 to Johannes Stark, a later Nobelist:

> I was somewhat taken aback to see that you did not acknowledge my priority regarding the connection between inertial mass and energy ...

Einstein begins with the usual two systems *S* and *S'* in relative motion one to another, much as already discussed. A packet of radiation ΔE is emitted from *S* such that its original state of energy

$$E_0 \to E = E_0 - \Delta E$$

As observed from *S'*

$$E_0' \to E' = E_0' - \gamma \Delta E$$

and

$$(E_0' - E_0) - (E' - E) = \Delta E\,(\gamma - 1)$$

where as usual

$$\gamma = (1 - v^2/c^2)^{-\frac{1}{2}}$$

At this point Einstein introduces the kinetic energy E_k and E'_k with that classical remark among mathematicians which so often warns one that precisely the most ambiguous passage in the entire work has just been skipped over. Thus he assures the reader "it is clear that" the primed and unprimed energies can differ "only by an additional constant C" such that

$$E_0' - E_0 = E_k + C$$

$$E' - E = E_k' + C$$

Therefore

$$(E_0' - E_0) - (E' - E) = E_k - E_k'$$

From which it follows that

$$E_k - E_k' = \Delta E\ (\gamma - 1)$$

But as Planck pointed out, this is an assumption "permissible only as a first approximation", also that in his E' - E and $E_o' - E_o$ relationships, Einstein was introducing primed values observed from one platform along with an energy value observed from the other:

$$E' = E_k' + E + C$$

Whereas Planck more or less dropped his criticism and went about his own derivation, Ives has brought its seriousness into full light. Consider the two kinetic energies in question

$$E_k = mc^2\ (\gamma - 1)$$

$$E_k' = m'c^2\ (\gamma - 1)$$

Then

$$E_k - E_k' = (m - m')\ c^2\ (\gamma - 1)$$

and the earlier relationship

$$(E_o' - E_o) - (E' - E) = \Delta E\ (\gamma - 1)$$

can be written

$$(E_o' - E_o) - (E' - E) = \frac{\Delta E}{(m - m')c^2} \cdot (E_k - E_k')$$

And since this is equivalent to expressing the difference in these two relationships:

$$E_o' - E = \frac{\Delta E}{(m - m')c^2} \cdot (E_k + C)$$

$$E' \quad E = \frac{\Delta E}{(m - m')c^2} \cdot (E_k' + C)$$

it becomes immediately apparent that those are *not* the equations of Einstein's simplified assumption

$$E_o' - E_o = E_k + C$$

$$E' - E = E_k' + C$$

but are mathematically in error by the very sizable factor $\Delta E/(m - m')c^2$.

In fine, Einstein's red-flag "it is clear that" marks the very spot where he surreptitiously slipped in *precisely the relation his derivation was seeking to prove:*

$$\Delta E/(m - m')c^2 = 1$$

through the assumption which Planck quickly recognized as an epistemological error.

As for the fifth criticism of Einstein's 1905 derivation, namely arriving at merely an approximated $E = mc^2$ as compared with the exactitude of Derivation I, his argument closes with the expression

$$E_k - E_k' = \tfrac{1}{2}\ \frac{\Delta E}{c^2}$$

obtained from neglecting magnitudes greater than second-order in the binomial theorem. From this he concludes rather simply that "if a body gives off the energy in the form of radiation, its mass diminishes by $\Delta E/c^2$ ...".

But such a conclusion can only follow from a step that he does not give:

$$E_k - E_k' = \tfrac{1}{2}\ (m - m')\ v^2$$

so that

$$\tfrac{1}{2}\ (m - m')v^2 = \tfrac{1}{2}\ \Delta E\ \frac{v^2}{c^2}$$

or

$$\Delta m = \Delta E/c^2$$

Nowhere in his paper does either this incremental relation or the more explicit $E = mc^2$ appear. Thus he went no further than to show that a change in energy brings about a corresponding change in mass. In 1906 Planck[269] arrived at an expression for kinetic energy

$$E_k = mc^2 (1 - \beta^2)^{-\frac{1}{2}} + \text{const}$$

and in 1907 obtained the whole expression as just mentioned[268]. Not until this same year of 1907 did Einstein[89] go back to mass-energy equivalence, pick up the usual kinetic energy E_k approach, but now from the quick vantage point of his "relativity principle" with its built-in cos θ factor, and then go from velocity-dependent mass

$$m = m_o (1 - v^2/c^2)^{-\frac{1}{2}}$$

to

$$E = m_o (1 - v^2/c^2)^{-\frac{1}{2}} c^2$$

with the generalization

$$E = mc^2$$

and even

$$E = m$$

in natural units where c = 1.

Relativistic Mass
$m=m_o(1-v^2/c^2)^{-\frac{1}{2}}$

The Magnetosphere in Relativistic Physics

At this point we move to Route II, from the considerations of radiant energy *E* itself as a carrier of inertia, to the theoretical propositions and experimental demonstrations that the classical Law of Conservation of Mass no longer holds even where rest mass and charge carriers are present, and that mass *m* itself is indeed a function of velocity

$$m = m_o (1 - v^2/c^2)^{-\frac{1}{2}}$$

as already indicated in deriving $E = mc^2$.

However, these derivations need technical as well as historical background; and our attention now falls specifically upon the nature of the constant *c* in the field equations, for the two reasons of (1) establishing the validity of Einstein's half-postulate regarding *c* as a limiting velocity in both mechanics and electrodynamics, and (2) establishing the validity of the magnetospheric envelope of celestial bodies, and specifically *the Earth's magnetosphere, as the locally absolute rest frame for all experimentation in electromagnetics conducted within its confines*. For this last, and because of both convenience and clarity, we shall adopt a terminology proposed in 1977[359 362], which extended the common term *heliosphere* for the solar magnetosphere, on the one hand, out to the *galactosphere* which embeds it, and on the other hand inward to the *geosphere* or terrestrial magnetosphere which the heliosphere in turn embeds. Because this matter of the local Maxwellian field of our magnetosphere embedding the instruments of experimental physics has been so incredibly ignored by relativists, let us take a few moments to bridge geophysics with relativistic physics. If the presentation seems unnecessarily elementary in parts, the answer is that the relativist apparently needs reminding of certain fundamental aspects of Maxwell-Hertz field theory which bear upon those experiments of his which seek to test the Special Theory. We wish particularly to draw attention to the field constant c, and to develop its background from rather early times of usage.

First of all, for those not yet introduced to the principal subject of our discussion, namely the terrestrial magnetosphere, we present in Figure 1 the diagram published by Ness[251A] shortly after the discovery of the Van Allen radiation belts; Figure 2 is the schematic released by NASA in 1967; and Figure 3, from the more recent work of Piddington[267A], shows that even on the tail side the field lines are probably closed.

Electromagnetics involves three kinds of force relationships between a magnet and a moving (point) charge. One is the action of the charge upon the magnet, discovered in 1820 by Oersted and put into

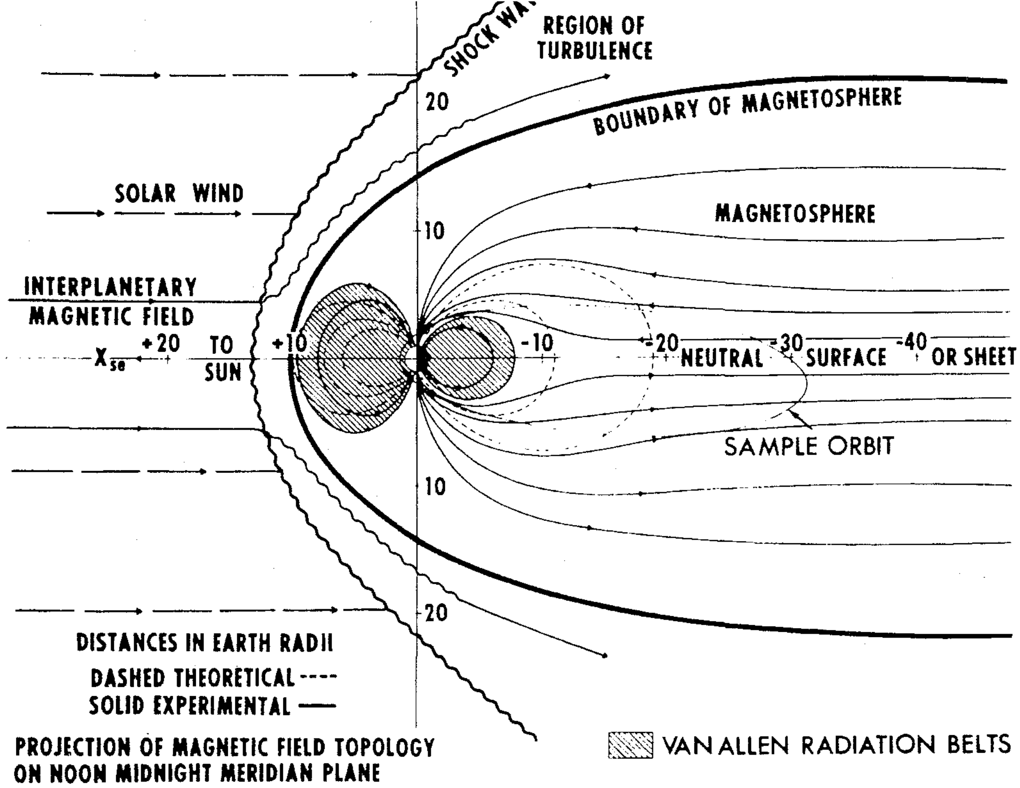


Figure 1: General structure of the terrestrial magnetosphere as developed by the early space flights of the late 1950's.

From Ness[251A]

form as the Biot-Savart Law:

$$d\,|H| = \frac{\sin\theta}{cr^2}\, I d\ell$$

or

$$|H| = \frac{|v|}{c}\,\frac{e}{r^2}\,\sin\theta$$

where *H* is the magnetic field strengh, *e* the charge magnitude, *v* the velocity vector, *r* the distance of the charge from whatever point in space is in question, θ the angle between *r* and *v*, and *c* a universal constant having no necessary relation at all to optics, and none to velocity except that its dimensions happen to be those of velocity. We shall return to considering *c* separately and in detail later.

Second is the reverse action of magnet on charge, which necessarily accompanies the Biot-Savart Law if Newton's Third Law is to remain valid. This is the *Lorentz force*

$$f = e\,(E + \frac{v}{c} \times B)$$

or

$$f = \frac{e}{c}\, v \times B$$

if considering the magnetic force alone. Now *E* and *B* are the electric and magnetic field quantities when independent of the particle. Again *c* appears as a universal constant.

Third is the force of electromagnetic induction. Ampère's very early and able hypothesis concerning the origin of magnetic fields shows as

$$\text{curl } H - \frac{1}{c}\frac{\partial D}{\partial t} = \frac{4\pi}{c}\, j$$

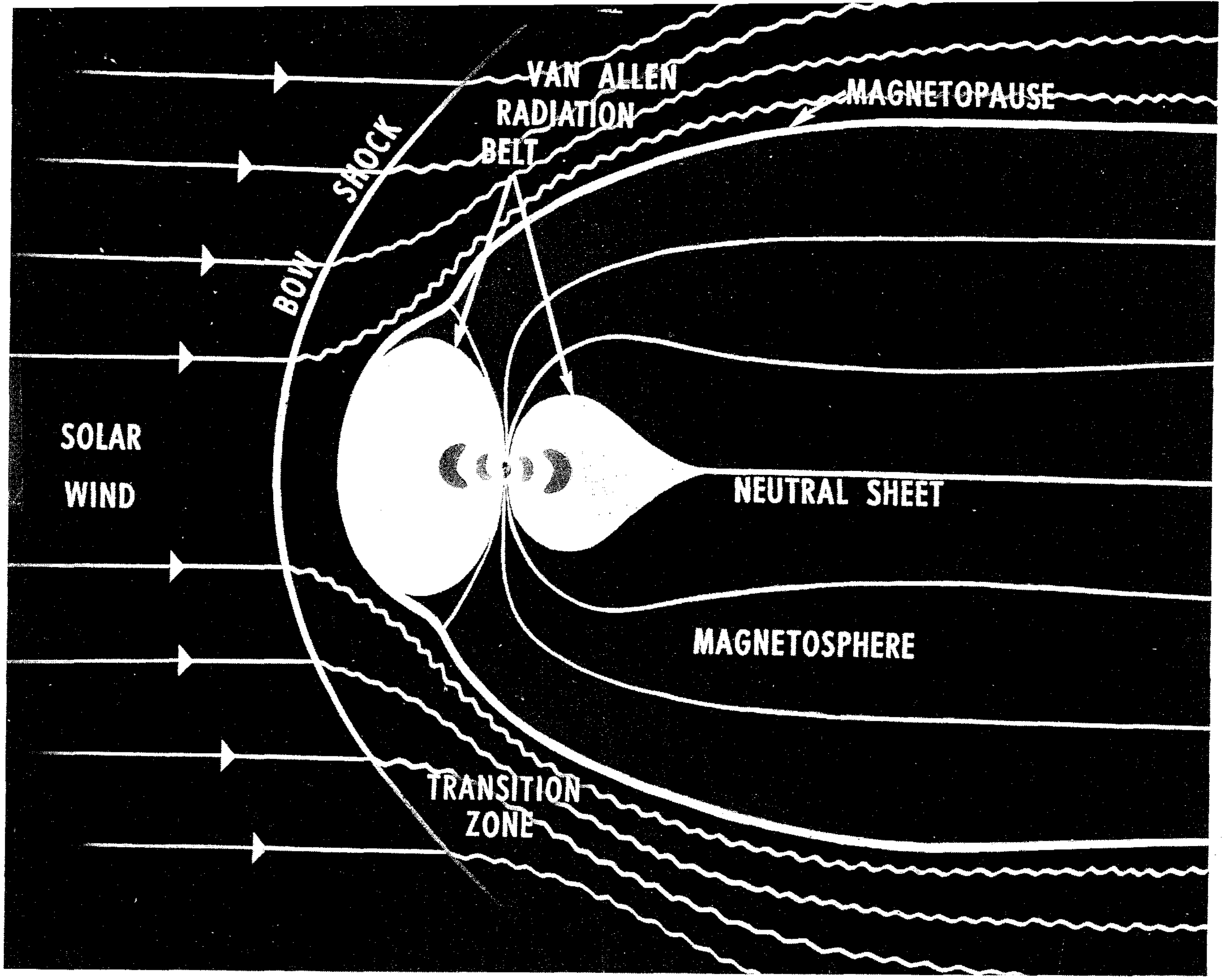
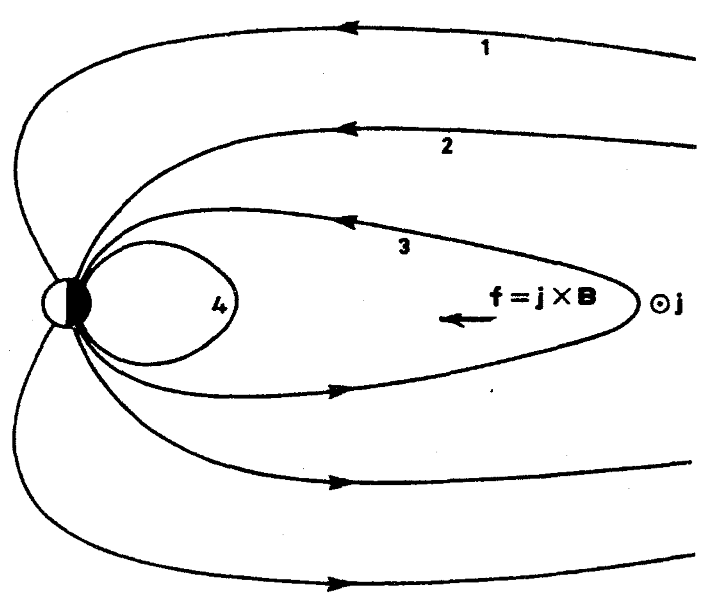


Figure 2: Schematic presentation of the terrestrial magnetosphere released by NASA in 1967.

Courtesy NASA

Figure 3: Simplified schematic representation of the closed magnetosphere model. Field Line 1 defines the most northerly boundary of the magnetotail, and field Line 2 the southern boundary of the northern long-tail section. Below Line 2, flux is being swept into the tail, some to join the long-tail 1-2 and some to remain closed within tens of Earth radii. Field Line 3 is closed, and is either being stretched further down the tail, or is contracting back to the corotating magnetosphere. In either case the current j flows out from the paper, and a Lorentz force $f = j \times B$ is exerted on the plasma. Field Line 4 is the outermost line of the corotating magnetosphere.

From Piddington[267A]



which we have already given in essentially this form when presenting Maxwell's equations. When the current distribution becomes stationary

$$\text{curl } H = \frac{4\pi}{c} j$$

In either case the inevitable *c* appears as a constant necessary to the formulation. The same is true for Faraday's Law

$$\text{curl } E + \frac{1}{c} \frac{\partial B}{\partial t} = 0$$

Bergmann[25] gives the conventional interpretation of this law, which we shall italicize because of its importance in establishing the terrestrial magnetosphere as a *Maxwellian field* embedding the terrestrial "inertial frame" of the Einstein model:

> *The mere change of the magnetic field in the course of time is to induce in space an electric field strength, even in the absence of any electric charges that might be considered the source of this field strength.*

As a passing comment, we might point to the interesting controversy[52 283] over this interpretation stirred up by Carl Hering[161] many years ago, who showed experimentally that a mere change in flux is not sufficient in itself to generate an actual current in a conductor, unless the conductor is given *motion* relative to the "lines of force".

More importantly, we wish to quote Bergmann again regarding the velocity vector *v* appearing in both the Lorentz force and the Biot-Savart Law:

> ...the vector V represents the motion of the electric particle *relative to the source of the magnetic field.*

The italics are his - - or we would have put them there ourselves.

For it has been known since the 16th Century that the Earth posseses an internal and dipolar magnetic field. Today it is the best studied of all astrophysical magnetic fields. The average strength at the lithospheric-hydrospheric surfaces of the planetary body is ≃0.5 gauss; the deviation from a perfect dipole is 10-20% on a continental scale; surface irregularities grow and decay in an apparently random fashion on a time scale $\simeq 10^3$ years; and the entire pattern drifts westward at a rate of $\sim 0.2^\circ$ longitude per year. Presently the dipole axis is tilted $\sim 10^\circ$ relative to the rotational axis[212].

While the origins of this field are believed to lie in convective motions of the fluid planetary core[110]; there are some grave problems presented by this theory, such that one is reminded of the century-old suggestion of G. Hinrichs[166] that the origin is external, rather than internal. Since the planetary body has the nature of an electrical conductor, its rotational motion within the heliosphere should "cut lines of force" and generate a field according to the Maxwellian equations. This kind of action would explain fields exhibited by other planetary bodies which are not believed to have a fluid core. In fact, one might propose that the heliosphere itself derives in this manner from rotation of the solar body within the galactic magnetosphere or galactosphere.

Be that as it may, the basic formulation of present interest is the conventional hydromagnetic equation

$$\frac{\partial B}{\partial t} = \nabla \times (v \times B) + \eta \nabla^2 B$$

where all symbols have been previously introduced except the magnetic diffusivity

$$\eta = c^2/4\pi\sigma$$

and σ is the electrical conductivity of the "fluid". Of course the field quantity *B* will hereafter refer to the magnetospheric field in question, and specifically to the geomagnetic field when discussing Earth dynamics. Here we see the constant c again, and the velocity vector V which Bergmann assures us has *the local magnetic field as its locally absolute rest frame.* The hydromagnetic equation then tells us that the lines of force of the magnetic field *tend to move with the fluid while simultaneously diffusing through it*, the extent of the motion being measured by the relative importance of the first and second terms on the right. Also, just as the field is affected by the motion of this magnetohydrodynamic fluid - - which in the terrestrial case is the magnetospheric plasma specifically provided by the gaseous atmosphere and ionosphere - - so is the motion influenced by the stress of the magnetic field. The complete expression then becomes

$$\rho \frac{\partial V}{\partial t} + \rho V.\nabla V + 2\,\rho\Omega X V =$$

$$-\nabla p + \frac{1}{4\pi}(\nabla X B)\ X B - \zeta\nabla X\nabla X V + F$$

where ρ is the density and ζ the viscosity, Ω is the rotation and p the effective pressure due to centrifugal force.

As for F, this is the imposed force responsible for the fluid motion; and the magnetic stress is the familiar Lorentz force of our earlier discussion, which we can write

$$F = c^{-1} j X B$$

$$j = (\frac{c}{4\pi})\nabla X B$$

This force can be decomposed through a common vector identity into the conceptually descriptive

$$\frac{1}{4\pi}(\nabla X B) X B = -\frac{1}{8\pi}\nabla B^2 + \frac{1}{4\pi} B.\nabla B$$

where the magnetic stress displays itself as (a) an isotropic magnetic pressure

$$B/4\pi$$

and (b) a tension along field lines

$$B^2/8\pi$$

reminiscent of tension in elastic strings. But note the geocentric c within the Lorentz force which generates the form for the equations of magnetic stress. Should Michelson and Morley - - or any of their tedious train of followers up to present times - - really have seriously searched for an effect of the planetary velocity v on this inframagnetospheric velocity c? Incredible!

Since every physicist now knows of the Van Allen radiation belts, and that beyond the electrodynamic neutrosphere of the atmospheric reaches lies the ionosphere, then the collision-free zone of the magnetosphere proper, let us close this discussion with a quick glance at two phenomena within the latter: (1) Plasma frequency, and (2) radio "whistlers". We could perhaps add the aurorae borealis and australis, though it should be self-evident that their optical field disturbances are unaffected by any planetary velocity v.

Consider an electron of mass m and charge q which takes on an oscillatory motion at that frequency f of the wave, which is characterized by its periodic electric field

$$E = E_0 e^{i\omega t}$$

Since this is equivalent to a current qV where V is the velocity of the electron, V can be easily calculated from

$$m\,(dV/dt) = qE$$

Then for N electrons per unit volume, the current becomes NqV which, added to the Maxwell displacement current, modifies the index of refraction such that

$$n^2 = 1 - (\frac{f_o}{f})^2$$

where

$$f_o{}^2 = (Nq^2)/(4n^2 m\varepsilon_o)$$

Here f_o is the plasma frequency for a free-space permittivity ε_o, and *the index of refraction n is the ratio between the velocity of waves in a vacuum - - namely c - - and in the plasma*. Naturally, the velocity c has the same geocentric reference axes as the magnetosphere within which the plasma generates its phenomenology.

As for the historic radio "whistler" associated with storm conditions, first given published mention by Barkhausen in 1919, this was found in later years to involve the cyclotron or gyrofrequency

$$f_b = qB/2\pi m$$

where m is the mass of whatever charged particle is in question. The gyration or spiralling arises from this particle behaving like a tiny magnet having a magnetic moment

$$\mu = -\frac{W_\perp}{B^2} B$$

which opposes the induction B. It may also be said to be equivalent to an electric current which generates its own magnetic induction. The associated wave train remains close to the magnetic lines of force within the magnetosphere, travels from one geomagnetic hemisphere to the other, and in so doing drags its lower frequencies throughout progressive echoing until the arrival of the wave packet takes the form of a high → low slide called the "whistler". Its timing t for passage between hemispheres becomes

$$t = \frac{1}{2c\sqrt{f}} \int \frac{f_o}{\sqrt{f_b}}\, ds$$

where ds is directed along the line of force, and c as usual is the velocity of light relative to the geocentric coordinates of the magnetospheric field which embeds it. These examples should now suffice to prove our point.

As a result, there develops a space model which, for the specific case of the terrestrial magnetosphere but with general application to all the bodies of astrophysics, specifies a *locally absolute rest frame, within whose domain the universal constant c refers to that specific Maxwellian field, and relative to which the velocity v has its proper reference*. Let us now turn to something that is really quite ironic:

Experimental physics has beautifully confirmed this through the long line of tests beginning in 1810 with Arago[9] and then Fresnel[129], next with Babinet[12 13] in 1829 and 1839, Fizeau[120 121] in the 1850's, Maxwell[238] in the 1860's, Mascart[235] in the 1870's, Michelson[244] and Michelson with Morley[246] in the 1880's, Lodge[217] in the 1890's, Rayleigh[285] and Brace[37] with Trouton and Noble[339] in the first few years of the present Century; next through the increasingly refined studies of Tomaschek[337] in 1924, Joos[179] in 1930, Kennedy and Thorndike[188] in 1932, Ives and Stilwell[172] at the close of that decade, Cedarholm and his associates[49] in the 1950's, Mandelberg and Witten[231] with Jaseja *et al.*[174] in the 1960's; finally to the 1979 study of Brillet and Hall[39] which establishes the stability and exactitude of the geospheric rest coordinates to something of the order of one part in 10^{15}. For although relativists have indeed never viewed it in this light, the statement as given stands far more defensible than the popular alternative which assumes that (a) such a local rest frame for electromagnetics does not exist, (b) the planetary velocity differential v obtains at the lithospheric surface, (c) that the null datum accordingly means the planetary motion is not detectable, whereupon (d) no motion through empty space is detectable.

Interestingly, the Rayleigh and Brace experiments with double refraction were designed to test for the FitzGerald-Lorentz contraction; and the data being null as usual, the tests on the one hand again confirmed the rest coordinates of the embedding terrestrial field. But on the other hand, they *disproved the thesis of contraction* - - if one insists upon the nonmagnetospheric "naked-Earth" model, as everyone did at the time, and apparently still do among relativists. For all parties agreed, and still agree, that the Earth has an orbital velocity v, whereupon the contraction should occur according to either Einstein or Lorentz. When Einstein shortly presumed to *dismiss* the ether as either noneffective or nonexistent, he nevertheless *retained* the contraction as an inherent feature of motion - - as did Lorentz, Poincaré and Larmor who also retained the ether. If the reasons for this experimental nonappearance of contraction in terms of either the Lorentz or Einstein models has ever been given satisfactory presentation, it has not been discovered in the present study.

Similarly Fizeau's famed experiments with water-filled tubes, as well as his lesser known attempts[121] to measure the planetary velocity after the manner of Arago[9] and Fresnel, *confirmed the local rest coordinates*. For if there were actual motion of his apparatus relative to the planetary "ether wind" of ~ 30 km sec^{-1}, why should its directional effects not completely dominate, or even mask out, his comparatively trivial water velocities of a few meters sec^{-1}? Einstein in later years admitted to having given much thought to the Fizeau experiments prior to phrasing his Special Theory. He answered his problems, however, with dismissal of the ether[91]. But when he later recanted and accepted an ether in field dress[100 101 104], why was that field not admitted to be geocentric as the Fizeau experiment dictated and all others indicated? As the compasses of every ship at sea depend upon? And as the geophysicists of the 20th Century have now defined in such elaborate detail?

Certainly these men were familiar with the works of Karl Friedrich Gauss. Decades before Einstein was born, Gauss developed basic mathematical forms for the planetary magnetic field, in days when the relationship between electricity and magnetism was not yet under attention. His primary assumption was that the field B was derivable from a scalar potential V represented by a series of spherical harmonic functions

$$V = a\sum_{n=1}^{\infty}\sum_{m=0}^{n}\left[\left(g_n^m \cos m\phi + h_n^m \sin m\phi\right)\left(\frac{a}{r}\right)^{n+1} + \left(G_n^m \cos m\phi + H_n^m \sin m\phi\right)\left(\frac{r}{a}\right)^{n}\right] P_n^m(\cos\theta)$$

where the g_n^m, h_n^m, G_n^m, H_n^m are harmonic coefficients or multipole parameters, and

$$B = -\text{grad } V$$

A quarter-century before Einstein's birth, the Ampère-Faraday-Maxwell line of inquiry was already producing

$$\nabla \times I_o = Q_m$$

which is the modern

$$\nabla \times A = B$$

And yet eleven years before Einstein's birth, Maxwell had the relationship

$$\nabla \times I_m = 4\pi \frac{\partial Q'_c}{\partial t}$$

which is our

$$\nabla \times H = 4\pi \frac{\partial D}{\partial t}$$

or

$$\nabla \times H = J + \dot{D}$$

So when Einstein properly seized upon the concept of a field to replace the outmoded cosmic ether, why did he not go full circle and relate this historically beautiful convergence of electricity and magnetism, which consummated in the very field equations serving as the subject of his 1905 paper, to the known terrestrial magnetic field which nested those instruments whose response of rest-position type he found so puzzling?

In 1913 Sagnac[302 303] performed experiments not acknowledged in the foregoing list because his results were non-null. But his rotating apparatus was in motion relative to the terrestrial field; whereupon the non-null data, derived from the known relative motion, proved again the geocentric rest coordinates of the terrestrial field. These experiments were repeated by Pogany in the 1920's, and Dufour and Prunier[81] in 1937 and 1942, again by Macek and Davis[228] in 1963. It is quite fascinating to the historian to observe the great hiatus in published comment[50] on Sagnac. For his experiments -- unlike those of the stationary null -- are an insuperable embarrassment to the Special Theory. However, let us return to considerations of the magnetosphere itself.

Three features of this locally absolute domain command attention so far as electrodynamics and relativistic physics are concerned: (1) The domain's outer boundary, (2) the irrotational nature of the field in the absence of matter, and (3) its corotational nature in the presence of matter. The first feature has been very thoroughly explored with our space probes [312 190 212]; and we can tentatively accept with assurance either the magnetopause or the magnetosheath as the null or equipotential between the heliocentric and geocentric Maxwellian fields. The only really important point is that both lie at positions many Earth diameters *beyond* the surface of the lithosphere, where every one of the historic researches of relativistic physics has been conducted. The second should direct the attention of experimental physicists back to the vastly significant and much-neglected experiments of Oliver Lodge[217] in 1893. For the interpretations of his null data have never taken into consideration the corotational and irrotational aspects of magnetospheric fields as geophysicists now know them. Perhaps his experiment illustrates the irrotational aspect - - or possibly the swamping of a small local field by that of the geosphere. As for the third feature in our list, this concerns a phenomenon which in turn concerns the measure of the second.

That is, ionospheric plasma which shares the planetary rotation polarizes to produce a *corotating* electric field

$$E = -(\omega X r) X B$$

where B is the planetary magnetic field, ω the planetary spin frequency, and r the radius vector relative to the spin axis. In cosmology and astrophysics, theories concerning bodies such as pulsars and neutron stars have depended heavily upon a corotating magnetosphere since Gold's[139] proposal in 1968. The role of the atmosphere is to provide a viscous transfer of momentum from lithosphere → ionosphere, where the plasma is then set into corotation by collisional friction between ions and neutral particles. Therefore planets having both atmosphere and magnetosphere are both predicted and found to exhibit corotation. Beyond the ionosphere, where essentially empty space takes over from matter, and the field equations tend to pass B → H and D → E, the inner corotating electric field zone still exerts an effect upon the outer magnetic field envelope, tending to bring the lines of force into corotation. But this aspect continues in debate so far as quantitative aspects are concerned; and we can only say that the present consensus has the corotational limit extending to the inertial limit[165] with the situation indecisive at greater radial distances.

Such a statement is sufficiently significant for the present discussion of the interrelationship between radiation and inertia, energy and mass. In the case of the Earth, this "plasmapause" lies at a minimum distance of ∿5 Earth radii, depending upon whether one measures toward the highly compacted bow shock or the greatly extended tail, the whole magnetospheric form being governed in points of size by the competing and embedding heliocentric field, and made cometary in form by the "solar wind". Hill[165] finds the "corotational lag" to be

$$L_o = (\pi \Sigma R_p^2 B_p^2 / M)^{1/4}$$

where L_o is in terms of planetary radii, R_p is the planetary radius, B_p the surface dipole strength, Σ the height-integrated Pedersen conductivity of the atmosphere, and M the total rate of production and outer transport of plasma mass. The critical distance L_o turns out to extend well beyond any reach of the geosphere, also far beyond the reach for the typical pulsar model; but for Jupiter $L_o \approx 60$, bringing it well within the "Joviosphere" at least part of the time. Both R_p and B_p for the Earth are a full order less than that for Jupiter, the value for M some two orders smaller, while Σ is a couple orders greater. However, *convection due to the solar wind* overwhelms corotation in the geosphere at $L_o \gtrsim 5$.

The Velocity C

Perhaps we can term this new model M-Space because structured from Maxwellian fields of magnetospheres, each bounded by its magnetosheath and magnetopause, interlocked and/or embedded one within the other - - much as one might discuss a G-Space when the forces under consideration are gravitational rather than electromagnetic, where the phenomenology belongs to mechanics rather than electrodynamics, and for which the field boundaries are properly the gravitational equipotentials rather than the magnetopause. In either case space is absolute because the fields are internally so, and are contiguous; but the proper reference frame is the gravitational for mechanics, and the electromagnetic for electrodynamics.

This then brings our discussion back to the original inquiry regarding the constancy of the velocity of light - - referred to as Einstein's "half-postulate", since we are only interested in this proposition that *c* represents a cosmic velocity limit, not that it also stands independent of motion on the part of either source or observer. Completion of the inquiry, however, will rule upon this "other half" as well.

Returning to Maxwell's original founding of the field equations[236], we first find him fully confirming that which we have just developed as the locally absolute rest frame governing electromagnetics, and therefore the proper reference frame for relativistic physics. Maxwell said:

> The electromagnetic field is that part of space which contains and surrounds bodies in electric or magnetic conditions.

This is by definition the magnetosphere. Einstein said essentially the same thing when he wrote[101]:

> There is no such thing as an empty space, *i.e.* a space without field.

In the course of reducing Faraday's experimental data to field theory, Maxwell found himself confronted with the fact that, while *electromagnetics* and *electrostatics* both involved measurement in terms of *mechanical* action, their units were not only independent of one another, but incompatible. To pass from one system to the other required conversion of every quantitative measure. Consider two bodies m_1 and m_2 carrying charges e_1 and e_2 and separated by a distance of r. Then the potential ψ can be expressed as

$$e_2 \frac{d\psi}{dr} = \frac{\kappa}{4\pi} \frac{e_1 e_2}{r^2}$$

where κ is the coefficient of "electric elasticity". Now, if one "electromagnetic unit" or *emu* contains *c* "electrostatic units" *esu*, then

$$c^2 \frac{e_1 e_2}{r^2} = \frac{\kappa}{4\pi} \frac{e_1 e_2}{r^2}$$

and

$$\kappa = 4\pi c^2$$

Historic experiments by Weber and Kohlrausch[346] measured κ with a condenser of known capacity charged with a known electromotive force, and discharged through a sensitive galvanometer. They then deduced the proportionality constant *c*. Optics never entered at all - - except for the light needed to read their instruments. Foucault[125] on the other hand used nothing but optics - - revolving mirrors and transmitted light signals. Thereafter experimental physics flooded the field with reports (a) refining the value for *c*, (b) proving it to be precisely the velocity value for a wave or any other type of disturbance traversing the Maxwellian field, and (c) relating it equally to the whole range of the electromagnetic spectrum from radio waves and heat to x-rays and gamma rays.

While this in itself should suffice to establish Einstein's "half-postulate" as holding *within any given magnetosphere* or single Maxwellian field - - for the obvious reason that to argue an altered *c* would be to argue an altered ratio emu/esu - - let us look more specifically at the disturbance of wave type in question. Consider some field point *P* at x, y, z, and time t, within some magnetospheric or Maxwellian domain such that

$$B = \mu_0 H$$

$$D = \varepsilon_0 E$$

where μ_0 and ε_0 are the respective magnetic and electric space constants[290]. Then in

M.K.S. units the field equations become

$$\text{curl } E = -\mu_0 \frac{\partial H}{\partial t}$$

$$\text{curl } H = \varepsilon_0 \frac{\partial E}{\partial t}$$

$$\text{div } E = \text{div } H = 0$$

Substituting curl E for curl H

$$\text{curl curl } E = -\mu_0 \frac{\partial}{\partial t} \text{ curl } H = -\mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2}$$

But

$$\text{curl curl } E = \text{grad div } E - \nabla^2 E$$

and since in empty space div E = 0, then

$$\nabla^2 E - \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2} = 0$$

With this we have arrived at a *wave* equation describing the behavior of the electric vector of radiation at the point *P* and time *t* due to an accelerating system of charges. The wave velocity $(\mu_0\varepsilon_0)^{-\frac{1}{2}}$ becomes precisely that of the field constant *c*

$$c = (\mu_0 \varepsilon_0)^{-\frac{1}{2}}$$

Furthermore, this value is *completely independent of the velocity of the accelerating charges* -- Einstein's "source", which a later generation would claim so novel. In fact, one is reminded of Young's prophetic Proposition I under his Hypothesis IV[353]

> All impulses are propagated
> in a homogenous elastic
> medium with an equable velocity...

While his "medium" was long identified with the "ether" of the ancients, we see it now here as the field within each *singular* Maxwellian domain with or without an associated ether concept. No experiment conducted *within* such a domain, by an instrument at rest relative to that domain's rest coordinates, can arrive correctly at anything but a transmission velocity *c* and a null v = 0 for any other contributing velocity, whether from internal motions such as those of the accelerated charges, or from external motions of the source relative to the local domain. Immediately one sees (a) corroboration of the hypothesis of the *constancy* of *c* within every Maxwellian domain as measured *within* that domain, (b) corroboration of the hypothesis of the *limiting value c* for all motions taking place within any given Maxwellian domain *as measured within that domain*, and (c) a ready basis for rejecting ballistic theories involving $c \pm v$ velocities as argued by Ritz[288] and his numerous proponents[77 126 156].

Nevertheless, let us follow Rosser[290] in taking one last look at these important matters, considering a system Σ' in uniform motion relative to the Σ just discussed, such that we now have a point P' with coordinates x', y', z', t', and the same situation of accelerating charges. The components of the equations merely become primed, including μ_0 and ε_0:

$$\text{curl}' E' = -\mu_0' \frac{\partial H'}{\partial t'}$$

$$\text{curl}' H' = \varepsilon_0' \frac{\partial E'}{\partial t'}$$

$$\text{div}' E' = \text{div}' H' = 0$$

Typical coordinates for the *curl'* and *div'* are

$$\frac{\partial H_x'}{\partial x'} + \frac{\partial H_y'}{\partial y'} + \frac{\partial H_z'}{\partial z'} \quad \ldots$$

and since the fields E', H' must be defined relative to their own system, as was done for E, H, the curl E' becomes

$$\nabla'^2 E' - \mu_0' \varepsilon_0' \frac{\partial^2 E'}{\partial t'^2} = 0$$

whereupon the wave velocity again becomes

$$c = (\mu_0' \varepsilon_0')^{-\frac{1}{2}}$$

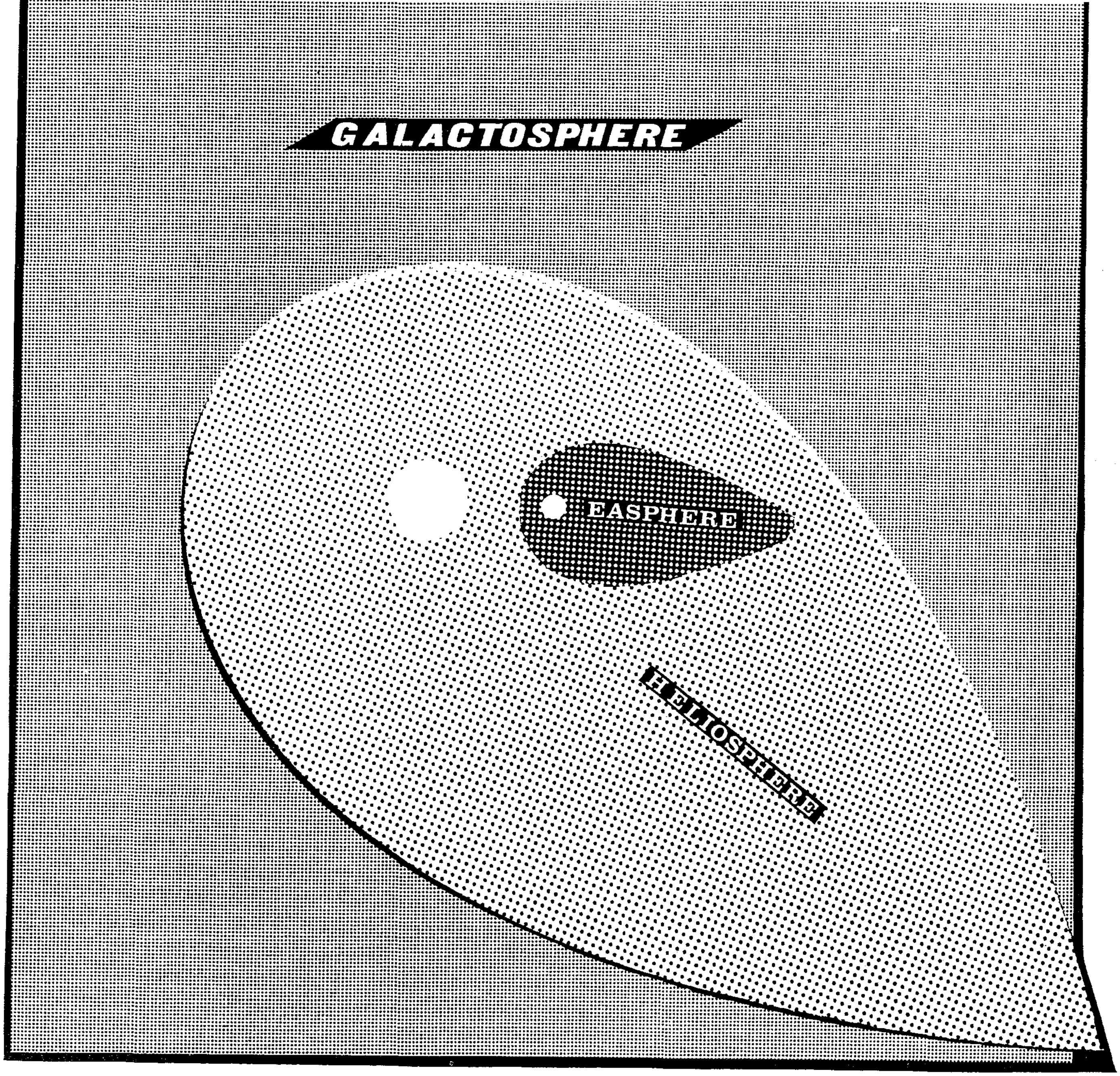


Figure 4. Tentative model for the magnetospheric structuring of space. Within each of the autonomous Maxwellian domains, the lesser embedded by the greater: (A) All laws of physics relative to electromagnetics are identical and equally valid, (B) the velocity *c* is a field constant, and (C) the rest frame is "locally absolute".

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and is independent of the velocity of the source.

We can close this section with the sketch in Figure 4 summarizing what we have done by way of structuring space with locally autonomous electromagnetic fields - - Maxwellian domains or magnetospheres, extending in the case of the Earth many Earth radii into space, whether built of "ether" or perhaps of Einstein's *selbständig existierende Dinge* - - within each of which all laws of electromagnetics hold equally true; also Figure 5 showing details of the highly significant matter of stellar aberration. As Resnick[286] stated:

> If we are to describe events, our first step is to establish a frame of reference.

This we have done; moreover, each frame is not only autonomous and equally governed by the same laws in any part of the universe, thus satisfying the requirements of the First Principle of Physics; but the frames are specifically those electromagnetic frames belonging to the electromagnetic experiments. Unfortunately, this stands in some distinction to Einstein's original statement of his First Postulate[103]:

> The same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good.

<u>It does by no means necessarily follow that inertial and electromagnetic domains are identical</u>.

Again to quote Resnick[286], and this time as a spokesman for the consensus of historic relativity:

> If an ether exists, the spinning and rotating Earth should be moving through it. An observer on Earth would sense an "ether wind", whose velocity is v relative to the Earth.

Nothing in modern geophysics and magnetospheric physics conveys any reason for presuming that an observer on the deeply embedded lithospheric surface of the total magnetospheric planetary body would experience an "ether wind", or indeed anything but the null datum v = 0 just mentioned. The magnetospheric body, not the lithospheric, moves *through* the heliospheric ether or field; and until the instruments of experimental physics are brought beyond the magnetosheath - - the boundary of the local Maxwellian domain - - no more "ether wind" will be detected than one might expect from testing for an atmospheric wind inside an airplane instead of out on the wing.

As for aberration, the present model seems so simple as to be obvious: A beam from some source outside the geosphere strikes the magnetosheath at time t, immediately leaving its relationship to the heliospheric field and thenceforth traveling relative to the field coordinates of the geosphere. In effect, this is to establish a pseudo-image on the outer wall or "domain ceiling", which thereafter acts as its own source, precisely as the case for sonics when a moving compartment is struck on its outer wall; and when the beam has reached the telescope at time t', the geosphere has moved a distance $v(t' - t)$ relative to the heliosphere and original beam entry. This displaces the image from the actual position by the usual angle $\theta = \sin^{-1}\beta$.

Suprisingly enough, the value $v = 30$ km sec^{-1} has been used unquestioningly since the first tests; yet this is the value for Earth motion relative to *heliocentric coordinates*. Nobody seems ever to have mentioned the strange distortions that should appear in the annual aberration circle, or ellipse, in view of the known greater motions of the solar system relative to the external stellar beam sources. Thus the Smoot, Muller, Gorenstein[250 313] group, following Peebles' suggestion, have measured the motion of the solar system relative to the 2.7°K background radiation an entire order greater than the planetary velocity v, and a galactic motion even twice that. From astronomical data Rubin, *et al.*[296] have found a celestial velocity of the solar system $v_s = 600 \pm 125$ kps in the direction $\ell = 135°$, b = -8°, and even a motion of the Local Galactic Cluster of ∿450 kps toward $\ell = 163°$, b = -11°.

One must therefore ask: From whence the simple symmetrical ellipse of stellar aberration? And if $\beta = v/c$ relative to a cosmic background of either radiation or ether, why should $v = 29.8$ *km/sec*, which is precisely and uniquely the local motion of our geosphere relative to its embedding heliosphere? This short-sighted interpretation is perhaps excusable for those living in days midway between Ptolemy and modern cosmology, when Copernicus had only upgraded astronomy from geocentricity to heliocentricity; but today the scenario has expanded even beyond the galactocentric - - and nobody yet asks why aberration should find its measure in the local $v = 29.8$ *km/sec*.

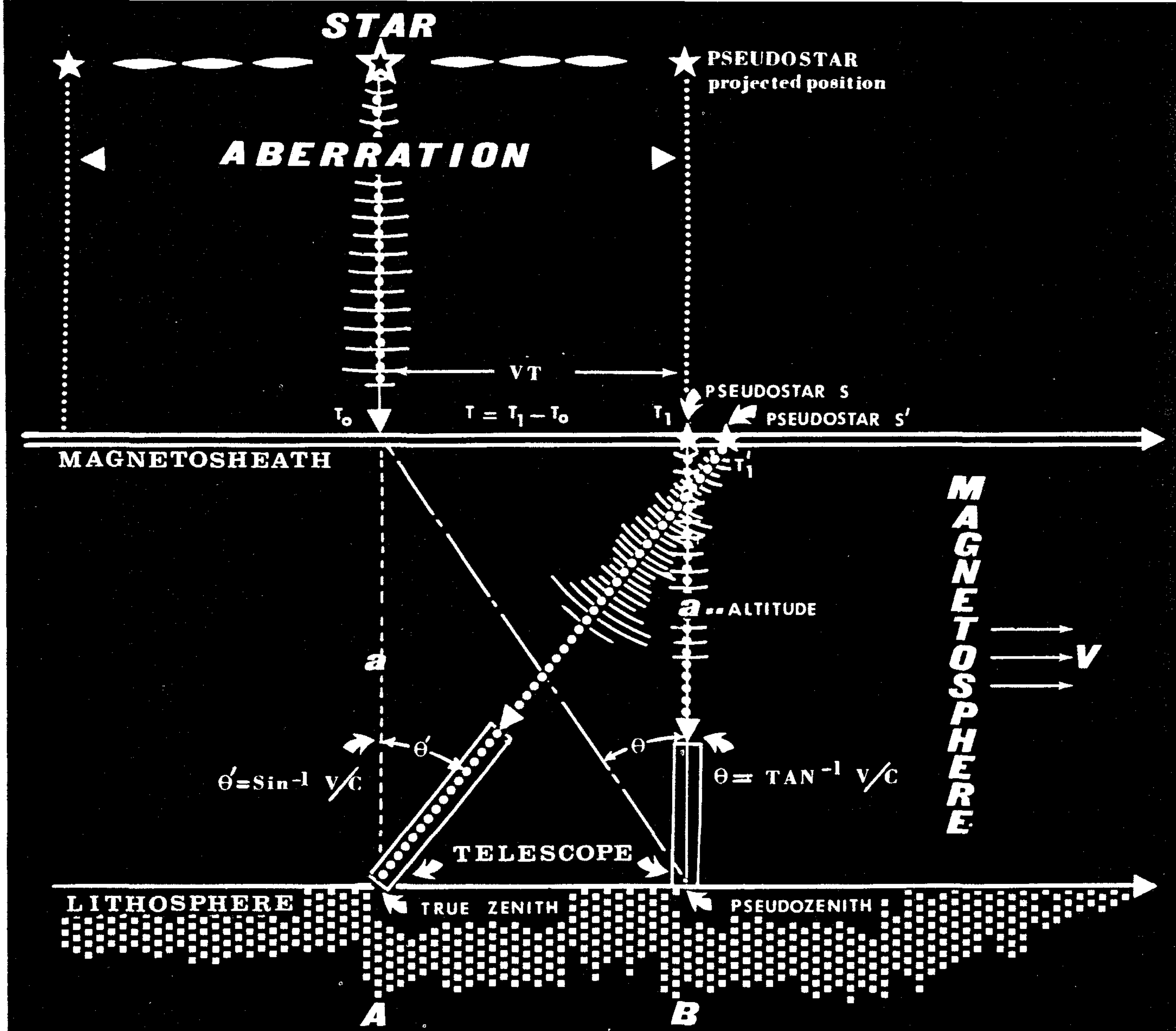


Figure 5. Aberration according to the magnetospheric model. As the terrestrial magnetospheric body, say, moves to the right in the course of its motion within the heliosphere which embeds it, electromagnetic signals within the field of the heliosphere, traveling at velocity *c* relative to that field, impinge upon the magnetosheath of the terrestrial field and then continue at velocity *c* relative to the new field coordinates. The *true* sky pattern accordingly becomes imprinted as an *apparent* pattern on the Earth observers' "ceiling"; and the displacement of the latter from the former becomes precisely measured by the aberration constant $\beta = v/t$. (A) Star at actual zenith, telescope tilted; (B) star at presumed zenith, telescope vertical.

For the two facts of (1) the symmetry, and (2) the uniquely identified velocity value should have long ago convinced relativists in turn (a) that aberration is a function of a protected embedded geosphere relative to the protective and embedding heliosphere only, (b) that the incoming stellar beam has adjusted its fixed velocity *c* to the geospheric coordinates, and (c) that previous to the geospheric entry, it had similarly adjusted its travel to velocity *c* relative to heliospheric coordinates.

Prediction of Relativistic Mass

With the limited velocity c thus established, these two considerations immediately command attention: (1) The c probably establishes an asymptotic limit for motion within an electromagnetic field much as the sonic velocity sets one for both aerodynamics and hydrodynamics, and (2) the most common relationship for such asymptotic approaches in physics and mechanics is the cosine/secant relation

$$\gamma^{-1} = \cos\theta = \cos(\sin^{-1}\frac{v}{c}) = \cos\sin^{-1}\beta$$

$$\gamma = \sec\theta = (\cos\sin^{-1}\beta)^{-1}$$

Let us return again to those early principles of physics, specifically the conservation laws and the radiation momentum established by Maxwellian field theory. As for the force formulation

$$F = d(mv)/dt$$

we can either grant this to Newton's original proposal, as earlier explained, or take it as inherent in his definition of force as the rate of change of momentum, or again simply introduce it as the proposition at hand, namely that mass is a variable. In no case shall we touch either the Special Theory or the Lorentz transformation.

Consider the kinetic energy in its ordinary form for mechanics and physics:

$$E_k = \tfrac{1}{2} mv^2 = \tfrac{1}{2} pv$$

We can then write

$$\begin{aligned} dE_k = vdp &= v \,.\, d\,(mv) \\ &= mv \,.\, dv + v^2 dm \\ &= pdv + v^2 dm \end{aligned}$$

But for $v = c$ we have already shown that

$$dm = dE/c^2$$

whereupon

$$\begin{aligned} dE_k &= c^2 dm \\ &= mv \,.\, dv + v^2 \,.\, dm \end{aligned}$$

$$c^2 \,.\, dm - v^2 \,.\, dm = mv \,.\, dv$$

so that

$$(c^2 - v^2)dm = mv \,.\, dv$$

and

$$\begin{aligned} (\frac{c^2 - v^2}{c^2}) \,.\, dm &= \frac{mv \,.\, dv}{c^2} \\ &= (1 - \frac{v^2}{c^2})dm \end{aligned}$$

Dividing by m and rearranging:

$$\begin{aligned} (1 - \frac{v^2}{c^2})\frac{dm}{m} &= \frac{v \,.\, dv}{c^2} \\ &= -\tfrac{1}{2}\, d\,(1 - \frac{v^2}{c^2}) \end{aligned}$$

such that

$$\frac{dm}{m} = -\tfrac{1}{2}\,\frac{d(1 - \frac{v^2}{c^2})}{(1 - v^2/c^2)}$$

which integrates to

$$\log m = -\tfrac{1}{2}\log(1 - \frac{v^2}{c^2}) + \log m_0$$

where $\log m_0$ as integration constant precisely expresses the rest mass m_0. Therefore

$$\log\frac{m}{m_0} = \log(1 - \frac{v^2}{c^2})^{-\frac{1}{2}}$$

and

$$m/m_0 = (1 - v^2/c^2)^{-\frac{1}{2}}$$

or

$$\begin{aligned} m &= m_0\,(1 - v^2/c^2)^{-\frac{1}{2}} \\ &= \gamma m_0 \end{aligned}$$

which introduces exactly that cosine (secant) factor which we predicted.

For as already mentioned, this is the same factor found in the linear equations for both hydrodynamics and aerodynamics, extrapolating to infinite values for the various mechanical measurements or forces required to propel mass through the respective medium at $v = c_1$ = Mach 1 using propeller-drive. In ballistics it is the factor which measures the horizontal travel of a projectile fired at angle θ to the horizontal; in optics it controls the shadow of the sundial; in mechanics again, the force required to push a vehicle up a ramp at angle θ. In fact, and as every physicist knows, cos θ is neither more nor less than the direction cosine of a vector which transforms x to its Cartesian component $x' = x \cos\theta$. We call attention to this simple matter in passing merely to prevent attaching special mathematical significance to the form of the Lorentz transformation:

$$x' = \gamma(x - vt) = \sec(\sin^{-1}\beta)\,(x - vt) = \frac{x - vt}{\cos\theta}$$

$$y', z' = y, z$$

$$t' = \gamma\left(t - \frac{vx}{c^2}\right) = \sec(\sin^{-1}\beta)\left(t - \frac{vx}{c^2}\right) = \frac{t - vx/c^2}{\cos\theta}$$

which is seen to differ from the Galilean transformation only in this factor $\cos\theta = (1 - v^2/c^2)^{\frac{1}{2}}$, or rather $\gamma = \sec\theta = \sec(\sin^{-1}\beta) = (1 - v^2/c^2)^{-\frac{1}{2}}$. The whole set of transformation equations resulted from, and continues to express, a very special kind of space model; but they follow as well from acoustics and even ballistics when one expunges from both time and space the secondary Doppler increments due to $(1 - v^2/c^2)$. Thus to retain the constancy of c

$$c = x/t = x'/t'$$

and since

$$(1 - v^2/c^2) = (1 - v^2/c^2)^{\frac{1}{2}} \cdot (1 - v^2/c^2)^{\frac{1}{2}}$$

then

$$c = \frac{\gamma(x - vt)}{\gamma(t - vx/c^2)}$$

which obviously conceals the Galilean transformation, and reduces to it as $v \to v' \ll c$.

This is not the place to argue the choice of transformations; but it is the place to point to this critical factor $(1 - v^2/c^2)^{-\frac{1}{2}}$, the hallmark of both relativistic mass and the Lorentz transformation equations, and to remind ourselves that it arises out of these foregoing considerations *completely independent of any transformation equations*. The Lorentz transformation equations may derive from *it*, but it does not arise from *them*. The reason for this remark is to urge the keeping of intellectual flexibility when it later becomes necessary to judge whether to treat measurements of γm_o and $\gamma\tau_o$ as scalars or vectors when considering transformation.

If we now return to considering the classical kinetic energy

$$E_k = \tfrac{1}{2} mv^2$$

and let m become a variable increasing as shown with $v \to c$, then

$$E_k = \tfrac{1}{2} mv^2 = (m - m_o)c^2 = mc^2\left[1 - \left(1 - \frac{v^2}{c^2}\right)^{-\frac{1}{2}}\right]$$

which becomes the generalized formula for the kinetic energy of any body moving at velocity $v < c$. Expanding the term on the right with the binomial theorem, and letting $\beta = v/c$

$$E_k = m_o c^2\left\{1 + \tfrac{1}{2}\beta^2 + \tfrac{3}{8}\beta^4 + \ldots\right\} - m_o c^2$$

we see that at small values of v/c

$$E_k = \tfrac{1}{2} mv^2$$

while at $v/c = 1$

$$E_k = E = mc^2$$

which ties this line of inquiry to the earlier consideration of mass-energy equilibrium, as well as to the relativistic factor $\gamma = (1 - v^2/c^2)^{-\frac{1}{2}}$.

Remarks on Historical Background

Experimental proof for m = f(v) came about through fusion of five mainlines of thought and discovery, arising conjointly out of theoretical and experimental physics, and rather uniformly consummating within the last third of the last Century:

1. Formulation of the Ampère-Faraday research data into field equations
2. Development of the gas-discharge tube with discovery of "cathode rays"
3. Discovery of radioactivity and the "Becquerel rays"
4. Theoretical modeling with eventual discovery of the electron
5. Discovery of magnetic deflection of the high-velocity electron "rays"

Foremost if not first was Maxwell's set of field equations[236 237], subsequently refined and somewhat modified by Helmholtz[159 160], J. J. Thomson[330], Hertz[163 164], Heaviside[153 154 155], also perhaps such as Boltzmann[34], FitzGerald[117], and Cohn[54]; and these equations then really nested anything that we have to say regarding the other four. For the work of Maxwell, when added to that of Newton, produced a complete physics, short of nuclear physics with its weak and strong interactions; and the other four lines of discovery all dealt with electromagnetics rather than mechanics. Note that we cut the listing of authors short of the intrusion of relativists Lorentz, Larmor, Poincaré, and Einstein for reasons of keeping a clear perspective, since nothing that we have to discuss will depend in any way upon their contributions. Our purpose, as already indicated, is to re-evaluate physics as it stood at the time of the relativistic revolution, so that we can stand where the founding fathers stood and follow their reasoning, then judge it in turn from our own superior stance of modern science. Let us now run quickly through the historic "roots" of our five-fold subject.

Electron theory, upon which the concept of relativistic or velocity-dependent mass essentially became founded, arose out of those long lines of inquiry into the nature of electricity and magnetism which would eventually result in the welding of electromagnetics and mechanics to establish physics. Certainly it is interesting to reflect that electricity in its passage through solid conductors ushered in the age of electrical engineering, that its passage through liquids opened such an entirely different array of phenomena as to alter all of chemistry, and that atomic and nuclear physics were born out of its passage through rarified gases.

Electricity in forms of electrostatics traces historically into immemorial times, the word itself deriving from the Greek ἤλεκτρον or *electron* meaning "amber"; and recorded discussions of giving amber an electric charge by rubbing it with cat's fur and other materials trace back to the pre-Aristotelian times of Thales[300] ∿600 B.C.; to Aristotle's pupil Theophrastus[328 329] several centuries later; and into the Roman Empire with Plinius Secundus[251] of the First Century A.D. Similarly magnetism had been recognized by ancient peoples handling "lodestone", or magnetic iron oxide Fe_3O_4; and the geomagnetic field was also detected at some unknown but early date because of the insistent directionalism always taken by lodestone, or by a piece of iron which had been rubbed with it, when freely suspended in air or floated on water. While origins of the compass are still strongly debated, there is no problem tracing it back to Roger Bacon's *Opus majus* in the 13th Century, Alexander Neckam's *De utensilibus* in the 12th Century, and so on.

In 1600 A.D. Sir William Gilbert (1540-1603), physicist and personal physician to Queen Elizabeth, established magnetism within physics by his great classic *De magnete*[136]; and he introduced the Latin term *vis electrica* for the strange invisible force. In 1650 Walter Charleton coined the word "electricity" in his strange little *Ternary of Paradoxes*; then during the next quarter-century Otto von Guericke initiated the long line of special studies that would eventuate in the dynamo or electric generator two centuries later. His spinning a sulfur sphere mounted on an axis was still limited to electrostatics; but his 1672 book *De vacuo spatia*, in which he discussed this experiment, did add the further dimenion of vacua to the new physics; and shortly after the turn of the new century, in 1705, F. Hawksbee in England not only discovered *luminescence* as an electrical phenomenon attending the rubbing of amber in an evacuated closed vessel, but also found it to be pressure-dependent.

During the 1700's electricity came into physics in both electrostatic and electrodynamic forms, and with its first theoretical models. Beginning about 1733, the Superintendent of Gardens for the King of France, by name C. F. du Fay (1706-90), discovered that sealing wax rubbed with cat fur gave one kind of charge, while a glass rod rubbed with silk gave another, such that bodies attracted to the one would be repelled by the other. He named them respectively "resinous" and "vitreous" electricity, for obvious reasons; and he thereby started the historic *Two-Fluid* model which would stand as a half-truth for over a century, prefiguring the ions of electrolysis, and indeed the proton and electron in the case of hydrogen. The other half-truth was shortly forthcoming from the English colonist Benjamin Franklin (1706-90), who strangely enough had the same lifespan as du Fay. Franklin's famous "kite experiment" of 1752, running current from lightning down a kite string into a "Leyden jar" recently invented by Musschenbroek in Leyden, and independently by Von Kleist in Kummin, established his international prestige. When in 1756, following a study of electrostatic induction, he wrote[247]:

> The electrical matter consists of particles extremely subtle, since it can permeate common matter, even the densest, with such freedom and ease as not to receive any appreciable resistance...

he not only gave the "particle" concept strong standing, but at the same time established a *One-Fluid* model by having these particles represent the electricity - - thus prefiguring the electron. Here is where the terms *negative* and *positive* also arose. For Franklin reasoned that his hand became deprived or "negative" of the particles when they passed into the amber during striking, giving the amber a "positive" supply.

Evacuated systems received renewed attention in 1752 with William Watson picking up the von Guericke-Hawksbee trend and evacuating a tube three inches in diameter and three feet long: Again *luminiscence*, which increased with decreasing pressure. In the 1760's Priestley, also Cavendish, established the Inverse Square Law for electrostatic force, later to become known as Coulomb's Law

$$F = k\,\frac{e_1 e_2}{r^2}$$

which bears such a striking similarity to Newton's Law for gravitational force

$$F = G\,\frac{m_1 m_2}{r^2}$$

both of which still hold sway today. In 1776 Cavendish further suggested that electricity involves two factors: (1) Quantity and (2) intensity - - these of course becoming respectively amperage and voltage. Then in the last two decades of that rather remarkable Century, while the United Colonies were becoming established as the United States, Luigi Galvani (1737-98) and Alessandro Volta (1745-1827) performed those experiments with frog legs and stacked metallic plates which introduced physics to electrodynamics.

Volta's announcement of his "pile" came by way of a letter from him, read to the Royal Society in London by Humphry Davy early in 1800; and by September of that same year Davy had his own paper on the subject in *Nicholson's Journal*, officially launching the subdiscipline of *electrolysis*. Within six months he had another six papers; and while still at age 26, in 1805, he received the Copley Medal of the Royal Society. The "voltaic piles" rapidly increased in size; arcing came under investigation; and Oersted in 1820 performed his famous lecture demonstration which thereafter linked electricity to magnetism, inspired Ampère to christen "electrodynamics" with a classical publication in 1825, and eventually led to Maxwell's fourth field equation

$$\nabla \times B = (4\pi/c)j + (\frac{1}{c})\,\dot{E}$$

Davy's able protégé Faraday quickly entered the field, confirming an observation by Christie in 1826 that magnetism and light were also interrelated, then discovered the laws of induction which became Maxwell's third field equation

$$\nabla \times E = -(\frac{1}{c})\,\dot{B}$$

Faraday himself in 1838 had picked up the evacuated tube technique, though now with use of an electrical circuit rather than merely an electrostatic charge; and he promptly encountered some strange matters of a glow layer on the cathode, separated from the glowing gas column by a "negative glow" or "dark space". Abria in France even obtained a striated structure. The tube used in those early times was known as the "Rumkorff apparatus", having been developed by a physicist of that name working in Paris with an induction coil surrounding an evacuated glass tube. If phosphorus were placed in the tube, both "dark space" and "striations" were easily obtainable in beautiful display. But this mainline of the gas-discharge tube waited upon Heinrich Geissler in Germany to develop his tube with platinum electric terminals sealed into the glass. Plücker[267A] in 1858 published the first outstanding paper in this field using the new tube. At first he followed the traditional setup of air at reduced pressure, and Hg present for evacuation; but then he replaced the air variously with H_2, P, vapors of etheric oils, and so on, finally removing the Hg as well when evacuation was completed. Now there appeared a greenish phosphorescence on the tube walls near the cathode, which Plücker rather cogently concluded was caused by some kind of emanation from the cathode. And as early as this, he noted the influence of a magnetic field on "electrically generated light" - - presumably the famous "arc blow" of modern welding, which in turn had been observed nearly a half-century before Plücker by Davy in England, also Arago in France.

Plücker published important contributions in 1859[270] and again in 1862[271], using commutators and other sophisticated equipment; but the next great hallmark was the work in 1869 of his pupil Hittorf[167], who tested the mysterious emanation from the cathode by placing various materials between it and the wall. Whether conductor or insulator, the blockage was complete.

In 1878 there was a fine research published by De la Rue and Müller[72] using their new "chloride of silver" battery running >1000 cells. But the showpiece of that year was the Bakerian Lecture before the Royal Society of London, given by William Crookes and entitled *On Repulsion Resulting from Radiation*[59]. For this brings us back to Newton's old query whether "...the Rays of light should possibly be globular bodies ..."[256], next ties the story into that of radiation pressure on our so-called Route I, and finally brings us to the very threshold of the discovery of velocity-dependent mass. For one may recall that in 1879 Crookes made his proposal of "matter in a fourth state"[60], adding that here is possibly "... where the corpuscular theory of light may be true"; and this with some further intriguing remarks by Goldstein in 1880 triggered the historic paper[330] of J. J. Thomson the following year, which essentially launched the search for m = f(v), and along both Routes I and II - - radiation pressure and velocity-dependent mass.

So here is the background for the development of relativistic physics in general, and in particular for Einstein's long-puzzling unreferenced paragraph opening his 1905 paper[87]. Thomson said[330]:

> According to Weber's Law, the force does not depend on the actual velocities of particles, but only on their velocity relative to each other, whereas according to the laws we have investigated, the forces depend on the actual velocities of the particles as well as on their relative velocities: thus there is a force between two charged particles moving with equal velocities in the same direction, in which case of course the relative velocity is nothing.

Here we see that which prompted Einstein; and it comes as some surprise to learn that Weber, whose powerful mid-Century hold on electromagnetics[344] was eventually overthrown, not only named *relative motion* as the key to electrodynamics, but avoided the false supposition, so popular throughout those times of ignorance regarding the magnetosphere, that the medium or field of the embedding heliosphere *washed through the planetary body* - - or at least across the face of the lithosphere, rather than being held to great distances by the geospheric field as we now know to be the case. As Thomson continues, he discloses in a single sentence that misconception which would be responsible for launching the new physics, beginning with the famed Michelson experiment[244] of that very same year:

> It must be remembered that what we have for convention called the actual velocity of the particle is, in fact, the velocity of the particle relative to the medium through which it is moving ...

- - this medium being the erroneously presumed cosmocentric "ether" which always appeared in their calculations with the doubled error of presumed heliocentricity.

Picking up the recent observations of Crookes and Goldstein on electrical discharges in high vacuum, Thomson introduced the idea of relativistic mass as follows:

> The charged sphere will produce an electric displacement throughout the field; and as the sphere moves, the magnitude of this displacement at any point will vary. Now, according to Maxwell's theory, a variation in the electric displacement produces the same effect as an electric current; and a field in which electric currents exist is a seat of energy; hence the motion of the charged sphere has developed energy, and consequently the charged sphere must experience a resistance as it moves through the dielectric. But as the theory of electric displacement does not take into account anything corresponding to resistance in conductors, there can be no dissipation of energy through the medium; hence the resistance cannot be analogous to an ordinary friction resistance, but must correspond to the resistance theoretically experienced by a solid in moving through a perfect liquid.
>
> *In other words, it must be equivalent to an increase in the mass of the charged moving sphere,* which we now proceed to calculate ...

We have supplied the italics, since the greatness of this remark was undoubtedly not even recognized by Thomson himself. Using the rather archaic symbols of his time, he calculated the kinetic energy to be

$$\tfrac{1}{2}\iiint \left(F\frac{df}{dt} + G\frac{dg}{dt} + H\frac{dh}{dt}\right) dxdydz = \frac{2\xi\varepsilon^2 p^2}{15a}$$

where p is not the momentum, but the velocity; a the radius; μ and ε the usual permeability coefficient and charge; f, g, h the components of the electric displacement, and so on. If we then let m be the mass of the sphere, the "whole kinetic energy" becomes

$$\left(\frac{m}{2} + \frac{2}{15}\cdot\frac{\mu\varepsilon^2}{a}\right) p^2$$

whereupon

> ... the effect of the electrification is the same as if the mass of the sphere were increased by
>
> $$\frac{4}{15}\ \frac{\mu\varepsilon^2}{a}$$
>
> or, if V be the potential of the sphere, by
>
> $$\frac{4}{15}\,\mu\kappa^2 V^2 a$$

where κ is the inductive capacity, with $\kappa = (9\text{x}10^{20})^{-1}$ at that time. This would mean that Thomson's historic expression for relativistic mass would be

$$m = m_0 + \frac{4}{15} \frac{\mu\varepsilon^2}{r}$$

Exactly two decades passed before this brilliant prediction was put to test, and particularly in the sense of taking advantage of the *V* factor in his fourth equation. The whole story essentially waited for particle velocities greater than those available to the gas-discharge tube at that stage of its development; and this introduces the third "mainline", namely the discovery of radioactivity. It was further necessary to distinguish wave radiation from the corpuscular electron beam, a pursuit consummating with the discovery of the electron on the fourth mainline; whereupon it only remained for the fifth - - the study of magnetic deflection - - to disclose the velocity dependence of mass for this corpuscular emanation. All three of these remaining research fields developed so explosively in so short a period of time as to merit the name "mad decade" for those closing years of the 19th Century. More precisely, this "mad decade" measured itself with interesting precision to either side of the centennial boundary, namely from the discovery of x-rays in 1895 to Einstein's paper in 1905; and it will now be seen in the following story of those critical years that the paths of derivation for both equations A and B were in maturity before the founders of relativistic physics were coming into public attention at all, so far as applying their new concepts to these lines of thought. Let us now attempt to run over in a few paragraphs a section in the history of physics which has supplied the contents for several hundred books.

On 8 November 1895 Wilhelm Röntgen[191 193 203 266 287 342 347] made the astonishing observation that a barium platinocyanide screen, which happened to be lying in his laboratory at some distance from the high-vacuum tube and completely obscured from "line-of-sight radiation", suddenly glowed when the tube was activated, then ceased when turned off. He immediately proceeded to check this surprising indication of a radiation which penetrated opaque bodies. Late in December, Röntgen communicated his observations at a meeting in Würzburg, and on 4 January 1896 to the German Physical Society in Berlin. Within 24 hours of this last, the news media of the entire world were carrying the shocking story of the man who photographed his own skeleton. The classic photograph, which shortly accompanied the story, showed the bones within a human hand, one finger of which wore a ring; and the record now seems to show that this hand belonged to Frau Röntgen - - though he undoubtedly took some photographs of his own hand also. This then introduced physics to x-rays - - the wave component among the emanations from the high-vacuum discharge tube. Interestingly, this year of 1895 marks the *discovery* date for x-rays;but the radiation had obviously been produced in laboratories using high-voltage vacuum discharge a full century back, and perhaps even as early as 1785 by William Morgan when he was still restricted to electrostatics.

At l'École Polytechnique in Paris in 1896, Antoine Henri Becquerel[23] initiated a series of six papers in *Compte rendus* for 1896 alone, with others following in 1897; but his attention, rather than upon discharge tubes, concerned *naturally occurring emanations* that might be found from materials known for their fluorescence. Potassium uranyl sulfate $K_2SO_4 \cdot UO_2SO_4 \cdot 2H_2O$ was one of these; and when its crystals, wrapped in black paper and placed on a photographic plate, darkened the plate, radioactivity came into physics. Becquerel proceeded to test numerous substances by placing them between plates charged at 100 V, using current fluctuation as a criterion for emanation-induced conductivity of the air. A number of substances evoked a response; but materials containing U were in a class by themselves, separated by at least two orders of magnitude.

On 24 March 1898 Schmidt[307] in Germany submitted a paper showing that thorium was similarly radioactive; but the mainstream remained in France where Becquerel had meantime recommended to Pierre and Marie Curie that they pick up his studies where he had to leave them off due to pressure of other obligations. The story is too well known to labor here, except to say that in July and December of 1898 this famed husband-wife team of physicists initiated their historic series of papers[63 64 65 67 68 306] which isolated and identified the new elements Ra and Po, using the impure ore *pech-blende* or uraninite containing 40-90% U_3O_8. Demarcay[74 75] quickly confirmed this, and established Ra as a new element displaying 16 distinctive spectral lines. Still in 1899, Debierne[21] discovered *actinium*, though his results were not published for several years.

Meantime behind scenes in the year of Röntgen's discovery was the equally epoch-making event of a young New Zealander named Ernest Rutherford, coming from Christchurch to Cambridge on a scholarship to study Hertzian electrodynamics under J. J. Thomson. Rutherford naturally became caught up in the new excitement over radioactivity, moved in 1898 to a professorship at McGill University in Toronto, and in 1899 showed that not only Becquerel rays emanated from U, but also another type of much less penetrating power. Pierre Curie[66] quickly confirmed this for Ra, showing that the one was highly penetrating and subject to deviation in a strong magnetic field, while the other was nondeviable and much less penetrating. And still again in this climactic year which closed the 19th Century, papers by Elster and Geitel[11] Meyer and Schweidler[243], and Becquerel[20] identified the "Becquerel ray" from radioactive sources as having the same fundamental nature as the "cathode ray" from the vacuum tube. The one was merely more powerful than the other.

In 1900 Rutherford[299] opened the new Century with his famed work on atomic physics; and six years later - - with the help of such as Strutt[323] in 1901, Crookes [61] in 1902, DesCoudres[76] and Becquerel[22] in 1903, MacKenzie[229] in 1905, and Huff[169] in 1906 - - he completed the distinguishing and cataloguing of radioactive and vacuum-tube emanations by identifying the sluggish and nondeviating component as the α-particle, or helium nucleus[298].

Electron Identification

There now remain just the two main-lines of electron identification and the measurement of its velocity-dependent mass by magnetic deflection. We have watched magnetic deflection already coming into use as a primary laboratory tool, and the vacuum tube rapidly increasing in charge potential, hence in "cathode ray" velocity. Meantime the Becquerel or β-rays had come into research availability at velocities far superior to those provided by the vacuum tube, at least in these early stages of its development; and the researches shortly to be discussed will be found divided between tests on (a) cathode rays and (b) Becquerel rays, with the latter taking a quick lead because of the velocity advantage.

As for electron identification, we shall broadly point out that the background of the electron arises out of the deep and undistinguishing confusion over "corpuscles" or "particles" in early theories for both light and electricity, to say nothing of the molecules of chemistry; that the "particles" of Benjamin Franklin, in days of translating the optical lightning flash into electricity, became on the one hand the "ions" of Grotthus, Clausius, Davy, Faraday, Kohlrausch, and Arrhenius in liquid electrolysis, while on the other hand becoming the "charge" or "unit of charge" in the gas-electrodynamics of Faraday, Maxwell, Lorentz; also that those who later founded relativistic physics - - notably Lorentz, Larmor, Poincaré, and Einstein - - were specifically concerned with transformation mathematics applicable to a "moving charge" or system of such charges within a Maxwellian field. That which Lorentz referred to, for example, as a "point charge" at the beginning of the "mad decade"[220], in the same year of the 1895 Röntgen discovery, gave way to the title *Theory of Electrons* for his book at the close of that decade[225].

In more detail, one can see the electron concept arising out of the 19th Century molecular chemistry[137]: Of what size is that minimum aggregate of the "indivisible atom" which, if broken into its component atom parts, loses its distinguishing features as a chemical? In fact, what size is the atom? For from these two questions naturally arose the third: Of what size is the unit charge of electricity, eventually called the electron?

Thomas Young in 1816, in his essay on *Cohesion* written for the *Encyclopaedia Britannica* came up with one of the first reasonable estimates for the size of the water molecule based on steam condensation: $\phi = 10^{-9}$inch. Mid-century both Clausius in Germany and Maxwell in England attempted calculations using viscosity equations for gas flow, but were left with two irresolvable unknowns of size and count. Loschmidt discovered the necessary second equation for this by assuming that the same gas condensed to liquid has its density likewise a function of size and count - - the famed Loschmidt Number[124]. This then went by way of determining Avogadro's Number in Chemistry, and the charge carried by the electron in physics. In 1874 G. Johnstone Stoney began his considerations of electricity as comprising units[176]. In 1881 he estimated his charge at $\sim 3 \times 10^{-11}$ "absolute electrical units"[322]; and in 1891 he gave it the name *electron*[321]. Six years later J. J. Thomson[329A] presented his classical paper on this subject, proving that such a particle did indeed exist, and that its mass was of the order of 10^{-3} that of the H atom. This value is now known to be $\sim 0.54 \times 10^{-3}$.

While the papers of Stoney and Thomson stand out in history today with great clarity, they were by no means the pushovers they seem, so far as minds of that time were concerned. For despite another strong stand taken by Thomson in 1898[331] and again in 1899[332], also an outstanding paper by Sutherland[324] identifying cathode rays and the so-called Lenard rays as streams of negative electrons, in contrast with the wave forms of Röntgen's rays, with still other papers in 1903 by Thomson[333] and H. A. Wilson[349], the famed World's Fair or St. Louis Exposition in 1904 still found an entire day devoted to debating this "atomic kinetic" concept from the British Isles *vs.* the continuum model of Ostwald and his fellow "Energetikers" on the Continent - - among whom were none less than Helm and Ernst Mach. Van't Hoff sided with the atomists, and Boltzmann supported Van't Hoff. This was the year, incidentally, that an international *Festschrift* celebrated Boltzmann's sixtieth birthday. Two years later he committed suicide. This St. Louis meeting was also the one at which Henry Poincaré presented his historic paper[274] on the newly emerging relativistic physics - - still one year short of the arrival of Einstein.

However, in 1906 Robert Millikan entered the field, and by 1909 ended the dispute[247] with his "balanced drop" experiments which were as indisputable as they were beautiful. His major paper on *The Isolation and Measurement of the Electron* appeared in 1910. Ostwald capitulated, running a foreword in the 1912 edition to his great *Allgemeine Chemie*, stating that atomic theory was now well-founded.

Experimental Verification of m = f(v)

As so typical of history when one comes to examine it more closely, it is the natural unfolding of events rather than the personal stature or accomplishments of discoverers that ring out the old and bring in the new. Consider this world-shaking announcement of Röntgen's in 1895, which brought him the Rumford Medal of the Royal Society of London in 1896, the Nobel Prize for physics in 1901, and eternal fame; also consider Becquerel's equally monumental discovery, and his sharing of the 1903 Nobel Prize with Pierre Curie. Then glance at the single volume of *Annalen der Physik* for the few months of 1895 prior to the one discovery, and but a year prior to the other. For one immediately comes upon Lenard's[207] great work on the absorption of cathode rays and the discovery that they penetrate opaque objects such as thin metal foils. Little wonder that those responsible for giving the Nobel Prize to Röntgen insisted on including Lenard as co-recipient.

Then there are outstanding articles by Paalzow and Neesen[260] giving a comprehensive treatment of the passage of electricity through rarified gases; by Lehrmann[206] on cathode rays, with a huge and elaborate colored folder detailing their characteristics; and by Wiedemann and Schmidt[348] discussing *luminescence*, also *photoluminescence* as distinguished from *cathodoluminescence*, with tests on a great many substances under both cathode radiation and monochromatic green light, and including *uranium compounds*. Within such a context, the action of Becquerel becomes understandable, and the chance observation of Röntgen expected.

Immediately after Becquerel's discovery in France, W. Kaufmann[182] in Germany initiated those studies of magnetic deflection of Becquerel rays which would move directly into establishing the velocity-dependent relationship of mass

$$m = m_0(1 - v^2/c^2)^{-\frac{1}{2}} \quad \ldots$$

Equation B

without aid other than superficial from any of the coeval developments in the new physics. His first publication in 1897 showed the deflection to be a function of the tube's discharge potential; and his e/m calculation in terms of "absolute electromagnetic units" gave something of the order of 10^7/gm. A second paper[183] that same year refined the calculation to e/m = 1.77 x 10^7, and left him convinced that the rays were particulate, as being claimed by Thomson that very year. In 1898 Kaufmann refined the value again to 1.86 x 10^7, though experiments by Jaumann[175] and Lenard[208] using electrostatic deflection were giving values somewhat different.

Then in 1901 Kaufmann[184] made that great historic breakthrough, the first of the experimental demonstrations of velocity-dependent mass. While deflection of the less powerful cathode rays failed to disclose a variability clearly outside experimental error, data for the radioactive emanation left no question that either the charge or the mass of the particle, as well as its deflection, was a function of field potential; and nothing in physics would lead one to regard charge as the variable. Some grave conceptual considerations immediately arose: Was the particle a mass which carried the charge, or was the particle itself simply charge? Upon what configurational basis or electron model should one explain such data?

Immediately in January 1902, the theoretical physicist M. Abraham[1] proposed the particular electron model that became known as the *starre Elektron* or "rigid electron", also the *Kugeltheorie*. Abraham argued that the "electric force"

$$E = (m_0 + m)\,\frac{d(\frac{v}{c})}{dt}$$

distinguished a "material mass" m_0 from the "electromagnetic mass" m, also (1) that there is a transverse mass as well as the longitudinal which had been earlier calculated by Searle, (2) that they differ in value, and (3) that the transverse responds more slowly than the longitudinal, though both → ∞ as v → c. In short, the asymptotic nature of the Maxwellian *c* was now coming into both recognition and experimental demonstration, with no relationship whatever to the Michelson-Morley experiment, neither to any of the other matters which were currently provoking the birth of relativistic physics. Abraham first defined these two masses m_ℓ and m_t in terms of the sum of the triple integrals for both electric and magnetic fields

$$W = W_e + W_m$$

$$W_e = \iiint \frac{dv}{8\pi} E^2$$

$$W_m = \iiint \frac{dv}{8\pi} H^2$$

with the longitudinal mass becoming

$$m_\ell = \frac{1}{v}\frac{dw}{dv}$$

But he then adopted the simplification that the *Bewegungsgrösse* G is solely a function of *v*. Whereupon

$$m_\ell = \frac{dG}{dv}$$

$$m_t = \frac{G}{v}$$

However, the second major question remained: Was the mass fully accountable by field theory, or does an independent component exist which carries the charge?

Later that same year of 1902, Kaufmann[186] answered this question with another series of convincing experiments. Here is his conclusion in the original German with original italics:

> *Die Masse der Elecktronen ist rein elektromagnetischer Natur.*

The mass of the electron is purely electromagnetic in nature.

In a second paper that same year Kaufmann[185] studied his data in the context of the Abraham model. He decided that

$$\frac{\varepsilon}{\mu} = \frac{\varepsilon}{\mu_o} \; \frac{4}{3} \; \frac{1}{\psi(\beta)}$$

$$\psi(\beta) = \frac{1}{\beta^2} \left| \frac{1 + \beta^2}{2\beta} \; \ell n \frac{(1 + \beta)}{(1 - \beta)} - 1 \right|$$

where $\beta = v/c$. Then when

$$\beta = 0 : \qquad \psi(\beta) = 4/3$$

$$\beta = 1 : \qquad \psi(\beta) = \infty$$

Abraham[2] agreed before the year was up: The mass is entirely electromagnetic; it is not a scalar but a tensor; and both m_ℓ and m_t increase as some $f(v)$. Interesting equations appear in his work, such as

$$\frac{|e|}{cm_o} = 1.865 \times 10^7$$

For if that constant on the right were to match the *c* at the left, we would immediately have $E = mc^2$.

In 1903 H. Starke[315] accomplished the notable result of raising cathode rays to a sufficient velocity for demonstrating $m = f(v)$; and Abraham[3] published a major work that same year. In 1904 Abraham[4] generally confirmed all that had been advanced before, and then boldly proposed that that which applied to the mass of electrons, applied as well to the mass of molecules. Thus was "relativistic mass" born, prior to relativistic physics -- more properly called *velocity-dependent mass*, since it had nothing to do with relativistic concepts until its later adoption by those working with transformation equations.

In this pivotal year of 1904, still one year before Einstein's paper, several dramatic developments occurred. First, Abraham's "rigid sphere" model came under challenge, on the one hand by Bucherer[41] who published an entire book on the subject, and on the other hand by Lorentz who had meantime developed his FitzGerald-Lorentz contraction model[218], and now in 1904 came out with his complete set of transformation equations for moving bodies in electrodynamics[224]. Through the remarkable set of circumstances which we shall not review here, Lorentz had been forced, specifically by failing to recognize the Michelson-Morley null as a proper registration of the magnetosphere's rest coordinates, to apply the *same Pythagorean or sec θ factor* to the foreshortening of his electron in line of motion that Kaufmann had experienced with velocity relationships, since both were limited by the same asymptotic *c*. Thus while Bucherer chose a simple constant-volume but deformable electron, in contrast to Abraham's rigid sphere, the restrictions placed upon the Lorentz electron by the transformation equations made it longitudinally compressible but not deformable. The penalty for this was that the particle vanished in points of volume as its mass increased toward infinity, which is not particularly impressive as an argument; but its bonus lay in this fortuitous circumstance of the asymptotic $(1 - v^2/c^2)^{-\frac{1}{2}}$ approach as $v \rightarrow c$. Thus the least logical physical model carried the most potent mathematical tool.

Exceedingly strange in hindsight is this selection of the Lorentz electron geometry which, as just remarked, was purely fortuitous because his transformation equations happened to carry the same asymptotic approach to *c*. For careful thought should have disclosed at least two violations of quite elementary logic: *First*, the asymptotic value for $m \rightarrow \gamma m_o$ becomes theoretically an infinite mass occupying an infinitesimally thin disc whose area is limited to the cross section of the normal at-rest electron. This violates one's own definitions, as well as his sense of reasoning. There is little problem with the assertion that an electron would *appear* as a disc of that limited size to an observer from whom the particle was receding at $v \simeq c$; but what has this to do with relativistic mass? Are we discussing appearances in optical communication, or an interplay of mass and energy? Relativists have two quite distinctive matters at hand here; and it is the rule to find them variously discussed in their literature in an undiscriminating manner.

Second, if one does attribute *increasing mass* to the observed e/m for the moving particle, but finds it only under conditions of an addition of E necessary to acceleration with respect to the embedding field in the original Lorentz-Kaufmann sense, and indeed as practiced today by all elementary-particle accelerators, then its velocity has an absolute parameter which destroys the Principle of Relativity. So again: Which is it? Vector or scalar? Relativistic reciprocity and "appearances only", as some noted relativists such as John Synge so stoutly maintain, or simply neoclassical velocity-dependent mass?

Finally, if velocity is absolute in the sense of having scalar parameters relative to the singular field which embeds the particle, then no requirement at all follows for accepting the full machinery of the Lorentz transformation to manipulate both x and t. Neither is there any requirement to restrict considerations on the shape and geometry of the moving particle or object to those restrictions Lorentz labored under in deriving his equations from a totally different category of experimental observations. No one has yet seen the shape of the objects in question; neither has any experimental datum even indicated, let alone stipulated, their shape or geometric behavior when in motion at velocities where the Lorentz contraction is alleged to occur. But let us return to this historic unfolding of the mutually entwined Lorentz transformation and Kaufmann's relativistic mass, bound together with the problem of asymptotic behavior in Maxwellian field dynamics:

Therefore three different electron models were in hand by 1904. In terms of $\beta = v/c$, they were

1. Abraham's rigid sphere

$$\phi(\beta) = m/m_0$$

$$= \frac{3}{4}\frac{1}{\beta^2}\left(\frac{1+\beta^2}{2\beta} \cdot \ell n \frac{1+\beta}{1-\beta} - 1\right)$$

2. Bucherer's (also Langevin's) compressible constant-volume model

$$\phi(\beta) = m/m_0 = (1-\beta^2)^{-1/3}$$

3. Lorentz's compressible in-line-of-motion-only model

$$\phi(\beta) = m/m_0 = (1-\beta^2)^{-\frac{1}{2}}$$

A brilliant young German physicist named Hasenöhrl[149 150], who was unfortunately lost to science a decade later in World War I, also entered this arena in 1904 with calculations which have led some such as Lenard[209] to regard him as the discoverer of $E = mc^2$. However, Hasenöhrl, like Comstock[55] several years after him, still had a problem deciding whether the *total* mass was electromagnetic. Thus in 1904 Hasenöhrl[149 150] derived the relationship

$$m' = \frac{8}{3}\frac{E}{c^2}$$

which he amended the following year to the still inaccurate

$$m' = \frac{4}{3}\frac{E}{c^2}$$

But he added some very perceptive statements regarding the mechanical mass of a body being increased by its heat energy, and the loss of solar mass over long periods of time due to radiation.

Second, the renowned French mathematician Henry Poincaré made his historic address[274], as we have already mentioned, at the International Science Conference in St. Louis, Missouri, where he put into published statement the *status quo* of our present Route II as of September 1904:

> The calculations of Abraham and the experiments of Kaufmann have then shown that the mechanical mass properly so-called is null, and that the mass of the electron ... is of exclusively electromagnetic origin.

This repeated verbatim of course the conclusions of Abraham and Kaufmann already cited. Poincaré then proceeded to state the two great consequences incident to such a conclusion. First, the fusion of the two classical conservation laws for mass and energy into a single law:

> This forces us to change the definition of mass. We cannot any longer distinguish mechanical mass and electrodynamic mass ... There is no mass other than electrodynamic inertia.

Note that this is merely the final surfacing of the electromagnetic momentum already inherent in Maxwell's equations, having nothing to do with either Lorentz contraction or time dilation, and despite the fortuitous entry of the Lorentz electron model as already discussed. As for the second and controlling consequence, Poincaré added:

> Perhaps ... we should construct a whole new mechanics ... where inertia, increasing with velocity, the velocity of light becomes an impassable limit.

This new "non-Newtonian" mechanics was then reconstructed - - we must now carefully notice - - not by Einstein, Poincaré, Lorentz, and Larmor as so commonly assumed, but *by G. N. Lewis in 1908* as given in presenting our Route I. For at the stage now under study, there is as yet no need whatever to intrude matters of optics, simultaneity, spatial contraction, time dilation. All that has been made necessary is to (a) add Maxwellian electrodynamics to Newtonian mechanics, (b) recognize the consequences of the asymptotic field velocity *c*, then (c) fuse the formerly separate conservation laws of mass and energy into a single law embodying mass-energy equivalence.

Pauli[224], interestingly enough, later took this and other statements of Poincaré on that occasion of the St. Louis meeting to "flesh in" his mathematics - - which Poincaré had held to a minimum at the time because of his somewhat nontechnical audience. Let us glance at his reasoning. In prospect again is that "little black box" so dear to the heart of the physicist, completely isolated and suspended loosely in the middle of nowhere. The model is essentially a cross between those of Einstein in our Derivations II and III, except that now there are two energy packets E/2 that are emitted simultaneously and in opposite directions such that $\Delta p = 0$. The model had also been used by Langevin in 1913[196], and again by Fox[126] in modern times. The idea is to let the same event occur a second time, but now with the transmitter in motion. According to the final settlement of these Kaufmann-Bucherer experiments upon $\phi(\beta) = (1 - v^2/c^2)^{-\frac{1}{2}}$, as we shall shortly summarize, the momentum now becomes

$$p = mv\,(1 - v^2/c^2)^{-\frac{1}{2}}$$

The frequency change in the respectively shortened and lengthened wave train becomes

$$\frac{E\,(1+\beta)}{2(1-\beta^2)^{\frac{1}{2}}}\quad,\quad\frac{E\,(1-\beta)}{2(1-\beta^2)^{\frac{1}{2}}}$$

According to Poincaré the momenta would be

$$\frac{E}{2c^2}\cdot\frac{(1+\beta)}{(1-\beta^2)^{\frac{1}{2}}}\quad,\quad\frac{E}{2c^2}\cdot\frac{(1-\beta)}{(1-\beta^2)^{\frac{1}{2}}}$$

and since oppositely directed, then

$$\Delta p = Ev/c^2(1-\beta^2)^{\frac{1}{2}}$$

Conservation of momentum requires

$$\frac{mv}{(1-\beta^2)^{\frac{1}{2}}} = \frac{m'v'}{(1-\beta^2)^{\frac{1}{2}}} + \frac{Ev}{c^2(1-\beta^2)^{\frac{1}{2}}}$$

where v' is the result of $v \rightarrow v'$. But Poincaré had for nine years prior to 1904 been espousing his *Postulat de rélativité*; and since this would preclude any change in position, it must follow that v' = v, and

$$\frac{(m-m')v}{(1-\beta^2)^{\frac{1}{2}}} = \frac{Ev}{c^2(1-\beta^2)^{\frac{1}{2}}}$$

whereupon

$$m - m' = E/c^2$$

Since this is now independent of velocity, it must hold for the rest-mass as well, such that for any emission of E there is a loss of mass according to

$$E = mc^2$$

Langevin[196] and Fox[126] merely used the $h\nu = E$ approach and the first-order Doppler frequencies

$$\Sigma p = h\nu\,(1 + \beta)/c - h\nu\,(1 - \beta)/c$$

$$= 2\,h\nu\beta/c$$

such that the momentum loss $2\,h\nu\beta/c$, not being attributable to velocity, can only be written

$$(\Delta m)v = 2\,h\nu\beta/c$$

$$= Ev/c^2$$

and

$$\Delta m = \Delta E/c^2$$

or, arguing from the particular to the general:

$$E = mc^2$$

Third and most spectacular among the hallmarks of 1904, of course, was Hendrik Lorentz's publication of his complete set of transformation equations for the electrodynamics of bodies in motion relative to a Maxwellian field embedded in a cosmic-ether background. Lorentz culminated the mainstream of traditional ether models (1) based upon a unique and absolute cosmic rest frame, (2) devoid of any consideration of the Earth's magnetospheric envelope, except for his dismissal[221 223 225] of the early and fragmentary "ether-drag" proposal of George Gabriel Stokes[317 318 319 320], (3) founded entirely upon the optical null from various experiments testing for boundary velocity differentials on the surface of the *lithosphere*, instead of tens of thousands of kilometers farther out, in the vicinity of the magnetosheath, and (4) using the short-sighted planetary velocity $v \simeq 30$ km $\sec^{-1}$ for all considerations of Earth motion relative to the supposed cosmic ether, despite the known fact that this is the velocity relative to the rest coordinates of the heliosphere, not the cosmos.

As we have remarked elsewhere[360 362], to test the planetary velocity using an interferometer, or any other electromagnetic instrument judged suitable to such an experiment, placed in a position *within* the bounding walls of the magnetosheath which protects the planetary electromagnetic domain, is as irrelevant and thoughtless as to use an anemometer inside the passenger compartment of an airplane to test the air speed, or to toss a knotline inside the hold of a ship instead of over the rail.

The Founding of Relativistic Physics

Earlier we used the word "intrude" for the founding of relativistic physics, referring to its imposition of altered transformation equations and space model upon a neo-classical physics which now contained Maxwellian electrodynamics as well as Newtonian mechanics, and contained everything necessary to explain the null datum which was solely responsible for provoking the revolution - - everything necessary, that is, once the maturing electromagnetic branch brought in magnetospheric geophysics and astrophysics. We must now watch this rather carefully chosen imputation with great care as the following events unfold.

For modern knowledge of magnetospheres in the field of electrodynamics, and gravitational equipotentials in matters of sending space vehicles outside the terrestrial field - - to say nothing of the General Theory of Relativity - - leaves one with a space model which is absolute in the sense of everywhere-contiguous domains, each of which is "locally absolute" in the sense of local autonomy over natural law. That is, within each magnetospheric domain the laws of electromagnetics hold equally true and valid, and within each gravitational domain the same holds for the laws of mechanics. Since gravitational and Maxwellian domains are not necessarily identical, we shall shortly confront an obvious source of error when the new relativistic physics equates the reference frames of electromagnetics with the inertial frames of mechanics. Next we shall confront the much more serious aspect of misdirected thought when the very experiments proving the now-known rest frame of the Earth's Maxwellian field are aborted toward a type of space that does not exist in reality. The argument is frequently heard that Maxwell's field equations are not covariant under a Galilean transformation, and that the Lorentz equations subserve their own proof in so doing. But this supposed failure of the Galilean transformation follows quite simply from the presupposition of the wrong space model. The Lorentz-Einstein equations do indeed provide covariant transformation, and covariant group transformation - - but for an erroneous space model, from whence the paradoxes of the Special Theory when extrapolated to real space.

However, let us examine this important event in somewhat more detail, namely the unfolding and founding of relativistic physics, and specifically Einstein's Special Theory of Relativity. We shall skip over the major body of this enormous subject, first on the presumption that its principal features are generally known, and secondly for the reason that we do not wish to digress from our main thesis any further than necessary to give proper context for judging the issues that are raised. We left the subject with the publication of Lorentz in 1904, establishing what is today known as the Lorentz transformation. The same transformation had been published by Larmor six years earlier[200], again four years earlier in a book[199]; and Poincaré had presented the equations before the French Academy of Science[275] while Einstein was still preparing his manuscript. Occasionally a claim[289] is made that Waldemar Voigt[341] published them as early as 8 January 1887 before a meeting of the Königlichen Gesellschaft der Wissenschaften in Göttingen; but this is merely another instance of careless reading. For although Voigt does consider what might be called the equivalent of Lorentz's later "local time", his equations are strictly classical in derivation, preserving the second-order Doppler effect rather than erasing it, and merely showing the Pythagorean factor $\sqrt{1 - v^2/c^2}$ where it belongs, namely for the transverse axes. Voigt's paper is indeed a masterpiece; and relativists should read it carefully enough to realize that, if one does wish to proceed on a basis of "local time" due to finite signal velocity, here is how to do it within real space, and without the foolishness of time dilation.

Einstein's Special Theory

When Einstein published his great classic[102] in 1905, as fourth in line of originators of the new transformation equations, he not only followed their lead in overlooking the possibilities that the geomagnetic field, though well known to him at the time, might well establish an electromagnetic rest frame extending far beyond the ground-based instruments of the physics laboratory, but he dismissed the entire ether concept - - or at least so he thought at the time. Instead he relied simply and entirely upon arbitrary thought-experiments and mathematical procedures for rationalizing a null optical datum, found frequently and properly demonstrated within the terrestrial rest frame, against a purely *gedankenexperimentische* "ether wind". We remarked earlier upon his having to renege on this drastic and thoughtless step: First, the *eigentümliche Konsequenz* as he called it, or "peculiar consequence" of permanent and irreversible clock alteration, which he himself discovered by the middle of that 1905 paper to be a consequence of his opening assumptions, immediately refutes his own Postulate of Relativity by distinguishing the actual traveler as the one who transits coordinates which are at least locally absolute; second, his subsequent development of the General Theory produced a space metric of absolute sort, every part of which has a gravitational potential whether an electromagnetic field is present or not, with these potentials - - per Einstein[100] himself as of 5 May 1920:

> ...conferring upon space its metric and qualities without which it cannot be imagined at all ...
>
> According to the general theory of relativity space without ether is unthinkable...

We earlier called attention to this "return to absolute space", marked mainly by the arguments of Ives and Builder at mid-Century, and the recent experimental demonstrations of an isotropic 2.7°K background radiation. To these, of course, should above all be added the achievements of the international space programs in defining in great detail the magnetospheric structure of our own planetary body, and the existence of similar magnetospheres embedding the Sun, a number of the planets, and even certain of the Galilean moons of Jupiter. There is no known space travel, certainly throughout the Solar System, which does not continually find the observer traversing a Maxwellian field, or crossing the boundary between fields. Assuredly the same will be found for outer Galactic and intergalactic space. And that any *real* motion relative to a Maxwellian field is detectable is assured by the entire armory of the field equations.

In fine, the bold adventure of the Einstein approach to the null datum problem in 1905 has since had to retract at least to the original Larmor-Lorentz-Poincaré model of spatial absoluteness based upon an ethereal cosmic background. So let us return to 1904, in order to hew a clean path from where we have been to where we are going.

For at this point in time - - 1904 - - and as we have now clearly seen, the two key matters of mass-energy equivalence (Equation A) and velocity-dependent or "relativistic" mass (Equation B) have already been established in all essentials without so much as touching this explosive and collateral line of development of the new physics, essentially beginning with the first Michelson experiment in 1881[244] and culminating with Einstein in 1905. We have not found it necessary even to mention, let alone explain, the long history of the null datum with prism optics, interferometers, turning-couples in charged condensers; the matter of time dilation and erratic clock behavior has as yet no relevance whatever; and the only reason for the FitzGerald-Lorentz contraction ever getting into the picture at all, as we just explained, was that physicists working Route II happened to make the arbitrary and entirely unnecessary choice of the "geometry sideroad", wherein matters of deformation and form take on whatever significance is necessary to the goal. This brought the Lorentz electron into the picture, not only because Lorentz was the leading authority on electron dynamics, but because he had already been forced by his misinterpretation of the Michelson-Morley experiment to lay in-line shrinkage of precisely this $\cos\theta = \cos(\sin^{-1} v/c)$ quantity upon everything that moved, from interferometer arms to electrons. But Lewis, we will also recall, achieved this same goal without any regard for electron geometry at all, and more directly.

Einstein's Two Postulates

Because Einstein's paper of 1905 introduced two postulates which have since stood as landmarks in physics, special care and respect must be paid them. The matter seems particularly important because we have here under study two virtually simultaneous streams of development, each lasting exactly a quarter-Century and beginning precisely in 1881, with both essentially consummating in 1905, yet showing remarkable independence of one another, despite the widespread assumption of their complete interdependence. For we will recall that the year of the first Michelson experiment in 1881 was also the year of Thomson's classic which initiated the studies of both velocity-dependent mass and mass-energy equivalence. These latter were essentially complete in the year of Einstein's publication, and prior to his publication.

In briefest thumbnail sketch, the dynamic train of thought in the new relativistic physics began with Michelson[244] 1881 → Potier's[280] calling him that winter[246] (see footnote in the latter referenced paper) on neglecting the Pythagorean factor of the transverse arm → Michelson and Morley's[246] repeat performance in 1887 → FitzGerald's suggestion[119] in 1889 that the arm in line of motion shrank by $(1 - v^2/c^2)^{\frac{1}{2}}$ → Lorentz's[219] incorporation of the contraction into his study of 1892 on Maxwellian electrodynamics → Lodge's[217] spectacular experiment in 1893 with rotating disks, and Larmor's[197 198] auspicious entry into the discussion → Lorentz's[220] development of a semi-Galilean "local time" in 1895, which immediately brought Poincaré[272] into the arena → Michelson's[245] thoughtful but unfortunate dismissal in 1897 of his "third hypothesis" → Larmor's[198 200] historic 1898 "first" (paper read 13 May 1897) in achieving the transformation equations since known as the Lorentz transformation → Lorentz's[221 222 223] aborting at the close of that Century the only promising model in physics, namely Stokes' fetal-stage magnetosphere[317 318 320] → Poincaré's paper on 11 December 1900 bluntly correcting Lorentz's charge transformation, and strangely enough on the occasion of being invited to address a meeting honoring the Silver Anniversary of Lorentz's 1875 doctorate → the staccato action of

27 May 1904 ... Lorentz[224] presents his classic paper in Amsterdam
24 Sep.1904 ... Poincaré[274] gives his historic address in St. Louis
18 Mar.1905 ... Einstein[84] submits his manuscript on Planck's quantum
11 May 1905 ... Einstein[86] submits his manuscript on Brownian motion
5 June 1905 ... Poincaré[275] presents his own transformation equations before the French Academy of Science, but credits Lorentz with their discovery
30 June 1905 ... Einstein submits his historic manuscript on electrodynamics
23 July 1905 ... Poincaré[276] gives a comprehensive lecture on relativity before Circalo Matematico di Palermo
26 Sept.1905 ... Einstein's classic[102], later to be known as the Special or Restricted Theory, appears in *Annalen der Physik*
27 Sept.1905 ... Einstein submits his manuscript on mass-energy equivalence[85] to *Annalen* ...

The history of physics has never been the same since.

Against this background, and arising solely out of the optical stream so far as can be determined from examining his paper, Einstein laid down what he called two postulates, and then proceeded to define simultaneity and signal-exchange in accordance with them. But if one studies these two postulates carefully, and particularly with our present advantages of hindsight, it becomes immediately apparent that there are in fact no less than six concealed within the two, since stated in various forms by many authors including Einstein himself, and often variously used as may suit a particular author's convenience -- including Einstein himself. Certainly a principal problem in modern physics is to analyse these postulates more critically, nail them down to a fixed set of crystal-clear statements, then check the stepwise reasoning of writers in the field of relativistic physics, easily to be found in uncountable numbers, who either imply things that are not so stated in Einstein's original, or who shift their interpretation as may suit their purposes. The six easily identified subheads can be listed as follows:

Ia. All laws of the natural order are equally applicable and valid throughout all parts of the physical creation.

Ib. Absolute space does not exist, there being no motion except relative motion.

Ic. Inertial frames serving the laws of mechanics similarly serve the laws of electrodynamics.

IIa. The velocity of light is constant within any Maxwellian field, and a limiting velocity for motions of both mass and energy.

IIb. The velocity of light is independent of the source.

IIc. The velocity of light is independent of the observer.

But Ia is a *principle*, not a postulate. In fact, we shall here designate it the *First Principle of Physics*. For without dependence upon the equality, identity, and universality of all natural laws throughout the entire physical creation, none of the disciplines and discussions of science could ever achieve more than trivial significance.

As for Ib, we have already witnessed its demolition; and with it, of course, goes the long-heralded and much-published Principle of Relativity, which even caused Bishop George Berkeley[26] nearly three centuries ago to predict:

> It does not appear to me that there can be any motion other than relative ...

and Poincaré to declare in 1895[272], and again before the French Academy of Science in 1905[275] -- hence at both beginning and end of the "mad decade":

> The impossibility of demonstrating absolute motion must be a general law of nature ...

To keep in clear focus exactly what it was that Einstein had in mind when phrasing his

Relativitätsprinzip of 1905, let us see how it appeared to others of that time, rather than rehash what Einstein actually said, or how it has become interpreted in modern times. Here is the top experimentalist Kaufmann[187], expressing in 1906 both the consensus and the enthusiasm with which the new concept was quickly greeted:

> The Principle of Relative Motion affirms the complete reciprocity of all laws of physics -- that is, the interchangeability of the so-called "stationary" and "moving" systems.

Note this eager grasping of "complete reciprocity". A virtually identical statement was made by Max Planck in the very opening sentence of his 1906 paper[269]. An age-old dream had been upset by the misinterpretation of the Michelson null. Einstein[91] himself, the following year, confirmed this very explicitly:

> Dieser Schluss ist auf die physikalische Voraussetzung gegründet, dass die Länge eines Massstabes, sowie die Ganggeschwindigkeit einer Uhr dadurch keine dauernde Änderungen erleiden, dass diese Gegenstände in Bewegung gesetzt und wieder zur Ruhe gebracht werden.
>
> *(This conclusion is founded upon the physical principle that neither the length of a ruler nor the rate of a clock suffers any permanent alteration when such instruments are set in motion and then brought back to rest.)*

Well!

What a stunning contradiction to be found within Einstein's own definitions, the inventor of the "slow equatorial clock" two years earlier, and co-founder of the Twin Paradox just four years later[92 195]! Einstein really never did come to a firm conviction as to whether time dilation as well as spatial contraction was real or only apparent; and in 1920 we find him carefully specifying that[101]

> *As judged from K* ... the time which elapses between two strokes of the clock is ... a somewhat longer time ...

But he then adds the flat statement:

> As a consequence of its motion the clock goes more slowly than when at rest.

What motion relative to *what?*
We shall later have cause to discuss his use of the General Theory (GTR) in defense of the impossible position that gravitational acceleration on a to-fro trip accounts for the permanent and one-sided effect of the paradox. There are still relativists today who bring the GTR into the arena of apologetics over time dilation; but they thereby succeed only in marking themselves as uninformed on matters in their own field, namely the epistemological dismissal of the GTR by such as Builder[45 46 47 48], and above all the flat experimental disproof of Bailey, *et al.*[16] studying muon decay, and Newman, *et al.*[255] on the Thomas precession.

Today it is becoming more and more clear, of course, that one *can* determine who really moves and who does not. But as the incisive Lewis[213] put it so early in his 1908 classic:

> The question whether a method is conceivable by which absolute motion in space may be distinguished from relative motion must be answered definitely in the affirmative ... A body is absolutely at rest when any motion imparted to it increases its mass, or when a certain force will give it the same acceleration in any direction ... in the same sense that a study of centrifugal forces enables us to determine absolute rotational motion.

Since we have already remarked upon the modern reasons for returning to an absolute space, and the fact that Einstein's irreversible time dilation immediately proved this absoluteness at the same time he was presuming to dismiss it, we shall here only add a remark of cosmologist Bondi made in discussing a paper of Møller[248]:

> Cosmologically speaking, there appears to be very little doubt that the motion of the universe defines a definite preferred velocity at each event, namely the velocity of the observer to whom the universe appears isotropic ...

and a recent statement of the very able relativist J. Edmonds, Jr.[83]:

> Physics *must* make sense to observers in the preferred *rest* frame of cosmology. All others are inferior and use *bad clocks and rods* for the measurements, so their results are of little interest.

The italics are his.

And of course once our space vehicles begin mounting interferometers for the same purposes originally motivating Michelson, but with the instruments properly in *real* motion relative to the local and *real* rest coordinates of geosphere, heliosphere, or galactosphere outside the Solar System, they will probably produce the fringe shifts that Michelson sought, and even to extents of providing a space odometer and a means for determining the boundaries of magnetospherically structured space[356 365].

Returning now to Ic: This we have already seen to be the greatest single error in the Einstein approach - - namely the proposition that the rest frames of mechanics can dependably and properly serve as the rest frames of electromagnetics. As Aspden[10] so succinctly put it:

> Einstein...presumed that in a vacuum light is propagated with the velocity *c* relative to an *inertial* reference frame. It is not. Light is an electromagnetic phenomenon. It is propagated relative to an electromagnetic reference frame. This distinction is of fundamental importance.

In fact, the Einstein approach is tantamount to equating the flatcar with the tankcar in the ballistics of fluid transport; or the closed sedan with the open touring car in points of acoustics and for purposes of conducting a conversation; or the asteroid Ceres with the Earth so far as magnetospheric electrodynamics is concerned. If it is indeed true that Ceres has no significant magnetosphere, then Michelson's interferometer - - placed right on its rocky and barren surface, as was done here on Earth - - should indeed register the asteroidal velocity relative to the heliosphere and show the desired fringes. Similarly if we should prove that the Maxwellian field of the Moon does not extend above its lithosphere, then an interferometer placed on its surface should register the Lunar velocity relative to the geosphere when and if embedded within it, and relative to the heliosphere when crossing the magnetosheath.

This now brings us to Einstein's much debated Second Postulate. But Postulate IIa, as delimited here, is a principle inherent within Maxwellian electromagnetics, as we have repeatedly explained. Furthermore, IIb follows as a necessary corollary of IIa, such that it needs no separate stipulation. For it becomes a violation of definition to set up either a medium, as in the acoustical cases of liquids and gases, or a field as in the delicate and intimate field balance between H and E in electromagnetics, then propose that a disturbance within that medium or field can move or translate at a speed exceeding the limiting velocity intrinsic to the structure.

With IIc we confront the essence of every unhappy consequence incident to the Special Theory. As Nobelist Bridgman viewed it, in his *A Sophisticate's Primer of Relativity*:

> The pronouncement that the velocity of light is the same in all reference systems is repulsive to common sense. For we know that when we change the velocity of the object with respect to which we are determining velocity, we change the velocity of every other object with respect to it.

Bridgman would not likely have an objection to "the pronouncement that the velocity of light is the same" within each magnetospheric domain, and relative to the rest coordinates of that domain.

For it is not motion of the *source* that produces any problem, since the transmission becomes picked up and immediately governed by the velocity c relative to the local field. But to propose that the *observer's* motion has no effect upon c, regardless of the observer's motion relative to the field transmitting the disturbance, is such an obvious violation of logic that the persistence of the argument is more remarkable than its breach. Consider this opening statement by an editor of a prestigious journal of physics[215]:

> One of the fundamental postulates of the Special Theory of Relativity is that the speed of light is uniform in all directions, and is independent of the motion of the emitter *or the observer*.

The italics here are ours. The usual reasoning then follows:

> The fundamental experiment to confirm the postulate is, of course, the Michelson-Morley experiment.

Sears and Brehme[309] say:

> All experimental evidence leads to the conclusion that this speed is the same for all observers...

Even Feynman[115] falls in line with this, for which he supplies the explanation mark himself - - else we would do it:

> If something is moving at the speed of light inside the ship, it will appear to be moving at the speed of light from the point of view of the man on the ground too!

But as little as we relish opposing a position taken by Feynman, we must remain with the analysis as given here.

In brief summary, we do feel justified in (A) rejecting the "relative motion only" proposition of the founders of relativistic physics, (B) requiring that our subsequent reasoning be based upon electromagnetic rather than inertial frames when discussing electromagnetics, (C) adopting only the Postulates Ia and IIa as given here, along with the IIb corollary, and (D) continuing along our path of a neo-classical or "Newtonian-Maxwellian" physics which (1) fuses the conservation laws for mass and energy while retaining all the others; (2) holds the field constant c in its triple role of (a) proportionality constant between the electromagnetic and electrostatic units, (b) inherent field velocity and velocity-limit for transmission of field alterations, and (c) universal velocity limit for electromagnetic mass-energy configurations; and perhaps (3) adds tentatively an immutability axiom that charge can neither be created nor destroyed - - until physics may prove otherwise. We enter this last because of the fact that to this day the data for velocity-dependent mass have been limited to measurements e/m; whereupon it becomes theoretically possible that the velocity-dependent increase of mass is instead a corresponding decrease in charge. But such experiments as those performed by Fleischmann and Kollath[122], also Kollath and Menzel[192], seem to assure charge immutability, and to confirm the logical expectation that we are observing changes in mass, not charge.

Elementary-Particle Decay: $N=N_o e^{-t'/\gamma\tau_o}$

From $m = m_0(1-\beta^2)^{-\frac{1}{2}}$ to $\tau = \tau_0(1-\beta^2)^{-\frac{1}{2}}$

While we have thus far demonstrated both historically and technically the derivation of Equations A and B independent of relativistic physics - - referring specifically to the Lorentz transformation and Einstein's Special Theory - - we must now confront Equation C, the most challenging and heavily-entrenched of them all.

Following the works of Kaufmann, Abraham, and Bucherer came the conceptual injection of the Lorentz-contracted electron which we have already traced, immediately followed by Einstein's striking proposal of defining a new "simultaneity" based upon the now-famous optical null, thereby avoiding the whole ether-search by means of an algebraic bypass. We mentioned Kaufmann's[187] rather excited response in 1906 to the reciprocity claims of Einstein's *Relativitätsprinzip* - - he paid no attention to the adventitious time dilations; and we will recall Planck's quick reactions, both criticizing and confirming the Special Theory. Within two years the two lines of development were so hopelessly entwined that even now one hesitates to attempt the unraveling. Nevertheless, here is a sketch of the quarter-century following Einstein's paper which, like the quarter-century preceding it, now saw the seeds which were separately planted in 1881 producing outgrowths which finally and unwittingly embraced each other because of a common inheritance of what we have been calling the Pythagorean or *cos* θ factor. By this we do *not* mean to say - - at least not yet - - that the Lorentz-Einstein transformation is or was improperly applied to this increasingly complex situation in physics, but only that this is *not* yet a stage which requires it, or even draws it forth. These same developments in the velocity-dependent branch of experimental physics would have taken place if Michelson followers had never entered the contest; and the identical equations for the now so-called "relativistic mass" would have matured just as well and entirely independently under some designation such as "velocity-dependent mass", thence treated with a Galilean transformation, and presumably with success, since no reason is in present view for denying it.

Thus when Kaufmann published his 1906 paper[187], he was still defending the Abraham model, which had nothing at all to do with relativity; but when Planck[269] promptly responded to Kaufmann in defense of Einstein, he did it from the new relativistic viewpoint, and furthermore confirmed what we have already given through Kaufmann as to the original consensus attending Einstein's pronouncement, namely that no one observer has any greater right than another to regard himself as privileged or "stationary". This lent Planck's position much heuristic force, since a postulated freedom from the problems of discovering absolute rest coordinates came as a great relief to many philosophers as well as physicists. Yet neither Kaufmann nor Planck required time dilation for their arguments concerning velocity-dependent mass, nor did they ever need or use the Lorentz contraction. Instead, Planck had come to mass-energy equivalence by way of the $\sqrt{1 - v^2/c^2}$ conveniently at hand in the Einstein-Lorentz transformation, thence to velocity-dependent mass; while Lorentz had meantime related the velocity-dependence to the shape of the charge-carrier under discussion, namely the electron.

In 1906 Lorentz was delivering those lectures at Columbia University which would become the body of his classical book *Theory of Electrons*[225]. Bucherer[42] returned to his work with Becquerel rays, and now found the exponent $(\ldots)^{-\frac{1}{2}}$ indicated, in place of his original $(\ldots)^{-1/3}$, thus seemingly confirming the Einstein-Lorentz model. However, we should carefully note that this in fact did no more than confirm the factor $\sqrt{1 - v^2/c^2}$ for an asymptotic c. Any further relationship to electron shape, or transformation equations, or space-time model becomes pure assumption. Bestelmeyer[27] and Classen[51] joined the search, but favored the Abraham model. Bucherer[44] criticized Bestelmeyer, who in turn[28] accused Bucherer of (a) drawing his weighty conclusion from a single test, (b) having a serious deficiency in his optical system, and further (c) having claimed as his own a process originated by Bestelmeyer. Bucherer[43] made a reply expressing his great indignation, which Bestelmeyer[29] replied to in turn, and in similar vein.

Thus it went for several years as the increasing experimental results for increasingly faster electrons slowly but convincingly proved that the velocity c was indeed an asymptotic limit, and that the graphical curvature for asymptotic approach of mass in motion was of the type

$$m = m_0 \cdot f(v) = m_0\,(\cos \sin^{-1}\beta)^{-1}$$

$$= m_0\,(\sec\theta) = \gamma m_0$$

Bucherer's principal contribution was his

1909 *Die experimentalle Bestätigung des Relativitätsprinzips*[44] using point-source β-rays from crystalline radium fluoride. The rays had a velocity range v/c = 0.317 - .687, and passed in vacuo between two planar plates of a circular condenser with a uniform magnetic field imposed parallel to the plates. These plates and crossed fields formed a "velocity filter" whose resolving power was a function of (a) plate spacing, and (b) length of path. The filtered velocity then depended upon (a) E/H ratio of the electric and magnetic field intensities, and (b) the angle θ between magnetic field and the radius of beam projection

$$v = cE/H \sin\theta$$

Electrons leaving the condenser were subjected to a magnetic field alone, the deflection being recorded by their striking a photographic plate. Since the sole criterion was, and remains today:

$$\frac{e}{m} = \frac{e}{m_0} \cdot f(v)$$

the constancy of e/m_0 is critical. Deflection being a direct function of momentum, the ratio e/m results very simply from measurements of (1) deflection, (2) H sin θ and (3) E . Bucherer concluded that "all of the observations become fully explained by the relativity principle", and that the "radiation mass" is accordingly E/c^2.

But once again we witness a breach of logic, and the type of loose thinking about which we complained in discussing Einstein's postulates. For this asymptotic $\sqrt{1 - v^2/c^2}$ approach to the universal velocity constant *c* in Maxwell's field equations has nothing at all to do with the "observer reciprocity" heralded by Einstein; whereupon the only remaining relationship to the *Relativitätsprinzips* is through Einstein's Second Postulate involving the limiting velocity *c*, which again brings us back to the field equations.

Bucherer had his student K. Wolz[351] perform some more experiments under his supervision, using ray velocities which were now β = 0.5 - .7; and then in 1913 he turned over both his apparatus and his supply of radium fluoride to Neumann who was working under Professor Schaefer [305]. Neumann considerably improved the procedure by developing a special photometric method[254], working with a β-source at one end of a rectangular condenser, refining his beam to essentially a spectral line rather than the continuous-spectrum smudge so long troubling the experimenters, and with the magnetic field and path angle at θ = π/2 - - mutually perpendicular. The data confirmed Bucherer in confirming Einstein - - so he concluded[253]:

> Die Resultate bestätigen also durchaus die Schlüsse, die Bucherer aus seinen Versuchen gezogen hatte.

Meantime Hupka, in a 1909 doctoral dissertation out of the University of Berlin, pushed the cathode-ray voltages from 17,000 → 88,000 by using electrons emitted from copper when irradiated with ultraviolet light. This gave him a workable β = 0.255 - 0.524 range; and his splendid graphical procedure for comparing the Abraham *vs*. Lorentz-Einstein models on the basis of e/m_0 *vs*. voltage makes interesting study today. While the line for the latter remained virtually horizontal at constant e/m_0 for all voltages, the "Kugeltheorie" of Abraham plunged steadily downward. During the next several years there were important studies in Germany by Heil[157], and Bestelmeyer[30] who developed a procedure using an oxide cathode, also Alberti[5]; while in France these studies were taken up by Guye and Ratnowsky[143] in 1910, and Malassez[230] in 1911. This last climaxed with work of Guye and his associates in 1915[144] and 1921[145] using high-velocity cathode rays, again confirming the model of the Special Theory - - as they concluded, though again merely confirming the asymptotic *cos* θ relationship.

In 1924 Ellis and Skinner[109] in England finally brought under control the natural line spectra within radiation from radium B and C; shortly Tricker[338] extended that work up to effective velocities of ∿500,000 V, or β ≃ 0.8; and then the long trail essentially ended with Zahn and Spees[355] in 1938 who substituted a Geiger counter for the traditional photographic plate, and reversed the positions of source and detector to avoid excessive scanning motions. These climactic studies of the 1920's and 1930's, interestingly enough, were still badgered by a persistence of the Abraham model well into the 1920's, when they next confronted a new so-called "β-ray paradox" involving the breakthrough into subatomic particles other than those carrying charge. This of course was the

$$\beta \rightarrow \varepsilon + \nu$$

disintegration, solved this same year of 1938 by Yukawa's[354] model for decay of the "mesotron", the particle intermediate in mass between electron and proton, and responsible for intranuclear forces. Thus the old haunt of a separate "material mass" carrying the velocity-dependent electromagnetic mass returned in the guise of some special type of "heavy electron" in addition to the one being studied. But the work of Zahn and Spees demolished both this spectre and the Abraham model forever, with an experimental error ≯1.5%.

Velocity-Dependent $\tau = \gamma\tau_0$

In 1939 a Cosmic Ray Symposium was held in Chicago to discuss the puzzling disintegration characteristics of these "mesotron" particles arriving from outer space and having a mass intermediate between proton and electron. Thus the transition from attention upon relativistic mass to relativistic particle decay shows in history as neatly pinned 1938-1939.

Rossi[291] attended this meeting, and immediately published a paper the same year. In his second opening paragraph he said:

> Let τ_0 be the lifetime of the mesotrons at rest. It then follows from the relativistic transformation formula of time intervals that the lifetime of a mesotron moving with a velocity βc is
>
> $$\tau = \tau_0 \ (1 - \beta^2)^{-\frac{1}{2}}$$

As given earlier for electrons, the energy of the mesotron is characterized by the momentum *p*, which is in turn a direct function of the radius of deflection or curvature ρ measured in a magnetic field

$$\frac{1}{e}\,pc = H\rho$$

where *pc* is measured in electron-volts.

Thus did the Special Theory, carried in fact only adventitiously throughout the study of velocity-dependent mass because of the factor common to them both, inobtrusively and virtually instantaneously slide into place with elementary-particle physics. As we have argued for velocity-dependent mass, there was nothing in the decay-delay data which in itself *required* a Lorentz contraction, neither did the data *necessitate* the drastically novel interpretation in terms of dilation of the time unit ∂t itself

$$\partial t = f(v) = \gamma\ (\partial t)_0$$

$$\tau = \tau_0 \int_0^v \frac{d(\partial t)}{dv} = \gamma\tau_0$$

rather than simply a function of a velocity-dependent mass-energy complex *m*

$$\tau = \tau_0\ f(m) = \tau_0 \int_0^v \frac{dm}{dv} = \gamma\tau_0$$

and perhaps a decay rate expressed as

$$N = N_0 e^{-m_0 t'/m\tau_0}$$

where the time interval t' and the rest-life τ_0 are both measured in cosmic time units. For this would mean little more than that kinetic energy, in increasing the inertial mass, similarly acts to increase the stability of the mass-energy complex. The transforms would be Galilean, similar to handling any other rate equation common to physical chemistry, thermodynamics, physics, and even mechanics. Those who have not followed the interesting discussions on the *chron* or *chronon*, the quantizing of time, and the suitability of the discrete partial differential rather than the continuous, should take a look at Levi[211], Latzin[202], Pokrowski[277 278], Beck[19], Wollaston and Miller[350], Ruark[295], Flint[123], March[232], Salecker and Wigner[304], and so on. There seems to be nothing of fundamental sort requiring dilation of the time unit rather than dilation of mass to supply the necessary rate factor $(1 - v^2/c^2)^{-\frac{1}{2}}$; and the latter has experimental basis.

In fact, as Hanson[148] has recently suggested, the velocity-increased mass might be considered in the light of a *new particle* with its own stability characteristics.

In any event, this was how it was done, when it was done, and by whom it was done. We do not mean to criticize the step that was taken, neither those who took it, but rather to point out that the selection was indeed arbitrary, and almost certainly a breach in logic as we shall go into more fully later. Regardless of its apologies today, the concept of time dilation arose solely out of the null-datum of optics, which has nothing to do with particle decay; and the reason for having taken that astonishing step lay solely in the failure to recognize the fact of the Earth's magnetospheric envelope, as we have repeatedly indicated. At the very least it was a violation of Newton's guideline: *hypotheses non fingo*. Indeed, at this stage the hypothetical level in relativistic physics has been shown to be stacked as much as fivefold[360] -- a matter that long ago led Poincaré, and later Langevin, to apply the term *coup de pouce*[273]. But let us resume our story.

Already by 1940 Rossi with Hilberry and Hoag[294] had another classic in the press, reporting on some brilliantly conceived tests comparing decay lives for particles passing through air as compared with those transiting a layer of graphite having equal path-integrated mass, also for altitudes varying from Chicago's 180m, and Denver's 1616m, to California's Echo Lake at 3240m and Colorado's Mt. Evans at 4300m. Protons striking nuclei of N and O in the planetary atmosphere, they reasoned, produce "emplasms" of π^+, π^-, and π^0 pions. The neutral π^0 go on to decay into γ-rays and showers of electron-positron $\varepsilon^-/\varepsilon^+$ pairs, while the charged particles variously produce mesotrons and neutrinos

$$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$$

$$\pi^\pm \rightarrow \mu^\pm + \bar{\nu}_\mu$$

whereupon the mesotrons in turn decay according to

$$\mu^- \rightarrow \varepsilon^- + \bar{\nu}_\varepsilon + \nu_\mu$$

$$\mu^\pm \rightarrow \varepsilon^\pm + \bar{\nu}_\varepsilon + \nu_\mu$$

or in general

$$\mu^\pm \rightarrow \varepsilon^\pm + \nu + \bar{\nu}$$

The path length L, due to the variable life τ, became

$$L = v\tau_0(1 - \beta^2)^{-\frac{1}{2}} = \gamma v\tau_0$$

$$= p(\frac{\tau_0}{m_0})$$

Not until the sixth page of their report do these authors rather casually mention that

> ...from the relativistic variation of time intervals with velocity, it follows that $\tau = \tau_0\ (1 - v^2/c^2)^{-\frac{1}{2}}$ where τ_0 is the lifetime of mesotrons at rest.

Nothing of fundamental significance for the present subject has occurred since that time except to refine the rest life τ_0. Rossi[292] opened 1940 with a paper, and closed it with another coauthored with Hall[293], this latter being generally regarded as the prime reference piece. Interestingly enough, their paper was entitled *Variation of the Rate of Decay of Mesons with Momentum*, yet they assigned the $(1 - \beta^2)^{-\frac{1}{2}}$ factor to the convenient Lorentz transformation and concluded that the data were

> ...in agreement with the theoretical predictions based on the relativity change in rate of a moving clock.

Again let us take a dispassionate glance at this historic and critical transition $dp/dv \rightarrow d\,(\partial t)/dv$: By the Lorentz route of a naked-Earthball and an "ether wind", this meant they were accepting (1) an *ad hoc* assumption of time dilation originally introduced because it was required by (2) an *ad hoc* assumption of in-line-of-motion contraction which had in turn been required by (3) the erroneous assumption that the Earth has no magnetosphere, and that the null-datum electromagnetic instruments of experimental physics were in actual motion relative to the embedding heliosphere or interplanetary space. To this day neither time dilation nor spatial contraction has ever been observed in optical experiments, yet it was optics which gave them both birth.

By the Einstein route of ethereal non-participation, Ross and Hall were choosing a type of time dilation which (1) results from the same erroneous assumption that the magnetosphere does not exist, (2) disproves its own thesis by rendering absolute that which was stated to be only relative, (3) runs further afoul of a third *ad hoc* assumption of Einstein's that the time unit can be defined $t = \frac{1}{2}(t_3 - t_1)$ for a to-fro beam regardless of embedded or embedding field or fields, and (4) becomes necessarily associated with a Lorentz-type contraction in which volume strangely vanishes as mass increases. From an original spherical volume

$$V = \frac{4}{3}\pi R^3$$

the volume of the Lorentz configuration decreases progressively, but not even uniformly, with γ, according to the changing volume of the spherical segment on the drag side

$$\frac{1}{3}\pi h^2\,(3R - h)$$

where h is the remaining portion of the diameter D along radius R in line of motion.

Thus at $\gamma = 2$ the mass has doubled while the volume has purportedly halved; and the former sphere now has the rather weird configuration of a half-orange hurtling through space with cut-face forward, the hemicircular rim razor-sharp, and butt free of any compensating bulge - - thanks to optical restrictions of a Michelson interferometer which was the original cause of it all. At the huge velocities of the recent CERN experiments, the entire body of the particle has almost disappeared according to Lorentz and Einstein, the hemisphere fading away to a miniscule tip. Strangely enough, this odd penalty stemming from the transverse arms of the Michelson instrument, under the Lorentz misinterpretation, seems never to have bothered relativists. But let us proceed with the historical unfolding of our subject, better to understand what we are trying to say.

One of the most cogent tests performed by the Rossi group was the testing of the decay behavior as affected by equal in-line masses of vastly differing density. For the interaction with matter might understandably delay decay. But the lifetime for passage through air was much different than that for passage through an equal mass of graphite. Rassetti[284] performed tests on decay behavior in solids of different density - - Fe and Al. There was no significant difference.

With advent of the powerful accelerators following World War II, and various types of exceedingly high-voltage instruments equipped with "storage rings", this field of study came to indisputable proof that the lifetime τ for transient particles

$$\tau = \tau_0(1 - \beta^2)^{-\frac{1}{2}}$$

$$= \gamma\tau_0$$

and that the particle count for any observer time t' is

$$N = N_0 e^{-t'/\gamma\tau_0} \qquad \ldots \qquad \text{Equation C}$$

In the 1960's a particularly definitive report appeared by Frisch and Smith[132], and in the 1970's it was primarily the works of Bailey *et al.*[14 15 16] at the European Organization for Nuclear Research (CERN) in Geneva, using the Muon Storage Ring for positive and negative muons in circular orbit. Let us examine their *interpretations* in some detail. No question arises as to their data, neither to the asymptotic relationship

$$(\cos\theta)^{-1} = \sec\theta = \sec\sin^{-1}(1 - v^2/c^2)^{\frac{1}{2}}$$

$$= \sec \sin^{-1} (1 - \beta^2)^{\frac{1}{2}}$$

$$= \gamma$$

which they established for both mass *m* and momentum *p*, also the life interval τ :

$$m = \gamma m_0$$

$$p = \gamma m_0 v$$

$$\tau = \gamma \tau_0$$

Frisch and Smith[132] used this opening sentence:

> One of the most startling predictions made by the Theory of Special Relativity is that moving clocks run slow, by a factor $(1 - v^2/c^2)^{\frac{1}{2}}$ ...

Their procedure involved the use of large thicknesses of Fe to cull the low-energy mesons, followed by thin plastic sheet for purposes of counting; and they performed such a spectacular stunt, comparing the counts for μ-mesons at 0.9950 - .9954c atop Mt. Washington with those at sea level, as to produce a stunning movie entitled: *Time Dilation - - an Experiment with μ-Mesons*. They then made these statements:

> As far as we know the probability of the radioactive decay of subatomic particles, and thus the average time they survive before decay, is set by forces entirely internal to their structures...
>
> Therefore *any dependence of the decay probability of radioactive particles on their speed is an example of a general property of clocks in motion relative to an observer* rather than a property of the speed of those particles relative to anything else in the universe. It is irrelevant, for example, that up to the present era the observer has happened to be on earth.
>
> We conclude that the mesons decay much more slowly when they are in rapid flight, relative to us, than when they are at rest.
>
> We conclude that *their clocks are running slow.*
>
> Hence, the larger fraction we expect to decay, because of the greater distance they go, is just compensated by the smaller interval of time we read on their clocks per unit distance they move.

Their closure is this:

> Thus, not only does our experiment give direct qualitative evidence of time dilation, but the observed numbers support the quantitative predictions of the Special Theory of Relativity.

The mean rest life τ_0 was found to be 2.21 μ sec, and the observed γ factor was 8.8 ± 0.8 as compared with a calculated 8.8 ± 0.2.

Bailey and his coworkers[16] had little to add except to refine τ to 2.1948(10) μsec, using enormous velocities of β = 0.9994 with γ = 29.33, and then to extrapolate the conclusions to cover the famous Twin Paradox of the STR. Here is their opening paragraph:

> Measurement of a lifetime of a sample of radioactive materials which is moving with a known velocity is a means of testing the so-called time dilation, or slowing down of moving clocks, predicted by the special theory of relativity ... If in addition the radioactive particles move in closed circular orbits,

then the conditions simulate those of the outward and return journey of the twin paradox which, according to the theory, the journeying twin ages more slowly than the one who stays at home ...

They further pointed out that this type of test also permits distinguishing "any modification of the theory due to acceleration"; and they then gave final dismissal to the repeated claims that the paradox has its sanction in the General Theory, by stating that

> No such effects are seen in this experiment.

In 1972 the same group[15] had similarly concluded that

> This result removes any lingering suspicion that some unsuspected effect associated with acceleration would compensate the time dilation in a circular or out-and-return trip; the *clock paradox* is established as an experimental fact.

And of course this represents the consensus in relativistic physics as it stands today.

The Positron Problem

Only with much reluctance does one criticize such an overwhelming consensus; yet the original purpose of the present analysis requires bringing its arguments to whatever conclusions they may lead, then leaving the matter for discussion by others. There are at least three major aspects deserving attention:

First, these equations with the γ-factor or cosine relationship, as we have repeatedly pointed out, have no inherent feature distinguishing them from ordinary rate equations which subsequently submit to whatever transformation one deems proper for other reasons. As Phipps[267] has stated:

> The existence of a finite limiting particle velocity in nature is compatible with the Galilean transformation.

Second, this captivity by a Lorentz transformation, when one need go no further than the rate equations of thermodynamics, imposes a requirement which not only violates orderly reasoning, but contradicts its own premises. We shall restrict our quotations to three modern textbooks. Consider Resnick[286]:

> The moving pion sees the laboratory distance contracted, and in its proper decay time can cover laboratory distances greater than that measured in its own frame.
>
> If we were sitting on the pion, the laboratory distance of 39m would appear much shorter ...

French[128] discusses the Mt. Washington experiment:

> From the point of view of the moving mesons, the distance between mountains and sea level is strongly contracted ... The earth and its atmosphere are rushing upward at a speed almost equal to c ... the distance between the top of the mountain and sea level is modified by the Lorentz contraction ...

Here is Rosser[290]:

> Relative to the μ-meson, there is no time-dilation, but the earth and the earth's atmosphere are Lorentz contracted...

As one can see, the penalty for using these transformation equations rather than rate equations is the "reciprocity" aspect. For few things could be so fanciful as those just cited, and so vulnerable to refutation: First, did we not just list the validations of absolute space which at the very least returned the Einstein model to the Lorentz model? But with an invariable spatial metric, how can distance itself be made to vary? The common answer to this is that it merely "seems" to vary, perhaps because of the traveler's foreshortened yardsticks; but this is an escapism that fails upon closer adherence to one's definitions. For did not the Lorentz contraction originate in the sense of *actual* longitudinal electromagnetic compression due to *real* motion relative to rest coordinates of the embedding Maxwellian field - - the "ether" of FitzGerald, Lorentz, Larmor, Poincaré? If *not*, then there must be that original Einstein promise of reciprocity, which we saw ruled out with the failure of the Special Theory and the return to absolute space. If *so*, on the other hand, then there is not even a claim for reciprocity, since only the observer at rest relative to the rest coordinates of the embedding field has the right clocks and rods - - again to quote Edmonds [83]. One need only substitute the measured time lag Δt in Einstein's own equation

$$\Delta t = t\{1 - (1 - v^2/c^2)^{\frac{1}{2}}\}$$

to solve for the uniquely defined moving and stationary systems.

Again, relativists are generally agreed - - and in fact must necessarily admit - - that the Lorentz contraction, whether real or merely apparent, is *not* applicable to measurements by the moving observer because all of his measures and his total environment are similarly contracted. Therefore the contraction only registers as a contraction on the part of the "stationary" observer. The contraction may then be either (1) real, due to this "electromagnetic compression" for lack of a better term, or (2) merely apparent due to restrictions of signal transmission. But if merely apparent to the *outside* observer, then the entire reasoning of the founders of relativistic physics concerning the Michelson-Morley experiment is invalidated. Furthermore, time dilation would similarly have to be a matter of external appearance only, hence reversing on the return journey.

If *real* on the other hand, due to actual metric relationships to the embedding field, then a violation of premise results. For the space which makes the motion real has its own independent metric; and one can quickly see that an "observer on a muon" traveling, say, at Bailey's $\beta = 0.9994$ and $\gamma = 29.33$, while still reading his own meters at 1000.000 mm, would have his sticks appear to the *laboratory observer* as measuring only 39.095 mm; and if that laboratory physicist were then to lace the muon trail with such markers as transverse laser beams or field blips at 39.095 mm intervals, so that Dr. Muon could measure his passage meter-by-meter, we would get the interesting report from him that he was traveling 29.33 times the velocity of light. Worse, with his clocks similarly slowed by an equal factor, he would report the trail *distance* as greater by a factor of 29.33, and his velocity as 58.66c.

Also, Dr. Muon would have something to say about rotation, if traveling in a storage ring. The conventional reply of the relativist would be that he sees the ring and all the rest of the universe rotate about him at 0.9994c. But what if the laboratory were to construct a second accelerator atop the first, reverse the travel direction, and then board Dr. Muon's twin for a simultaneous run at 0.9994c? Which direction is the universe rotating now, and how shall anybody seriously believe that his velocity relative to his twin is to be measured by Einstein's composition of velocity law, rather than being 2 x 0.9994c = 1.9988c? This introduction of a third observer has always been a thorn in the side of the facile escapism of a mere two observers isolated from everything else belonging to reality. Those who fail to get the point should review the *Gedankenexperiment* on "The Twin Paradox and the Triplet Disaster"[363], also "A Metallurgical Gedankenexperiment Testing the Lorentz Transformation and the Special Theory of Relativity"[361].

Finally and more important are the observations already coming to hand within elementary-particle physics itself which violate the Lorentz transformation and particularly the time-dilation concept, which relativists seem either to be ignorant of, or deliberately avoid. We shall only mention in passing the difficulty that McCarthy[239] has discussed in the matter of matching data on nuclear cross sections with the peculiar model of a Lorentz-contracted particle losing its volume because of no change in transverse measurements as its mass increases toward infinity with $v \to c$. But let us look instead at the problem presented by the *positron*, which shows the same asymptotic *c* function as any other elementary particle so far as $\tau = f(v)$ is concerned[301]. For metallurgists use τ data for studying dislocation densities in metals, fatigue, recrystallization and grain growth, thermal equilibrium, latticular recovery - - none of which has anything whatsoever to do with particle motion, all velocities $v_i = 0$.

For example, K. G. Lynn, *et al.*[227] in 1974 demonstrated the positron lifetime τ to be a function of fatigue damage in Ni-base superalloys, and in turn a function of lattice vacancies, dislocations, and vacancies in thermal equilibrium. For lifetime τ increased so rapidly up to a saturation value near 7% of the fatigue life, and for stresses $\sigma \geqslant \sigma_y$ where σ_y is the yield stress, that the positron came under consideration as an NDT (nondestructive test). Two years later Lynn and Byrne[226] applied the technique to AISI 4340 low-alloy steel at the two Rockwell hardness levels of R_c27 and R_c51. Using an $Na^{22}Cl$ source enclosed in 0.103 cm mylar sheets, and inserted between fatigue samples in a Sontag SF-2-U fatigue machine at a fixed frequency of 30Hz, they coupled the scintillation crystals to RCA phototubes and a special fast-fast coincidence circuit, enabling simultaneous energy and timing discrimination on the two γ-ray signals associated with the birth and annihilation of each ε^+ at 1.28 and 0.511 Mev respectively. Data from 2-hour periods were evaluated by a special computer program called *Positronfit*, which handles several lifetimes:

Primary τ_1 100-200 ps ... the mean lifetime representing average weighted behavior in a perfect crystal

$\tau_2 \simeq 360$ ps ... lifetime in the source itself ($Na^{22}Cl$)

$\tau_3 \simeq 1600$ ps ... lifetime in the mylar envelope

They found τ to *increase* 119 → 165 ps when subjecting soft steel to cantilever-bend cycling at a stress $\sigma = 0.67$, but to *decrease* by ∿40 ps when cycling hard steel. That the lifetime of this elementary particle was actually a function of dislocation density and particle size was shown by the change in diffuseness of Debye diffraction rings. (See Figure 6.)

So which "twin" is composed of which elementary particles? And is he going to age less rapidly due to Einstein time-dilation when in motion, or more rapidly due to the Lorentz contraction reducing his dislocation density? Or should he correct his clocks?

In 1977 Hadnagy, Byrne, and Miller[147] checked positron $\tau = f(p)$ where *p* is the porosity fraction in hot-pressed and sintered α-Al_2O_3. The relationship is so good they considered it as a tool for gauging porosity. Their interpretation was that the electron density within a material is altered in the neighborhood of a void. Johnson *et al.*[177] that same year, also the Byrne group[263], used the τ technique for studying the progression of precipitation-hardening in Al-base alloys. The criterion was Doppler energy broadening of α-photons resulting from the ε^+ annihilation. They called attention to differences in the momentum of conduction electrons as compared with core electrons, which influences the probability of positron annihilation - - still one more variable for the "aging twin" hypothesis. We shall conclude this part of the discussion by mentioning the further work of Johnson *et al.*[178] on the recovery, recrystallization, and grain growth of coldworked Cu, Ni, and α-brass using the Doppler broadening technique, and finding τ variations 130 - 185 ps, also the study of Alexopoulos and Byrne[6] on Cu fatigue.

For those who have so freely made the enormous extrapolation from muons to human beings, on the heuristic premise that everything is composed of "elementary particles" of nuclear rather than molecular type, perhaps we should call attention to the "timekeeping enzyme" in the pineal gland[31]. For this is the "biological clock" closely linked to all internal timing mechanisms. And while kinetic energy due to high velocity may indeed act to increase the stability of the "gluons" within the nucleus, it might just as likely tend to tear apart

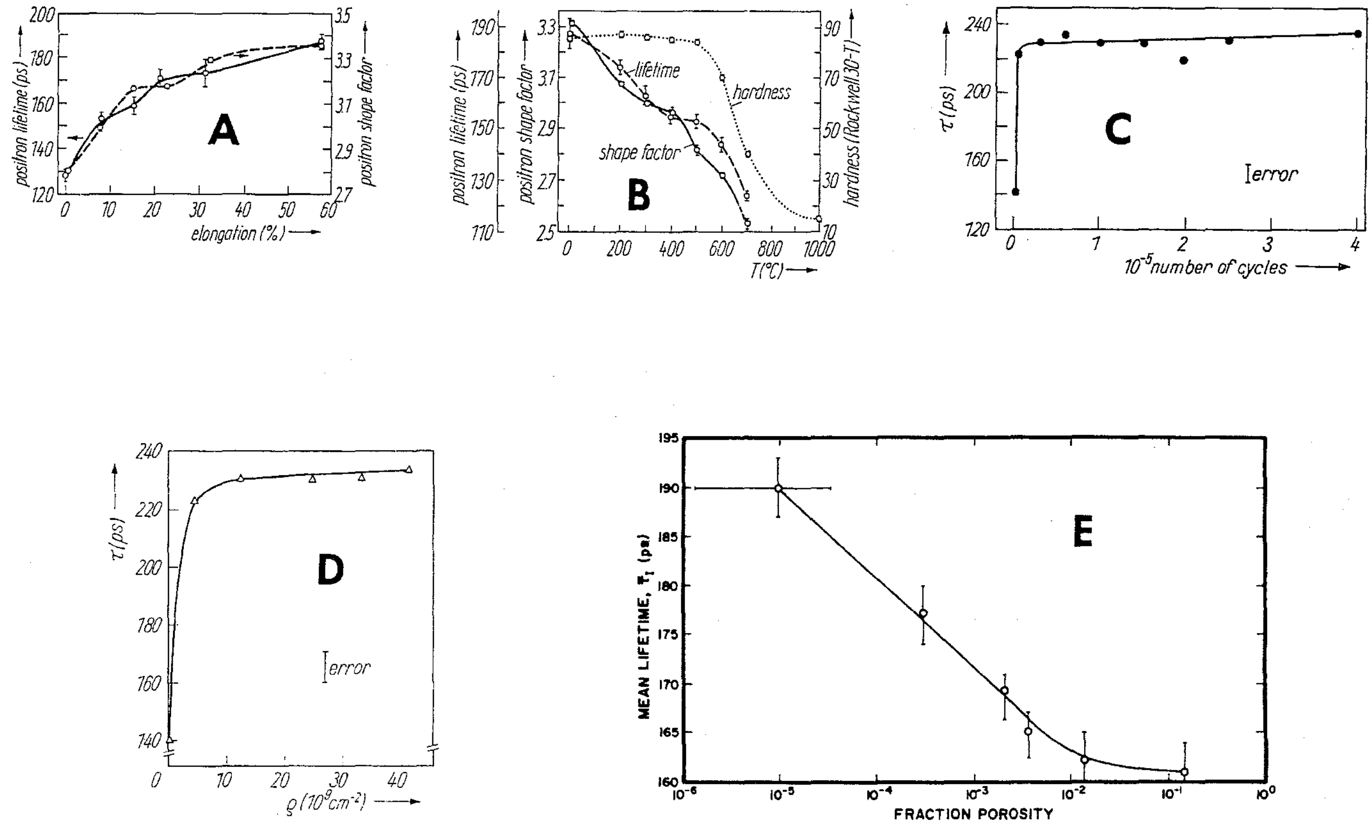
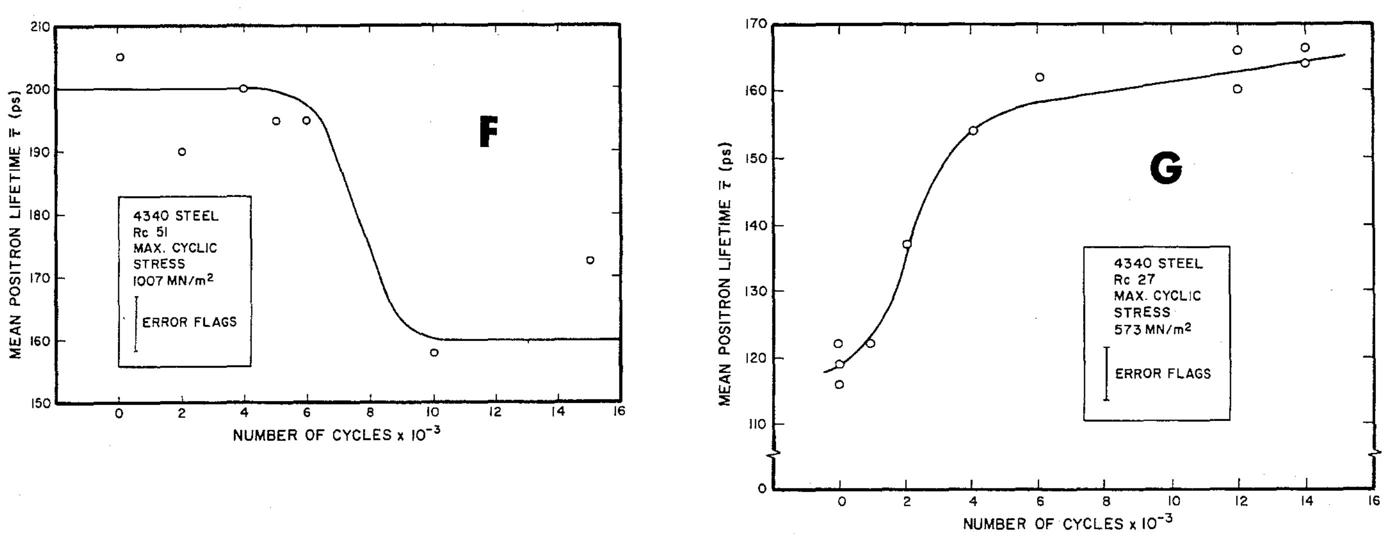
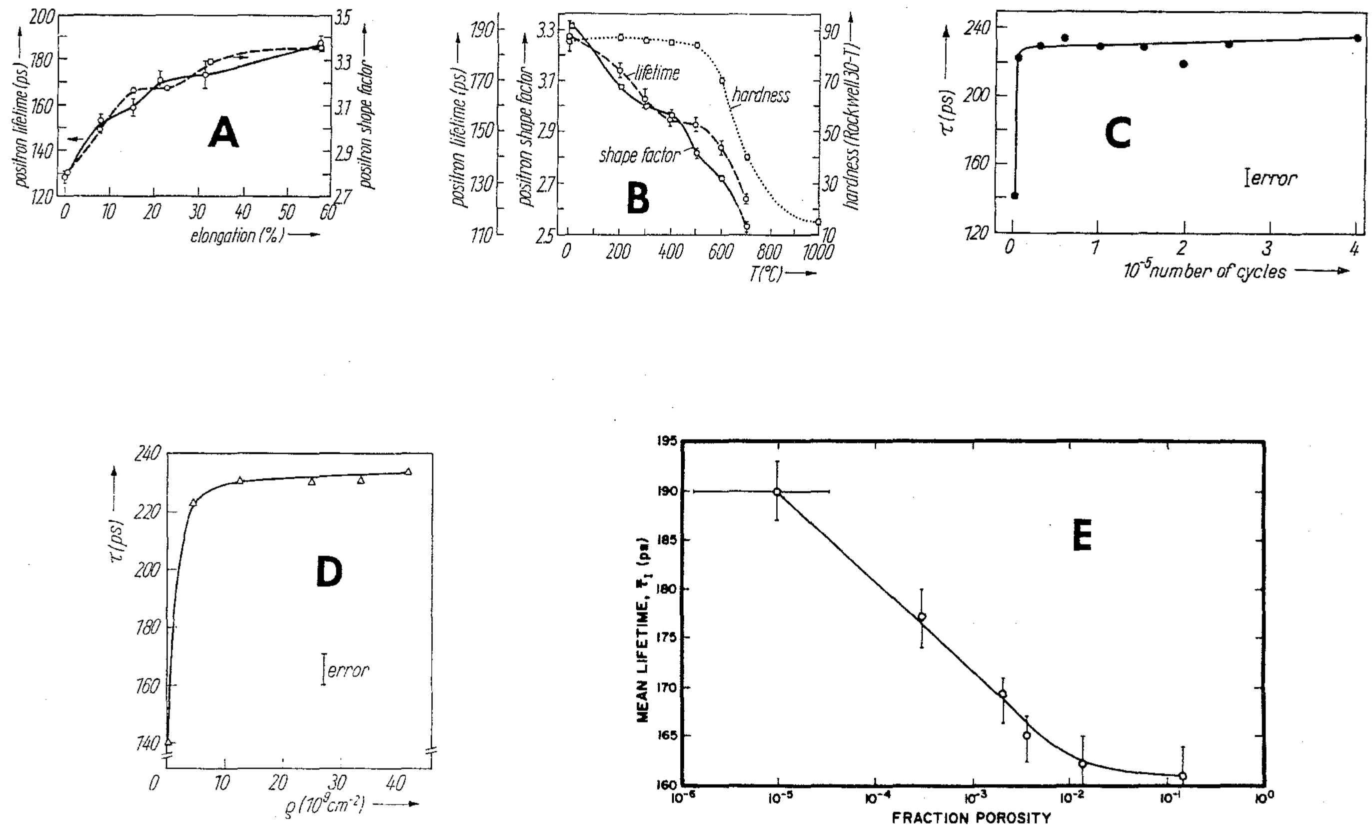


Figure 6: Examples of mean positron lifetime τ in pico seconds (ps) as a non-velocity function of (A) percentage elongation in Ni; (B) hardness, annealing temperature, and positron shape factor for 69% cold rolled Ni; (C) cyclic deformation at 31.7 kp/mm^2 maximum bending stress in Ni–66.5% Co alloy; (D) calculated dislocation density in Ni–66.5 Co; (E) porosity fraction in $\alpha-Al_2O_3$; (F) number of fatigue cycles at maximum cyclic stress of 1007 MN/m^2 for Type 4340 steel at an initial hardness of Rc–51; (G) same as F but at 573 MN/m^2 and Rc–27. Note the wide variation in curve types, the common appearance of an approach to an asymptotic limit, and the completely reversed behavior for the same specimen in F and G depending upon mechanical properties and test condition.

Data variously from Lynn *et al.* [226,229], Johnson *et al.* [178], and Hadnagy *et al.* [147].





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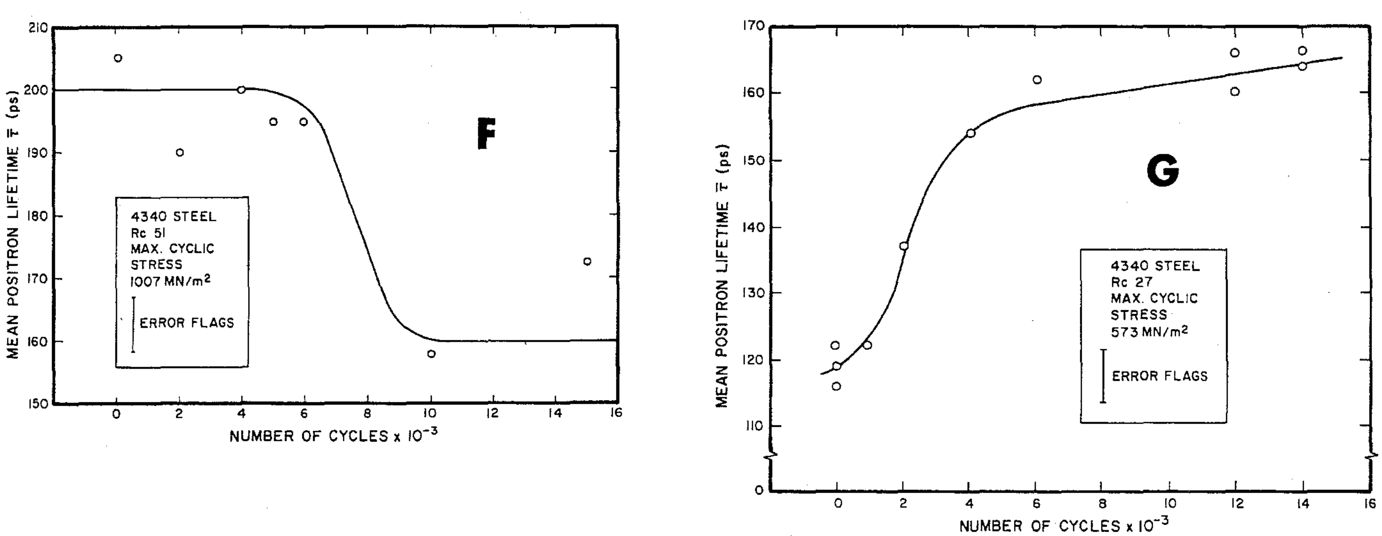

but with *Kritikus* now taking the "fall guy" place of Simplicio in setting up the right questions for the anonymous (?) *Relativist*. Einstein does not delay his scenario, but opens the second page with the main "hang-up":

> *Kritikus:* Nun kommt der Haken ...

For this question concerned the reciprocity, namely the ability to exchange coordinate systems at will with identical results, the very Principle of Relativity itself. Four decades later the simmering dissatisfaction with Einstein's explanation, and the continuing annoyance of the seemingly insurmountable self-contradictions incident to the Clock Paradox, would explode in 1957 with the famed Dingle controversy[35 57 62 70 78 79 127 133 240 241 261], would cause Builder[45 57] to rewrite the Special Theory in terms of absolute space[46 48], and would lead to book-length anti-relativistic works of increasing number to this very day[10 56 62 80 112 152 180 181 201 233 261 314 362], as we earlier mentioned.

To those of us who admire this most unusual man, his 1918 defense of the STR using GTR machinery is not only disappointing, but embarrassing. For no less than five grave errors in his reasoning display themselves, covering a wide range of (a) mechanics, (b) geometry, and (c) his own definitions, with at least another two in his *Gedankenexperiment*.

First, and as Essen[112] has also noted, it is an obvious breach of logic to propose that some consequences of a theory completed in 1905 from all points of (a) derivation, (b) formulation, (c) explanation, and even (d) extrapolation, should require its explanation to be found in some second theory not even in existence for almost another decade.

Second, the very name *"Spezielle" Theorie* records its specified limitation to inertial rather than gravitational reference frames; whereupon it stands as an outright contradiction in points of both epistemology and logic for Einstein to call in the reference frames excluded by his own definitions.

Third, a similar error stands with respect to his geometry. For the one theory is so clearly confined to Euclidean space that the birth of the second theory actually represents a completely novel concept arising out of *non*-Euclidean space.

Fourth, in phrasing his original 1905 *Gedankenexperiment* with a to-fro journey degenerating into a polygonal and then a curvilinear path, Einstein implicitly introduced *acceleration*, thereby immediately violating a principal term and concept in his First Postulate, namely that of the inertial frame. And as we have already indicated, he then further violated the Principle of Relativity itself by discovering time dilation in his *moving* clock. And now when he returns to this model with GTR tools, he is found (a) trying to explain something, (b) that was already there in 1905, and (c) which had proved at that time that *acceleration is not a factor* in the Lorentz transformation which is patently based upon $v = dx/dt$, not $a\ (\equiv g) = d^2x/dt^2$. For if that author in 1905 could use a *rotational* model to illustrate an *inertial* velocity effect - - based on the supposition that the <u>rotation does not matter</u> - - then on what authority is he proceeding in 1918 to explain an inertial velocity effect as *caused* by acceleration?

Fifth, it does seem a necessary conclusion that this labored attempt in 1918 to answer a charge of self-contradiction in his 1905 model, solely with GTR machinery which draws little or nothing from the STR, stands as an admission that the alleged self-contradiction indeed exists within the STR itself.

Because the findings of modern high-energy physics now prove that acceleration is *not* a factor in chronometric behavior due to motion, as we shall shortly detail more fully, we can proceed with assurance to analyze errors inherent within Einstein's 1918 argument. Let us begin with his answer to *Kritikus:*

> *Relativist:* Es is sicherlich richtig ...

It is certainly correct, he began, that the Reciprocity Principle holds - - viewing the *Relativitätsprinzip* in its broad form. *However,* - - he continues - - one should easily observe that the two systems in question *are in no way equivalent:*

> Aber man sieht leicht ein, dass die Systeme K und K' mit Bezug auf den betrachteten Vorgang keineswegs gleichwertig sind ...

Whereupon he runs two columns carrying comparisons of five features, and basing his conclusions on the strange and ultimately untenable assumption that the one system *K'* is accelerated by "outside forces" while *K* is subjected instead to strangely and conveniently varying gravitational fields. Immediately the realist must counter that any "aussere Kräfte", such as rocket thrust, would be both visible and known to all parties as the problem reduces to the astronaut in *K'* trying to regard himself as at rest while the universe rushes back and forth as may be necessary to the scenario. We do not mean to deny to the theoretical physicist the right to engage in any intellectual gymnastics he may desire, as repugnant as some of them may become to the engineer and realist. For they do aid in testing the mathematical apparatus. But the physicist must at some time come to terms with the real world of the engineer, who eventually inherits the theoretical model and becomes responsible for its practicability. To accomodate both parties, we shall hold the following analysis to the essentially undeniable errors.

First is the outright violation of the Principle of Equivalence which Einstein himself defined at Princeton University just three years later as "the assumption of the complete physical equivalence of the systems of coordinates, *K* and *K'*..." - - the one accelerated by mechanical force, the other by gravitational field. He nevertheless proceeds to subject *K'* to a 4-cycle acceleration/deceleration programming, in which the slowing of his clock is solely produced by the interim velocity dx/dt, regardless of d^2x/dt^2; while he allows K' to view *K* from standpoints of an identical gravitational-field programming in which the relative *speeding* of the *K* clock due to gravitation is so much greater than the time loss due to velocity that it *überkompensiert* - - and conveniently by an exact factor of two, such as to make the $-\Delta t$ of the *K* clock read $+\Delta t$ when the two come back together. This happily turns out to be the same result as calculated from observations in *K*, which then explains the paradox.

One can only presume that the principles of equivalence and reciprocity contradict one another; and perhaps they do.

Moreover, Einstein's *überkompensiert* factor of 2.000 seems an unacceptable convenience. Consider several circumorbiting satellites at various constant altitudes ranging from Einstein's equatorial clock at Earth radius r_o to other altitudes r_t. From velocity standpoints of inertial frames ranging in turn from linear → polygonal → curvilinear as in Einstein's 1905 model, the motion from point $P = (x, y, z, t)$ → $P' = \{(x + \partial x), (y + \partial y), (z + \partial z), (t + \partial t)\}$ gives us

$$\partial s^2 = \partial x^2 + \partial y^2 + \partial z^2 - c^2 \partial t^2 = -c^2\ \partial\tau^2$$

$$\partial\tau = \partial t\ (1 - v^2/c^2)^{\frac{1}{2}}$$

with the usual time dilation in the moving system. If we then in turn generalize this rotationally accelerated system back to a linearly accelerated system such as the typical rocket *Gedankenexperiment*, letting v now represent instantaneous velocities along an integrated path

$$\int d\tau = (ic)^{-1} \int ds = \int dt\ (1 - v^2/c^2)^{\frac{1}{2}}$$

then

$$\tau = \int_{t_1}^{t_2} (1 - v^2/c^2)^{\frac{1}{2}}\ dt$$

which again give us the traditional

$$t = \gamma\tau$$

or

$$\tau = \gamma\tau_0$$

However, gravitational fields now definitely enter the model, rather than rotational acceleration; and if we let

$$g = GM/r_0^{\ 2}$$

express the general gravitational constant G and the specific terrestrial constant g at radius r_o, then

$$mv^2/r_i = mGM/r_i^2$$

where *m* is the mass of the rocket, and *M* the mass of the Earth. From this we get a velocity

$$v_i^2 = GM/r_i = \frac{GM}{r_0}\ \{\frac{r_0}{r}\} = gr_0\ \{\frac{r_0}{r}\}$$

Returning now to the Lorentzian time dilation

$$t = \gamma\tau$$

$$\tau = (1 - v^2/c^2)^{\frac{1}{2}}t \approx (1 - \tfrac{1}{2}v^2/c^2)t$$

and converting the time dilation $\Delta t = t-\tau$ into terms of beat frequency $\Delta\nu = \nu_0 - \nu'$ then

$$\Delta\nu/\nu_0 \approx -\tfrac{1}{2}\ v^2/c^2$$

to second order. Substituting this in our gravitational equation

$$\Delta\nu/\nu_0 = -\frac{1}{2}\ \frac{gr_0}{c^2}\ \{\frac{r_0}{r}\}$$

expressing the Lorentz loss for the moving body.

But an increasing gravitational potential *increases* the beat frequency by an amount

$$\nu_0 gh/c^2$$

for a uniform field, or

$$\Delta\nu/\nu_0 = \Delta\phi/c^2$$

for a variable potential ϕ. Since

$$\Delta\phi = \int_{r_0}^{r} \frac{GM}{r_i^2}\ dr = -\ GM\ (\frac{1}{r_i} - \frac{1}{r_0})$$

$$= \frac{GM}{r_0}\ (1 - \frac{r_0}{r_i})$$

$$= gr_0\ (1 - \frac{r_0}{r_i})$$

then

$$\Delta\nu/\nu_0 = \frac{gr_0}{c^2}\ \{1 - \frac{r_0}{r_i}\}$$

which indicates an *increased* beat rate, or *time contraction* rather than time dilation. This expresses what seems to be a general conclusion that an increasing gravitational potential *increases* clock rates.

But this is *opposite* to the velocity effect measured by the Lorentz transformation; whereupon we must add this gravitational gain to the previously derived Lorentz loss, giving us

$$\Delta\nu = \frac{\nu_0 gr_0}{c^2}\ \{1 - \frac{3r_0}{2r_i}\}$$

for the frequency change in the satellite clock as compared with the ground-based duplicate.

Immediately one sees that at $r_i > \frac{3}{2}\ r_0$, or ≈3200 km above sea level, $\Delta\nu$ becomes *positive*, which would translate into *more rapid aging* for the astronaut than for the one remaining on the pad. Only at lesser altitudes will the Lorentz effect predominate. So at least in this type of situation there is nothing suggesting a convenient and fixed *überkompensiert* factor 2.00 which Einstein seemed to find.

Since these matters tread on tremulous ground, we shall simply refer to their more able presentations by Cochran[53] and Rosser[290], and will now proceed instead with our critique on certain further objectionable aspects of this strange 1918 *Dialog* ... .

Our second major criticism is this: If the theoretical physicist is permitted to define some completely isolated and stationary system for his *Gedankenexperimenten*, wherein "it is not reasonable to propose that the center of mass actually moves" (Einstein 1906[88]), then he must be held to that same premise when glibly shifting the universe back and forth to suit his alleged reciprocity scenario.

For it is not only the Earth that "rushes" to or from the traveling *K'* - - and this applies to the muon as well as the astronaut - - but instead the *entire cosmos*. And into *what* shall the cosmos be said to move? Therefore the cosmos does *not* move, let alone "rush" back and forth as may suit some local petty purpose; and those who are unable to distinguish their own sudden changes in motion, when given as the only alternative hypothesis that it was the entire cosmos which did the moving, should not be allowed to clutter the press with their printed statements. Let us glance again at a couple of typical excerpts from popular texts. Here is Rosser in his Introductory Relativity[290]:

> Relative to the μ-meson, there is no time dilation, but the Earth and the Earth's atmosphere are Lorentz contracted.
>
> *Relative to the moving rocket, the distance from the Earth to the star is Lorentz-contracted by a factor* $\gamma \sim 10^{14}$ ...

Here is French in his Special Relativity[128]:

> From the point of view of the moving mesons, the distance between mountaintop and sea level is strongly contracted ... the Earth and its atmosphere are rushing upward at a speed almost equal to *c* ...

Back to Rosser[290]:

> *Relative to a proton of energy* 10^{19} *eV the dimensions of the galaxy are Lorentz-contracted by a factor of* $\gamma \simeq 10^{10}$. *In the direction of relative motion of the proton and the galaxy, relative to the proton the galaxy would have roughly the dimensions of the solar system.*

Are such authors proposing to contract the entire universe, or just half of it? And contracted *from* what? If Riemannian-finite, does the 4-sphere flatten in line of motion only? And what's that? If infinite, what shrinks? And do the transformation equations provide for such a thing as a "Lorentz expansion" for the receding hemisphere? Certainly the future historians of science will gaze upon statements such as these with facial expressions exercising every muscle in the human body which reacts to sensations of incredibility.

As for the following quotation, this seems to establish a new "equivalence principle" between technical error and personal arrogance[133]:

> We subject the entire universe to a uniform gravitational field opposite in direction to *v* ...

We do not doubt that the universe will *appear* distorted to any one in real motion relative to the frame of the fixed stars and the 2.7°K background radiation; but then the term "apparent" must be affixed. Once affixed, it should remain affixed; and if this applies to measurements of space, then it likely refers similarly to measurements of time. But again let us return to the story.

In 1924 Born[36] followed Einstein's lead in implying that the paradox for the round trip was the result of acceleration, though he offered no explanation. One decade later Tolman[336] gave the subject its first technical presentation - - since Einstein had not gone into details beyond positing the general approach. Then in 1952 Møller[249] published the first thoroughly quantitative description. This became the general standard, for such as Leffert and Donahue[205], Crawford[58], Terrell[327], Scott[308], Frye and Brigham[133]. When Levi[210] used the GTR approach, however, he found the Rocket Twin observing his Earthling brother "age instantaneously by $\tau = 2\,vL/c^2$ " at the instant of turnaround. Palacios ran the plan to purposeful absurdity by having various clocks jump variously backward and forward throughout the course of the trip; and it was Crawford's [58] paper in 1957 which triggered the Dingle[78] controversy over "Einstein's regrettable error", as Dingle somewhat regrettably termed it.

While many fine arguments have at last torn down Einstein's GTR approach to the Clock Paradox over these many years, the point of the present discussion is that the matter has been finally settled by experiment - - at least in the opinion of some. Let us look again at Bailey, *et al.*[15] in more extended quotation, as they draw their conclusions on the role of *acceleration* from data on high-energy elementary particles in accelerators and the muon storage ring at CERN:

> The time dilation of special relativity is verified to within 1.1% for $\gamma = 12$. It is emphasized that this experiment involves muons traveling in a circular orbit, simulating the out-and-return journey often discussed in connection with the twin paradox. This result removes any lingering suspicion that some unsuspected effect associated with acceleration would compensate the time dilation in a circular or out-and-return journey; the *clock paradox* is established as an experimental fact.

In 1977 Van Dyck, Schwinberg, and Dehmelt[340] checked out the cyclotron and spin cyclotron beat frequencies for a single electron of 5×10^{-4}eV, corresponding to $\beta = 5 \times 10^{-5}$, caught in a Penning trap with a field B = 20 kG; and they found *no effect of acceleration* within an accuracy range of 5×10^{-9}.

In 1977 Bailey, *et al.*[16] returned to this matter. Their "muon clocks" were now at an acceleration of 10^{21} cm sec^{-2} with a velocity ratio of $\beta = 0.9994$ at a resolution of 10^{-3}. The "clocks" were in circular motion in the Storage Ring - - an exact replication of Einstein's equatorial clock of 1905, and the to-fro Rocket Twins of 1911 and thereafter. The authors first pointed out that:

> In this situation it is also possible to search for any modification of the theory due to acceleration ...

and they came to the conclusion that

> No such effects, insofar as they affect the particle lifetime, are seen in this experiment where the transverse acceleration is $\sim 10^{18}$g.

In 1968 Farley, Bailey, and Picasso[114] pointed out that "huge magnets ... bend the beams with great accelerations"; but they seem to have concluded that there was no relationship to the GTR because the gravitational constant never enters their calculations. We shall certainly have to question this conclusion if the Equivalence Principle for inertial and gravitational mass is to be extended to equivalence between acceleration and gravitation. For they themselves have just given statement to a definition of acceleration in terms of the gravitational constant. More than one able physicist[83] has questioned the Equivalence Principle; and it has been pointed out that Einstein's famous *Gedankenexperiment* involving the elevator under the several conditions of free-fall, gravitational field, and vertical acceleration neglects the rather significant fact that there are *lateral* forces also working upon the contents of the elevator in the case of a gravitational *field*, whereas the supposed duplication by an upward acceleration $-a \equiv g$ in a zero-gravity field involves neither of the two lateral vectors[358].

Let us now turn to the study of the Thomas Precession published by Newman, Ford, Rich, and Sweetman[255] in 1978. Consider a free electron orbiting within a cyclotron under conditions of an imposed perpendicular magnetic field. The rotational frequency becomes

$$\omega_c = \varepsilon B/\bar{\gamma}mc$$

where

$$\bar{\gamma} = (p/m)dp/dE$$

and is not yet necessarily equivalent to the Lorentz γ .

But spin precession develops such that

$$\omega_g = g\varepsilon B/2mc + (1 - \gamma)\omega_c$$

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But spin precession develops such that

$$\omega_g = g\varepsilon B/2mc + (1 - \gamma)\omega_c$$

Here the first term is the normal precession due to interaction of the electron's magnetic moment

$$\vec{\mu} = g\varepsilon\vec{S}/2mc$$

with the cyclotron's magnetic field; the second term is the Thomas precession; and γ then remains to be defined by the experiment according to

$$\gamma = (1 - \beta^2)^{-\frac{1}{2}}$$

$$\beta = \frac{1}{c}\frac{dE}{dp}$$

Data with a precision of 5×10^{-9} then proved the identity $\bar{\gamma} = \gamma$, leading the authors to proclaim the test to be

> ... the most precise laboratory confirmation to date of the predictions of special relativity.

But we must remember, strictly speaking, that this is nothing more than a confirmation of the limiting velocity *c* in the Maxwellian electromagnetics, such that relating it to the entire STR paraphernalia is purely arbitrary and extrapolative. The authors next turn their attention upon this frequently discussed factor of acceleration in time dilation:

> We also consider limits on possible results of acceleration ...

from which they concluded there were

> ... no effects of such acceleration on the internal structure of electrons, or on relativity.

They nevertheless still regarded the precession itself to be

> ... a result of the kinematics of special relativity as applied to accelerated systems.

But the data on precession carry no *requirement* for an assumption of Lorentz contraction, whereupon the pairing with time dilation becomes an assumption. Certainly the explanation of Thomas precession follows more simply and directly from the asymptotic *c* of the very Maxwellian field which one employs to accelerate the particle.

In fine, what we really seem to be discussing is the instantaneous velocity *v* of a particle relative to the autonomous or "locally absolute" field which embeds it, such that no distinction arises between dx/dt and d^2x/dt^2 except in the pattern of successive velocity values. To return to Einstein's opening paragraph in his 1905 paper[87]:

> The observable phenomenon here depends only on the relative motion of the conductor and the magnet.

The absence of distinction between linear velocity and the velocity pattern of acceleration, so far as velocity-dependent effects are concerned, further shows in tests of other type. For example, Lobkowicz, *et al.*[216], working with the hydrogen maser and the second-order tranverse Doppler effect, observed no alteration of their data due to rotation, neither have those studying Mössbauer recoil-free electrons on a rotating apparatus[151 281] - - certainly typical "clocks in circular motion". The results have been conclusive: *No effects upon fundamental processes due to the acceleration of rotation.*

If we then agree that acceleration is *not* a factor in chronometry, must we not either abandon the chronometric factor assigned to gravitational potential, or abandon the Equivalence Principle? For it seems inescapable that, if the so-called "time dilation" is to be freed from effects of acceleration, and if acceleration due to mechanical force is indistinguishable from that due to gravitational force, then gravitation is no chronometric factor. While this appears as a most disturbing situation, in view of certain areas of experimental physics, the following two observations may offer an escape route!

First, there is reason to believe that relativists have not taken sufficient care in defining their "clocks". That is, a "decay" clock measuring the resistance to disintegration in terms of *particle lifetime* carries fundamental distinctions from a "photon" clock based upon *changes in frequency*. For the decay phenomenon intimately and undeniably involves velocity-dependent mass, which obviously is not true for a photon always traveling at velocity c In fact, physics does not yet possess proof, as we earlier pointed out, that the observed $\Delta\tau$ is not a secondary characteristic belonging to an altered particle. In any event, *gravity should play no significant part in particle-decay whether acceleration does or does not*. The claimed time-dilation $\Delta\tau$ is purely Lorentz-derived as a *velocity* function, and in present opinion is due to actual motion relative to the embedding field.

Second, as for the *photon*, this does have to do with gravitation, and perhaps gravitation only, as just indicated, since its velocity is a constant. For the photon as a carrier of inertia becomes subject to a gravitational field; and experiments seem to confirm that the cosmic velocity constant c does thereby become altered. Highly definitive tests have recently been conducted by Anderson, *et al.*[7] using Mariner 6 and 7 flights, and by Shapiro, *et al.*[310] with the so-called *Viking Relativity Experiment*. Both confirmed the time delay predicted by the GTR, the latter with 2-5% accuracy using interplanetary radio signals The round-trip delay time amounted to as much as 250 μs.

But a field-variable c has nothing to do with a Lorentz transformation. Signals of electromagnetic type, entering such a variable field and returning from it, would merely present anew the 1905 problem of choosing whether to accept or reject the second-order Doppler effect. Nothing in an altered *c per se* requires Lorentz-type equations. Therefore the gravitational field, while producing its own causes of *signal delay*, carries no tool for altering clocks in the manner of the Lorentz transformation. The changes in $d\mu/d\phi$ convey information on the field, and on signal velocity, but not on clocks.

Therefore some experiments such as those of the cited Mariner and Viking probes cannot be claimed to support either a chronometric factor in gravitation, or the GTR itself; and those authors were careful to point out that the confirmation of *predictions* of the GTR is no proof of the GTR itself, since the data also confirm the predictions of alternative theories as well.

A Remark on the Relativistic Transverse Doppler Effect

In 1906, just one year following Einstein's 1905 paper and entirely independent of it, Stark[316] published an account of the Doppler behavior of the positive H ions called "canal rays" at that time. In addition to the classical effects, he noted an anomalous second-order red shift of small but definite sort. Einstein[90] immediately explained this in terms of his Special Theory, pointing out that the different clock rates of stationary and moving observers

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

would develop a frequency difference

$$\frac{\Delta\nu}{\nu_o} = (1 - \frac{v^2}{c^2})^{\frac{1}{2}} - 1 \simeq -\frac{1}{2}(\frac{v}{c})^2$$

in contrast to the classical $\nu = \nu_o$. Although J. Stark's data differed from Einstein's calculation by a factor of ten, they retained strong heuristic appeal as confirming the Einstein model. Since directly confirming measurements from a position necessarily perpendicular or near-perpendicular to the line of motion would encounter grave problems in separating linear from quadratic effects, Stark's promising observation remained infertile for a third of a century, when Ives and Stilwell[172] in 1938 and 1941 succeeded in extrapolating the orthogonal measurement with great accuracy through the clever procedure of measuring *both* the blue and red shifts for the respective approaching and receding waves at some convenient angle θ to the in-line motion. The blue shifted wavelength of the forward beam becomes

$$\lambda_b = \gamma\lambda_o (1 - \beta \cos\theta)$$

$$\simeq \lambda_o (1 - \beta\cos\theta + \tfrac{1}{2}\beta^2)$$

where θ is measured in the frame of the laboratory, and λ_o in the frame of the moving atom. The $\beta \cos\theta$ term represents the first-order Doppler shift; the Lorentzian γ, the second order. The receding front similarly has the red-shift

$$\lambda_r = \gamma\lambda_o (1 + \beta\cos\theta)$$

$$\simeq \lambda_o (1 + \beta\cos\theta + \tfrac{1}{2}\beta^2)$$

which then immediately provides an average value

$$\bar{\lambda} \equiv (\lambda_b + \lambda_r)/2$$

$$= \lambda_o (1 + \tfrac{1}{2}\beta^2)$$

for that which would be measured by the theoretical observer at $\theta = \pi/2$. Mandelberg and Witten[231] repeated this experiment with improved accuracy in 1962, as did Kündig[194] in 1963 using Mössbauer data in a rotating system, also Fillippas and Fox[116] in 1964 studying in-flight gamma ray emission from π^o decay particles moving at $\beta = 0.2$.

All confirmed the gamma-factor for ν, $\lambda = f(v)$, such that no reasonable doubt any longer exists concerning that which is now called the relativistic transverse Doppler effect.

But again the careful analyst must raise this question: *Do these data require any explanation which goes beyond that already inherent within pre-Lorentz electromagnetics?* For if the radiation emitted both forward and backward from a moving hydrogen ion must travel at the velocity *c* relative to the embedding field, and the ion itself must obey the $\cos\theta = \sqrt{1 - v^2/c^2}$ law in its asymptotic approach to this same velocity *c*, *then precisely this same factor explaining the experimental measurements lies within the pre-Lorentzian parameters of the system under study.* Time dilation plays no necessary part whatever, and becomes in fact erroneous - - "bad clocks", to quote Edmonds for the third time. The *velocity* which produces the phenomena is *real*, in the sense that it is both measurable and confirmable by all parties, relative to the embedding field of the instrument and/or geosphere, which in turn is now generally agreed to have a determinable velocity relative to larger embedding fields in terms of either heliosphere or 3^oK background radiation, or the cosmological metric of an expanding universe. Therefore the "observer" aboard the moving system *S'* is obliged to adjust his velocity-sensitive clocks and rods to account for their inconstancy under conditions of motion; and his transformation equations should be selected with this in mind.

Incidentally, a too-common error lies in the following typical statement[116]:

> ...the velocities of the source and the radiation are assumed additive by the rules of Galilean kinematics.

While this was true of Galileo in his own time, and for those during the following centuries who stayed with *mechanics*, it is patently in error to make such a remark following publication of Maxwell's field equations in 1865, to say nothing of their elaboration relative to the field constant *c* over those pre-Lorentz days when electromagnetics took its proper place in physics alongside Newtonian-Galilean mechanics. There is no more problem with an asymptotic approach to a limiting *field* velocity in a Galilean transformation than there is for a limiting *medium* velocity; and that transformation has long successfully handled both acoustics and ballistics. The same authors conclude that

> ... the velocity of radiation from a moving source is not the *classical* vector sum of *c* and the velocity of the source. Within our accuracy, the resultant sum is *c* as required by special relativity.

"Classical" is purposefully italicized here For does not Maxwell's electromagnetics belong to "classical" physics? Or does the relativist regard himself solely as a mechanic? Even in mechanics, however, the speed of a man rowing his boat at velocity v_1 cannot exceed the hydrodynamic asymptote c even when aided by a propeller-drive whose own potential velocity v_2 might be such that $v_1 + v_2 > c$ as a "classical vector sum".

In fine, the data on the so-called relativistic Doppler effect do *not* require special relativity. In fact, specific problems quite quickly appear when so doing. Consider this statement of Kündig[194] regarding his study of a Mössbauer source at the center of a high-speed centrifuge, and the absorber on a radial arm:

> When the experiment is analyzed in a reference frame K attached to the accelerated observer, the problem could be treated by the principle of equivalence and the general theory of relativity ...

He refers to Pauli[264 265] as his authority for saying this. Kündig continues:

> The centrifugal force acting on the absorber is then interpreted as a gravitational force with the potential
>
> $$\phi = -\tfrac{1}{2} R_A^2 \quad \omega^2$$
>
> Thus, the observer in K will come to the conclusion that his clock is slowed down by the gravitational potential.

But did we not just quote Bailey, *et al.*[16] disavowing acceleration in time dilation, even up to a transverse 10^{18} g? Newman, *et al.* introduced their own work on the subject with the statement that

> ... previous experiments have found no effects in fundamental processes from acceleration of rotation, thermal vibrations, or cyclotron motion.

And Kündig himself, we will recall from an earlier discussion of Thomas precession, concluded there were

> ...no effects of such acceleration on the internal structure of electrons or on relativity which would affect spin precession.

Kündig adds:

> We then see that the transverse Doppler effect and time dilation produced by gravitation appear as two different modes expressing the same fact, namely that *the clock which experiences acceleration is retarded compared to the clock at rest.*

The italics are ours, first to call attention to the consensus we defined earlier, that the retardation is due to the *motion*, not the acceleration, the only importance of acceleration lying in the motion it produces. Second, if gravitation ≡ acceleration, and acceleration in itself is *not* a factor, why should gravitation produce dilation if it produces no motion? In fact is it not true[311] that experiments searching for an intrinsic frequency shift in Fe^{57} nuclei due to thermally produced accelerations have always demonstrated nulls for values up to 10^{16}g, and with an accuracy >1pp 10^{13}? Are we to distinguish thermally produced from mechanically induced acceleration, and these in turn from gravitation? Or should we follow another suggestion of Edmonds[83] that Einstein "was probably wrong about the equivalence of acceleration and gravitation"?

In any event a dilemma of serious sort seems again at hand, impressive as the proponents' arguments have been. We shall attempt no more here than to return to the pre-Lorentzian principles advanced for reinterpreting "relativistic" mass. For: (1) If it is true that $E = mc^2$ and $m = E/c^2$ as dictated by the field constant and momentum terms in Maxwell's field equations, and (2) in view of the demonstrated asymptotic increase in $m(\equiv E/c^2)$ as $v \to c$, then

(3) changes in the frequency and wavelength of photons emitted from a body having velocity v relative to the locally embedding field simply become

$$\nu, \lambda = f(v) \equiv f(m) \equiv f(E/c^2)$$

$$\nu = \nu_o m_o/m = \gamma^{-1}\nu_o$$

$$\lambda = \lambda_o m/m_o = \gamma\lambda_o$$

and again we have a picture of (1) frequency and wavelength changing with mass, (2) the mass in turn varying with velocity v according to $m = \gamma m_o$, and (3) this due to the combined facts of mass-energy equivalence and the limiting field velocity c. Glancing back at elementary-particle decay, one might say that the frequency decreases and the stability increases as that mass-energy complex called "relativistic mass" increases according to $\gamma = (1 - \beta^2)^{-\frac{1}{2}}$; and certainly this presents no particular difficulties in mental imaging.

Dismissal of the Lorentz Contraction, Lorentz Transformation, and the Principle of Relativity

With this background, it now seems opportune to present specific reasons for dismissing the FitzGerald-Lorentz contraction from physics, also to confront the consequences of such dismissal for the Einstein-Lorentz transformation, and indeed the Principle of Relativity itself. This is *not* to say that moving material objects do not foreshorten - - in the original Lorentz sense of an actual interaction of compressive electromagnetic sort between particle and field; but it does deny the stilted, artificial, and illogical convenience of a $\sqrt{(1-v^2/c^2)}$ shrink in line of motion only, accompanied by an increase in relativistic mass. And it insists upon *actual* motion relative to a real embedding field. Such shrinkage has to this date not even been indicated experimentally, let alone discovered. If anything does become compressed along x when moving in that direction, it should logically bulge in some more or less compensating manner along y and/or z; and this, we will recall, was one of the early electron models which became shelved because such behavior would fail to explain the null datum for a Michelson interferometer in presumed motion.

Similarly, this is *not* to say that objects in motion relative to an observer do not *appear* foreshortened due to signal delay when using signals of finite velocity. It simply denies the improperly derived Pythagorean $\sqrt{(1-v^2/c^2)}$ factor for this delay, and returns the problem to the original classical Dopplerian $(1-v^2/c^2)$.

In fact, it should be sufficient to dismiss all three of these on the mere basis of the return of absolute space to physics. For if space is absolute, so is time. Nevertheless, many relativists still believe that the Lorentz equations should remain in effect even after proving space absolute; and the very impressive apologetics by theoreticians of the Lorentz school, particularly Ives[152] and Builder[45 46 47 48], makes a specific refutation virtually mandatory.

So let us once again permit the metallurgical engineer to grapple with the relativist, in case Essays II and III of the earlier booklet failed to make their mark[362].

Consider a coil of annealed austenitic stainless steel wire strung out in space as sketched in Figure 7, such that the Earth drags it along during its orbital motion around the Sun. The coil is placed at one of the Poles, and swiveled to avoid any tangling due to rotational Earth motion. The wire is the AISI Type 302 grade commonly used for wire recorders, but in the fully annealed condition of nonmagnetic face-centered-cubic austenite. However, at each 100 m spacing, a 1 m section is coldworked to transform the gamma-phase locally to ferromagnetic α' martensite, suitable for detection by any passing space vehicle properly equipped with magnetic sensors.

In fine, we have now set up an experimental system which goes no further than to place a *physically marked metric* upon

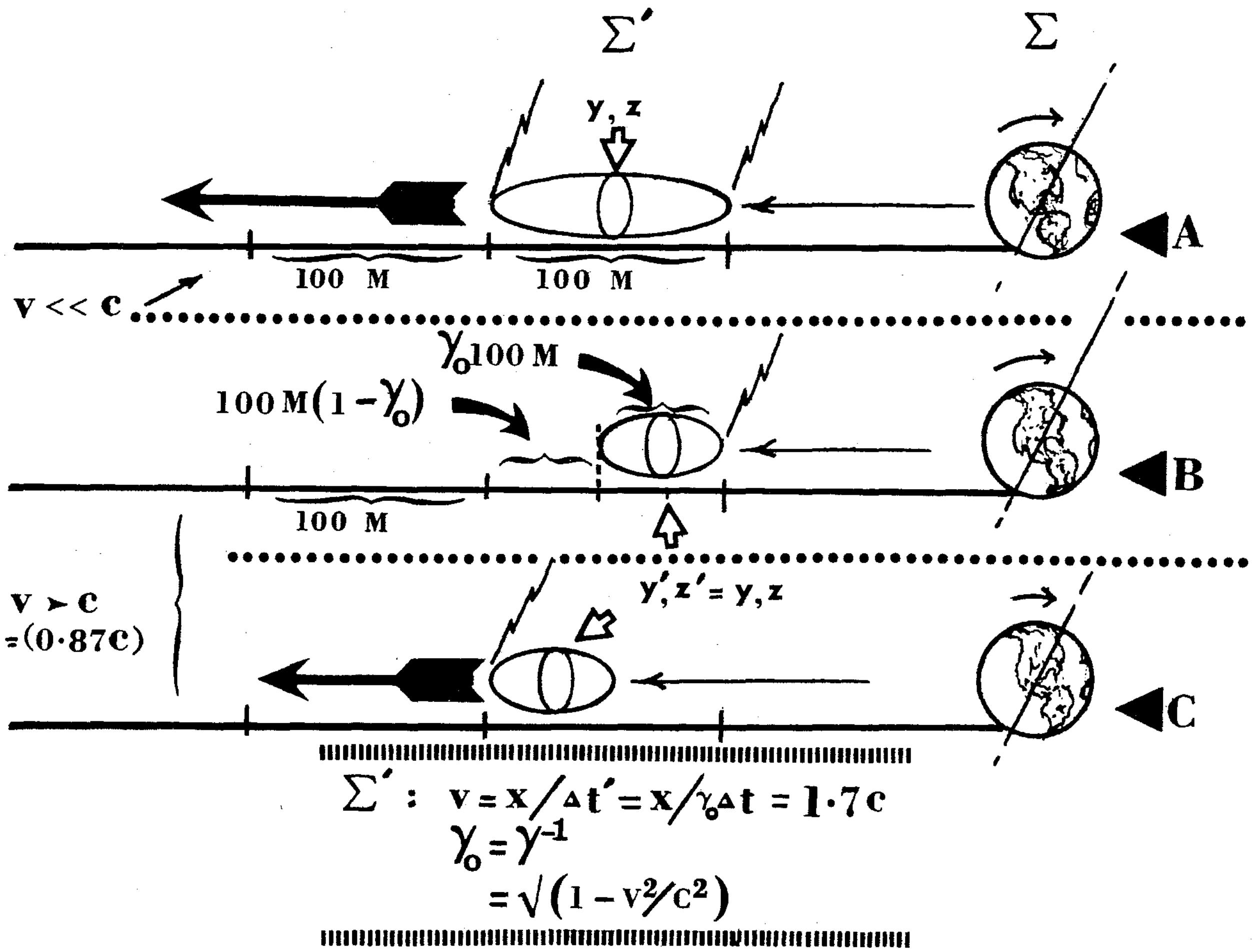

Figure 7: An engineering approach to the alleged Einstein-Lorentz contraction in absolute space. For convenience in sketching, calculations here are made for v = 0.867c and γ = 2. Discussion in the text is for v = 0.8c and γ = 1.67.

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what even the relativist is coming to grant as absolute space - - whether in terms of an Einstein space metric, gravitational field, electromagnetic field, cosmic background radiation, neutrino sea, subquantic medium, PPN space, etc. - - or even the ancient ether. Nothing hypothetical is added.

Now consider a space vehicle 100 m in length, hence exactly matching the 100 m spacing of the wire metric *as measured in the planetary system* Σ. Mounted both fore and aft are properly instrumented magnetic sensors, with a conjoint computerized feed such that they register a precise simultaneity of signal discharge for a rest position in Σ. Any lag in this fore/aft response due to Lorentz contraction when in motion then converts directly to velocity *v* relative to the wire metric.

<u>Test time</u>:

A. The spacecraft takes off at a launch velocity $v << c$, such that a pass of this 100 m craft parallel to the wire produces an essentially *simultaneous discharge* of both fore and aft sensors at each 100 m pair of emitters (see Figure 7A).

B. Cruising interplanetary space on an accelerating pre-test course, the vehicle boosts its velocity to v = 0.8c, then swings back for the test pass in the best sense of Einstein's *original* stipulation of an *unaccelerated* or inertial frame - - uniform motion only.

C. Because the craft allegedly contracts - - according to the original FitzGerald-Lorentz model for both electron and the whole forward arm of Michelson's interferometer, also the rim of the revolving wheel in the Ehrenfest Paradox built on Einstein's model - - such that $x' = x/\gamma$, the craft now measures only $x(1-v^2/c^2)^{\frac{1}{2}} =$ 60.0 m. On the other hand, the *astronaut* - - and this is assuredly in the best sense of relativistic physics - - cannot detect this with his own measuring sticks because every time he points one in the direction of motion, an identical contraction in amount 1.0 → 0.6 m affects the ruler and disguises the effect.

D. HOWEVER - - in this case the measuring device is *outside* his Σ' so far as any dependable metric is concerned, but *inside* for signal registry. And in no way is that man going to shorten the wire, which here both represents and measures the space through which he is moving, just because his face flattens. His astronautic odometer, triggered to fire the *aft* signal upon crossing a marker, does so when the *fore* sensor is still *40 m short* of the next one (see Figure 7B). Similarly, whenever the *fore* sensor fires, the aft has already registered, and now only has another 60 m to go instead of the expected 100 m. The odometer quite properly registers v = 0.8c, which is the target velocity of the test.

E. Immediately the astronaut knows that (1) he is in motion relative to the wire system Σ, (2) his velocity is 0.8c as planned, and (3) his vehicle is Lorentz-contracted to 60 m - - despite the fact that nothing registers this on his ruler, neither in an altered spacing of the cabin panels, or even the length of his own feet.

F. Upon returning to the launch site, he also learns (1) that his clock ran slower than Earth clocks by a factor of 0.6, and (2) tha t his clock was obviously faulty, since 0.8c/.6 = 1.25c.

Repeated trips at various velocities then make abundantly clear that the Earth system Σ constitutes a *unique and locally absolute frame* because its clocks are *always faster than his own*. No matter how he might alter his motion relative to Σ - - and we will now stipulate that the wire is stationary relative to the field embedding the instrument - - the Σ-timepiece is always the fast one, to be matched by his own only at v = 0.

From such considerations, these three rather dramatic conclusions follow:

First, whether bodies do or do not contract while in motion, *space* assuredly does not contract, but rather the body that moves through it, and then only in the original Lorentz sense. Anything else is appearance only, due to classical Dopplerian signal delay. Accordingly, it is worse than foolishness to say that a distance from A to B "would appear much shorter"[286], when as a matter of such simple logic and demonstration it can only "appear" longer; or to say the "distance contracted"[128 286 290], when the relativists' own definition of a rod shrinking 1 m → 0.6 m would obviously measure a 100 m distance at 166.7 m. Therefore, if shrinkage of some type and extent does occur during absolute motion, it would not only be detectable with appropriate instrumentation as just described, but it would necessarily be regarded as a spurious measurement requiring calibration with the standards of the locally embedding gravitational or electromagnetic system. Such matters, viewed with the repugnant monoaxial geometry of the Lorentz contraction, and the model correction now demanded by magnetospheric physics, lead to the conclusion that *the postulated FitzGerald-Lorentz contraction should be dismissed from physics,* at least in its present form. Whether a vehicle does deform or not in any manner when subjected to actual motion through absolute space, the effect does not belong to a 4-vector transformation equation, because the data are 3-scalars which submit to calibration relative to a unique reference frame.

Second, and directly following from the first: *The Lorentz transformation obviously proves inappropriate* if both time and space calibrate to standards of a singular, unique, and absolute frame. As carefully pointed out in earlier discussions, this has nothing to do with use of the γ-factor $(1-v^2/c^2)^{-\frac{1}{2}}$ for *velocity-dependent functions*, wherever such asymptotic relationships might occur, and notably the so-called relativistic mass and elementary-particle decay. But to be velocity-dependent, the velocity must not only be relative to something, but to a unique something - - as proved by the test flights just structured, and indeed by the simple fact in Einstein's 1905 paper that he found the clocks of *just one* of two systems in relative motion to go slow. His own definitions proved that the system which had the slow clock must have been in motion relative to an absolute frame; and in our own time Hafele and Keating[147A] not only accepted this idea, but presumed to have proved it.

Finally, and most surprisingly, it seems now necessary to make the flat statement that *there is no such thing as the Principle of Relativity* in the physics of the real world - - certainly not in its true and original sense of *reciprocity* due to an absolute indeterminacy of position. The only indeterminacy problem in physics now proves to be nothing more than an inadequacy of instrumentation in the relativistic *Gedankenexperimenten*; and this is no excuse for remodeling time and space.

Given proper test conditions and field sensors: All parameters of mechanics should calibrate to the standard rest system of whatever gravitational field embeds and controls the bodies, and those of electrodynamics to the frame of the embedding Maxwellian field.

Conclusions

While this research into the background of relativistic physics has produced interesting results regarding derivation of several fundamental concepts, it has at the same time disclosed some exceedingly significant technical points. The results are essentially these:

I. Mass-energy equivalence $E = mc^2$ follows not from Einstein's Special Theory, as so commonly supposed, but rather from the two features of (1) the field constant c, and (2) the momentum of radiation contained in the Maxwell-Hertz equations. This equivalence was postulated even prior to Maxwell's time, was subsequently calculated from his equations as early as 1881 by J. Thomson, then confirmed experimentally by Kaufmann several years prior to Einstein's entry into the discussion. The only aspect of the famous equation traceable to any part of relativistic physics is its finalized form $E = mc^2$; and this followed solely from the fortuitous coincidence that the factor $(1 - v^2/c^2)^{-\frac{1}{2}}$ used by Lorentz, Larmor, Poincaré, and Einstein in a collateral and quite unrelated research, to eliminate the second-order Doppler $(1 - v^2/c^2)$ increment in their misconstrued null datum of optical experimentation, is the same factor as that for the asymptotic velocity c controlling mass-energy equivalence.

II. Similarly the so-called "relativistic" mass $m = m_o(1 - v^2/c^2)^{-\frac{1}{2}}$, which would be more properly termed the velocity-dependent mass, arose from this same pre-Einstein background, and for identical reasons, since the velocity-dependence of mass became the key to the discovery of mass-energy equivalence.

III. Neglect of the magnetosphere as the proper reference frame for terrestrial electrodynamics, with use instead of the inertial reference frames of pre-Maxwellian mechanics, stands as the sole reason for the origin of relativistic physics.

IV. Since there is no longer any reason for supposing that motion cannot be detected relative to the rest frame of any given magnetospheric domain which embeds the instrument, and indeed detecting so-called "absolute motion" relative to the cosmological metric itself, there is no Principle of Relativity, at least not in its original sense. There does remain a Principle of Physics conveying a part of Einstein's original idea, in fact what might be called the First Principle of Physics, namely that the same laws of nature are equally valid throughout all parts of the physical creation. For properly interpreted in terms of the locally embedding Maxwellian domain, here specifically the terrestrial magnetosphere, the historic and repetitive null datum merely attested to that domain's rest coordinates, within which the particular instrument had been situated, and within which all laws of electrodynamics indeed apply with equal validity. The same would be true for the heliosphere, next for the galactosphere, and then perhaps for a cosmosphere embedding the totality of galactomagnetic cavities developed by the individual galaxies. In fact, we shall propose here that, in the light of the magnetospheric space model, the widely discussed 2.7°K cosmic background radiation may *not* be the residue of some 4-dimensional cosmological Big Bang as so widely presumed, but instead a field entrapment of subatomic particles similar to our local ionosphere and radiation belts, and possibly, though not necessarily, representing a residuum of our own primordial galactic explosion. This would immediately remove the objections to misinterpreted Big Bang geometry, without affecting any of the rest of the chronometric features except in points of reference. On the other hand, nobody regards the Van Allen belts as expressing or recording planetary origins. They simply represent field phenomena.

V. Accordingly, there is no cause for resorting to transformation equations which alter the units of both time and space in order to remove a supposed second-order Doppler increment which never did exist, since v = 0 for all experiments in question, and not $v \simeq 30$ km sec^{-1} as so universally supposed. When any given Maxwellian field suffers an internal imbalance - - or "field disturbance" in Maxwell's terms - - the geometry of its readjustment, which takes the form of a spherical wavefront, travels outward at the velocity of the field constant *c* regardless of any motion of the source relative to the field rest frame, and precisely as obtains for all internal wave propagation whether in field or medium - - electromagnetic, gravitational, acoustical. Therefore Einstein's Second Postulate is trivial and unnecessary, in its original wording, which makes the velocity *c* independent of motion of the *source*. As for motion of the *observer* relative to the rest coordinates of the embedding field, the proper geometry is *not*

$$ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2$$
$$= dx'^2 + dy'^2 + dz'^2 - c^2dt'^2 = 0$$

but

$$ds'^2 = dx'^2 + dy'^2 + dz'^2 - (c\pm v)^2dt'^2$$
$$= 0$$

for the moving system, the wave propagation showing as

$$\nabla^2\psi - \frac{1}{(c\pm v)^2} = \left(\frac{\partial^2\psi}{\partial t^2}\right) = 0$$

where

$$\psi(x,y,z,t) = \frac{f(t-r/c)}{r}$$

And the transformation equations are *not* those of Einstein-Lorentz

$$x' = \frac{x-vt}{(1-v^2/c^2)^{\frac{1}{2}}}$$
$$y',z' = y,z$$
$$t' = \frac{x-vt}{c(1-v^2/c^2)^{\frac{1}{2}}}$$

but instead simply the Galilean

$$x' = x-vt$$
$$y',z',t' = y,z,t$$

or in terms of signal delay and "local time" as originally given by Voigt:

$$x' = \frac{x-vt}{(1-v^2/c^2)}$$

$$y',z' = \frac{y,z}{(1-v^2/c^2)^{\frac{1}{2}}}$$

$$t' = \frac{x-vt}{c(1-v^2/c^2)}$$

(See Figures 8, 9, 10).

VI. Regarding elementary-particle decay, the availability of the factor $(1 - v^2/c^2)^{-\frac{1}{2}}$ in the Lorentz transformation is no more than fortuitous, there being no requirement whatever to assume a FitzGerald-Lorentz contraction; and the lifetime τ is as readily related to the experimentally established velocity-dependent mass increase $m = m_0\ (1 - v^2/c^2)^{-\frac{1}{2}}$ as to the purely hypothetical and philosophically repugnant dilation of the time unit $d(\partial t)/dv = (1-v^2/c^2)^{-\frac{1}{2}}$. The extended lifetime can as well remain

$$\tau = \gamma\tau_0$$

but with τ, τ_0 measured in cosmic time units ∂t; and the decay rate

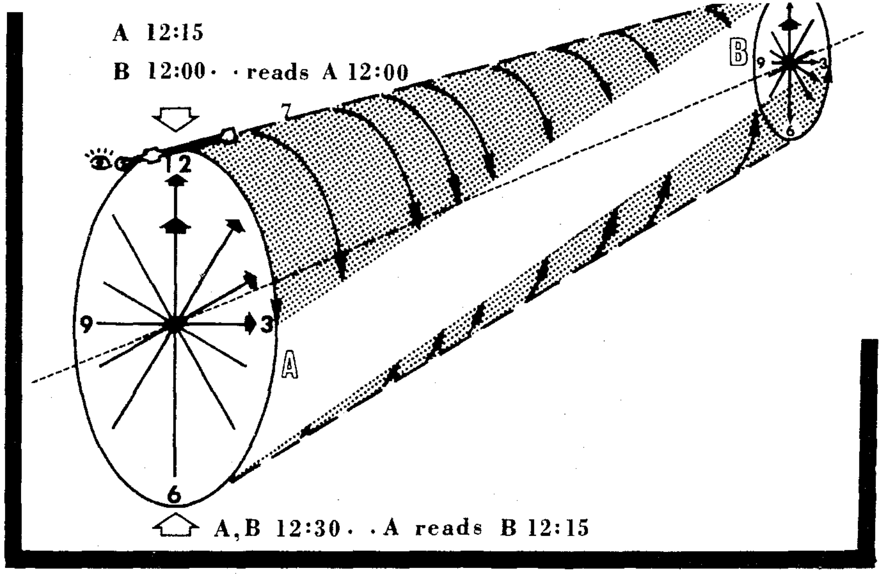

Figure 8: A simplistic sketch of *apparent* clock behavior as a function of distance and/or relative motion for optical or any other type of to-fro signal at constant and finite velocity *c*. For every clock which slows on going from Paris to Los Angeles, an identical but opposite reaction occurs upon returning to Paris. The effects are Dopplerian, not Einsteinian; and there is no paradoxical "time dilation".

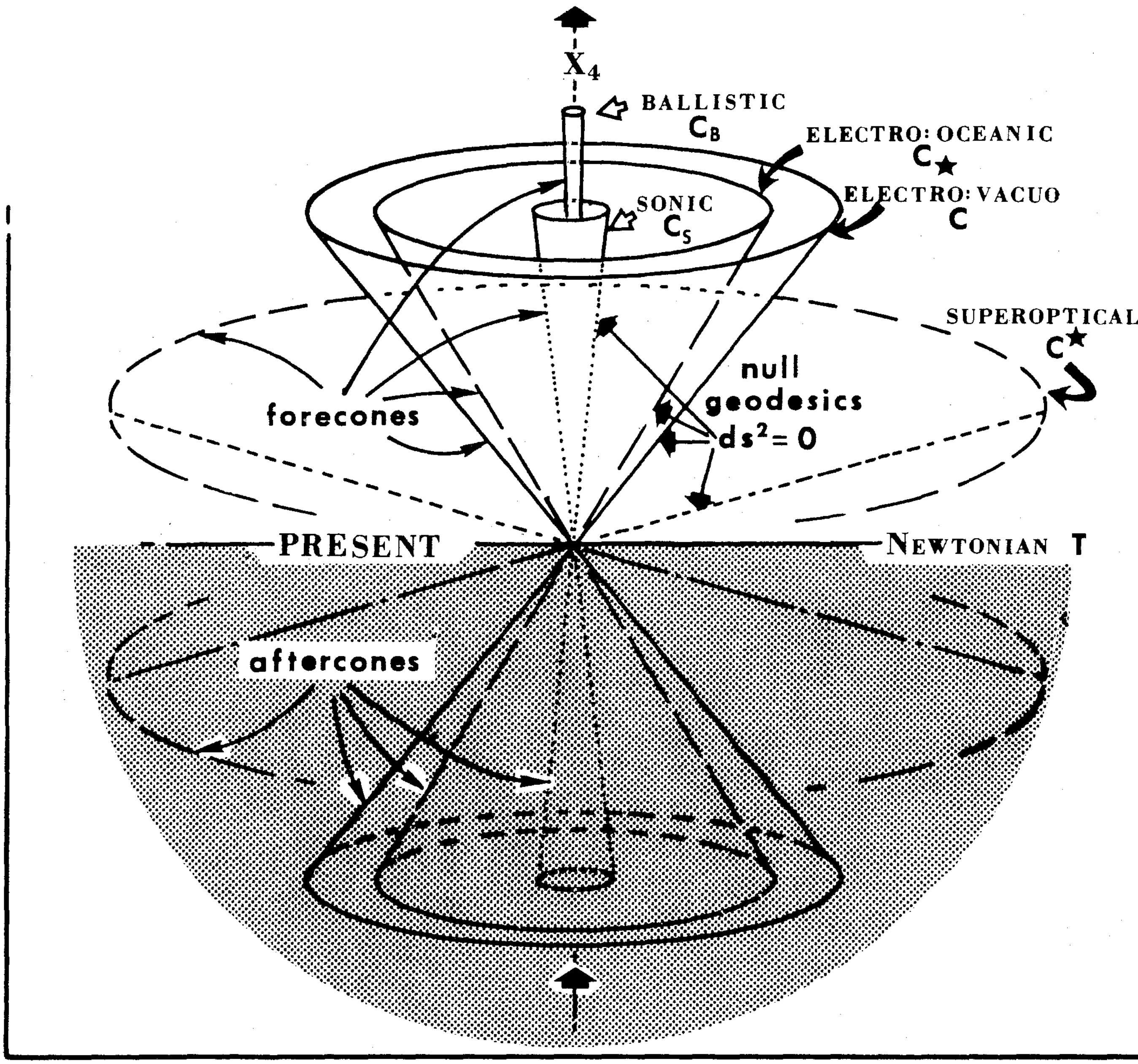

Figure 9: Minkowskian time-space relationships reworked in generalized terms of signal delay for any type of informational exchange by signals of finite velocity, of which electromagnetic waves are but one example, and not regarded as unique in manners of traversing space. Clocks of to-fro signal type suffer no more irreversible permanent "dilation" than those of modern jet flights cutting purely arbitrary time lines.

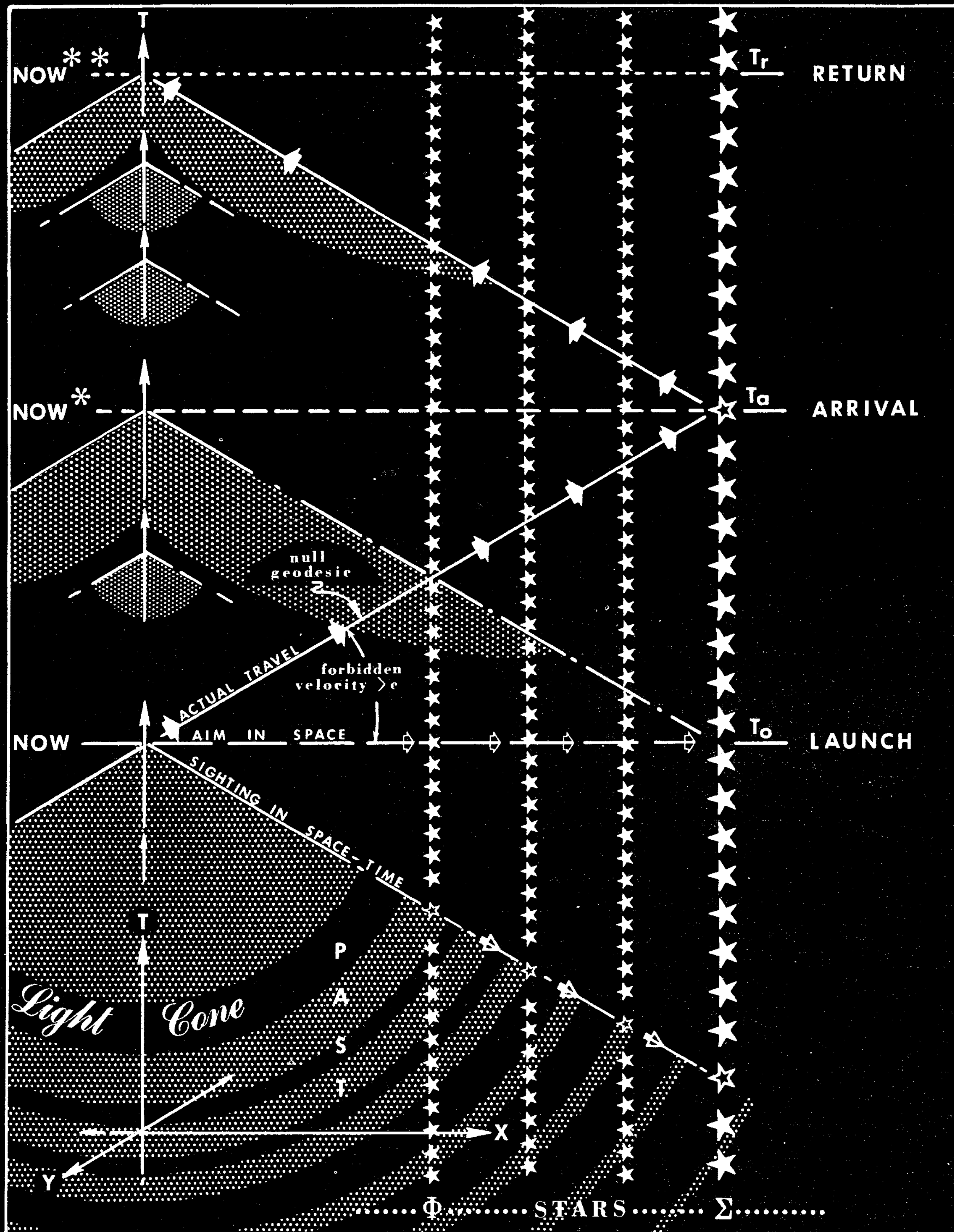

Figure 10: A reworking of the classical Rocket Twin scenario on the basis of absolute space. Here we consider the usual blast-off to some stellar designation Σ and return, but showing by a modified Minkowski-type diagram the nature of *real* simultaneity as compared to apparent or "observer" simultaneity.

$$N = N_o e^{-t/\gamma\tau_o}$$

can perhaps be expressed as well if not more accurately in some form such as

$$N = N_o e^{-m_o t/m\tau_o} \equiv N_o e^{-t/\gamma\tau_o}$$

Thus the "observer on the muon" would be aware of his uniquely designated motion relative to his embedding field; all data affected by the asymptotic *c* limitation in the measure $(1 - v^2/c^2)^{-\frac{1}{2}}$ would transform as 3-scalars, not 4-vectors; and the traveler would accordingly *not* find (a) his mass the normal m_o, (b) his lifetime the normal τ_o, and (c) "space" itself contracted.

VII. Since acceleration is now found through numerous experiments of high-energy physics *not* to be a factor in velocity-dependent changes due to the asymptotic *c*, a serious situation arises regarding the Equivalence Principle for inertial and gravitational mass in the General Theory. For either this principle is not valid, or gravitational fields exert no influence on chronometry. That is, if the field ϕ *does* affect chronometry in the usual sense of time dilation, then acceleration due to this field is *not* indistinguishable from acceleration due to imposed mechanical force, as Einstein supposed. Whereas if the principle *is* valid, then ϕ is without influence on chronometry. A possible answer to this problem is suggested in drawing careful distinctions among these three situations: (1) a variable field velocity *c* due to gravitational alteration slowing the photon, which in itself has nothing to do with Lorentz-Einstein time dilation during a to-fro trip, (2) a variable frequency ν of radiation due to a gravitational field ϕ, which in itself imposes no special requirement upon treating it with a Lorentz transformation rather than a Galilean, and (3) the true problem of the second-order Doppler effect under conditions of constant *c* which did, and does, give rise to the Lorentz transformation when one presumes that magnetospheric rest coordinates do not exist. But this is tantamount to presuming the magnetosphere itself does not exist; and strangely enough, the entire history of relativistic physics attests to having presumed just this, apparently unaware of concurrent developments in geophysics.

While it is now a fact of experimental physics that the γ-factor distinguishing Lorentzian from Galilean transformations similarly defines the velocity-dependent behavior of such parameters as mass, momentum, frequency, and decay timing in high-energy physics, no aspect of these data even remotely suggests, let alone requires, that the second-order Doppler effect does not obtain in electromagnetic signal transmission, neither that the motion of an *observing instrument relative to the Maxwellian field which embeds it* is without effect upon the *observed* field velocity *c*. This purely extrapolative aspect of the Lorentz transformation equations therefore goes beyond experimental observation, and should accordingly be re-examined. A first step would seem to be taking Michelson's allegedly "flying" interferometer[357] and putting it in actual motion during some space flight[365]. Michelson was no astronaut.

However, these matters involve the possibility of exceedingly grave readjustments throughout much of modern physics, and will require much further discussion by physicists in several fields of expertise before eventual clarification can be expected. As stated at the outset, the principal purpose of the present study is only to call attention to the great need for a thorough re-examination of the very foundations of modern physics.

* *

The science of space must still be classed as unfinished business.

Closing sentence in Concepts of Space - The History of Theories of Space in Physics by M. Jammer (1954)

Acknowledgement

While this has been strictly a solo flight from technical standpoints, with no significant help from anyone except referees whose negative attitudes kept driving me back to the books, no man is an island; and certainly the present situation required aid of vast order from companions of two different sorts. First was the problem of handling the research materials, and producing the innumerable manuscripts and rewrites, incident to a program whose comprehensiveness may well be in a class by itself even among relativists. For where we list a bibliography of a few hundred references here, the background research file runs many thousands. We have thirty shelf-feet of unbound materials alone. The person handling this great responsibility, and in strikingly efficient and able manner, is my secretary Jeanne L. Griffith.

Second in listing but first in importance is the companion who made the whole thing possible by providing a home atmosphere, family situation, and general living conditions suitable to absorbing the impositions, abrasions, and countless sacrifices incident to such an additional work load stacked upon an already full-time profession. This one, of course, is my wife Denise, without whom there would be no disturbing of the relativistic peace, at least not from this quarter.

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