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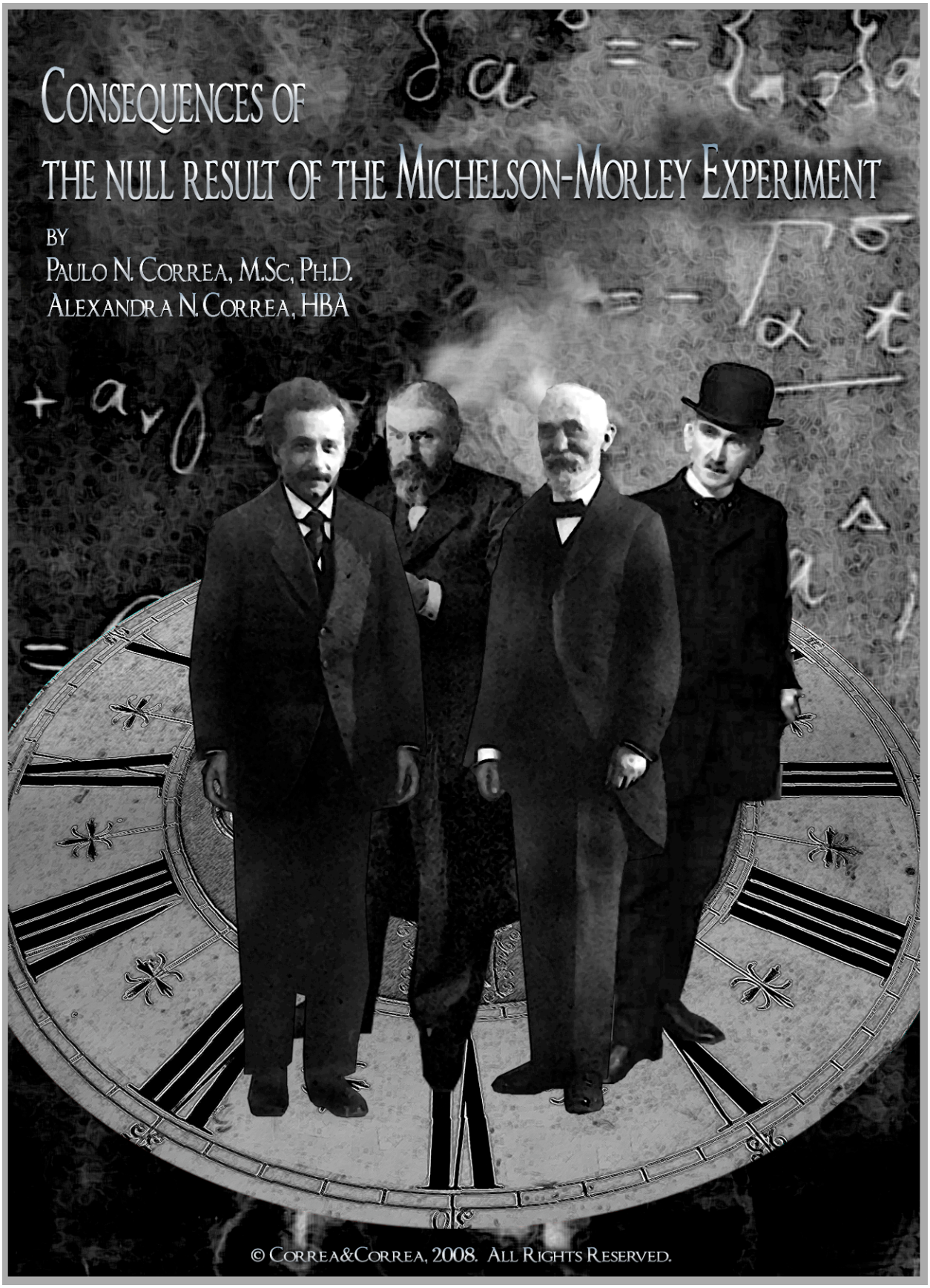

CONSEQUENCES OF THE NULL RESULT OF THE MICHELSON-MORLEY EXPERIMENT: THE DEMISE OF THE STATIONARY AETHER, THE RISE OF SPECIAL RELATIVITY, AND THE HEURISTIC CONCEPT OF THE PHOTON

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ABSTRACT

The extant edifice of electromagnetism owes its inception in the early XXth century to a profound modification of Maxwell's XIXth century electromagnetic field theory, first prompted by the null result of the Michelson-Morley experiment and condensed in what Einstein termed the Special Theory of Relativity (SR), and then complemented by Einstein's light particle hypothesis and the Planck distribution that introduced fundamental discontinuity into blackbody radiation.

SR did not so much introduce new parameters, as it displaced the sense of what Poincaré called the "Lorentz transformations". Whereas these were intended as mathematical artifices employed to salvage the classical theory of an imponderable but stationary aether, they would gain a physical sense with Special Relativity (SR). This displacement most noticeably precluded what Reichenbach once called a Physics of Time.

The first principle of SR posits that there is no absolute motion referenced to an unchanging frame of Space, since all translatory motion is relative to an observer at rest in its own inertial frame of reference. As the covariant complement to the contraction of length in the direction of motion is the objective dilation of time, SR is constrained to 'spatialize Time' by reducing it to a length of Space. Subsequently, once all lengths are treated as covariant intervals, the simultaneity of events is no longer invariant, nor, for that matter, is the notion of spatial coincidence. Synchronicity is considered to be an actual impossibility, and the function for a spatio-temporal continuum remains dissociated from any concept of energy, being flattened onto four-dimensional Space-Time.

SR's second principle postulates that the speed of light is a constant for every inertial frame of reference, that is, is the same in all directions and for all observers, and independent of the motion of the source of light or the motion of the receiver, for as long as we are considering solely 'substantial translatory motions'. SR's position in this respect is somewhat paradoxical: one can say that it satisfies Machian relationism by positing all electromagnetically valid observers as being at rest in inertial frames of translation, their *speeds being all relative and none absolute*. But with the second principle, it explicitly recognizes some form of *absolute velocity*, an *absolute speed* of radiation *in vacuo* which is *constant* for all inertial frames in 'sufficient translation'.

Where SR had proposed that one should conclude from the MM experiment that there is no stationary aether, and that the propagation of light is independent from the inertial frame of the observer, Einstein's photon theory proposes a new model where there is no need to take recourse to an aether in order to explain the propagation of light.

The authors propose that, whereas SR was correct in positing the abolition of the *stationary* aether and in postulating as invariant the electromagnetic speed c, its requirements for adoption of the Lorentz transformations rely entirely upon the classical electrodynamic interpretation of the Kauffman-Bucherer-Bertozzi-type experiments. Since there are critical alternative evaluations of these experiments, this is a tenuous foundation for the abolition of synchronicity. Furthermore, the authors propose that Einstein's heuristic hypothesis be taken as factual - the result being that electromagnetic radiation becomes secondary to an energy continuum that is neither electromagnetic nor amenable to a four-dimensional reduction. It follows that the second principle of SR only applies to photon production, which is always and only a local discontinuity. It does not apply to non-electromagnetic radiation, nor, *a fortiori*, to the propagation of energy responsible for local photon production.

"It was you [my honored Dr. Michelson,] who led the physicists into new paths, and through your marvelous experimental work paved the way for the development of the Theory of Relativity. You uncovered an insidious defect in the ether theory of light as it then existed, and stimulated the ideas of Lorentz and Fitzgerald, out of which the Special Theory of Relativity developed. Without your work, this theory would today be scarcely more than an interesting speculation."

A. Einstein, speech at the Pasadena Atheneum banquet, Jan. 1931

1.The Michelson-Morley experiment: the pivot of the XXth century aether wars.

1.1. Background of the Michelson-Morley experiment

"Ether or aether (aiqhr probably from αιθω, I burn), a material substance of a more subtle kind than visible bodies, supposed to exist in those parts of space which are apparently empty" - so began the article on the "Ether" written by J.C. Maxwell for Encyclopedia Britannica, and O. Lodge's last-ditch stand against Relativity - his book entitled "The ether of space". The age of the luminiferous aether had come to a close because of a little known experiment in the annals of science. The Michelson Morley experiment (1887) posed, at the turn of our century, an unexpected and major doubt with respect to the wave theory of the stationary luminiferous aether: the apparent velocity of the earth through the aether was zero. Often it is said that the negative result of the MM experiment is proof of Einstein's Special Relativity (SR), yet how can one invoke an experiment as proof for a theory that was created to explain the unexpected result of an experiment, after the fact? The MM experiment no more proves the correctness of SR than it proves the correctness of other theories that also purport to explain its negative result. But it is undoubtedly here, at the crossroads created by this experiment and the multitude of follow-ups, that all contender theories meet to do battle.

Performance of the MM experiment in its essentials had been achieved by 1887 [(1)], though it was thereafter repeated and improved upon, again and again, by Michelson, Morley, Miller and others, over a period of nearly 40 years, before other experiments - carried out by Michelson, and, independently, by Miller and still others - briefly re-opened in the 1920's the whole controversy generated by the original findings. The initial thrust of the experiment was to test the XIXth century hypothesis of a stationary aether in space. If such an aether existed, it should, in principle, permit determination of the sum-total velocity of the earth's motion through space; specifically, as was thought at the time, it should permit determination of the orbital motion of the earth around the sun.

The initial motivation for the experiment, on Michelson's part, stemmed from the discrepancy between Fizeau's 1859 experiment, which showed an 'aether drag' effect in the propagation of light through moving water, and Michelson's own 1881 first 'aether drift'

experiment which appeared to indicate that there was no displacement of the fringe patterns (in Michelson's own words, "the actual displacement was about one hundredth [the distance between fringes, instead of one tenth], and this [was] assignable to the errors of the experiment"). The MM experiment is therefore a long story of attempts to correct what was supposed to be an error - the 1881 experiment, whose result would be further confirmed by subsequent improved repetitions and was opposite to the one expected, as it came to provide instead the interpretive basis for discarding all XIXth century aether theories, whether based upon aether-wind or aether-drag models.

All of the conflicting aether theories (Fizeau's and Fresnel's partial aether drag theory; W. Thomson's elastic-jelly model; Stokes' 1845 theory of differential aether drag; Maxwell's electromagnetic field theory, to name the most important) struggling at the time for recognition shared the same positioning of the aether problem - in the context of the undulatory theory of light which had displaced the Newtonian theory of light corpuscles and owed much to T. Young's theory of the 'luminiferous aether'. Young had postulated that the 'lumination' of a body is caused by excitation of an aether, highly rarefied and elastic, which pervades space and matter, all 'material bodies' undergoing an attraction for this fluid which permits them to accumulate it 'within their substance'. Light then would consist of the propagation of an excitation in the aethereal medium that fills space, locally being made manifest by the vibrations of this medium and transmitted at a distance in the form of waves of the same medium.

The context for the domination of the undulatory theory of light must be understood. For over a century, two fundamentally opposed visions of nature and of Physics had divided Continental and British philosophers and scientists: Descartes' theory of space as a *Plenum* of seamless aether vortices, and Newton's theory of the aether as the *Sensorium Dei*, an absolute space of reference for mechanical motion. Newton also conceptualized light as the mechanical motion of corpuscles in absolute space, as if light consisted of bodies hurled across space. Eventually, in distinction from Descartes' notion of a Plenum, Newton would come to regard action over 'empty' distances as an indication that the aether was synonymous with the Vacuum, and that this alone defined 'absolute space', selfsame and unmovable, a pure container against which we could measure the absolute speed of any and every motion, including that of light's corpuscles.

The Cartesian-Newtonian split betrays how old the foundations of the XXth century aether wars are: they date back to the schism in Rationalism at the time of the emergence of Physics, in its classical age. The first serious crack in the Newtonian edifice would come precisely with its corpuscular theory of light as a result of its effective inability to account for the periodic light properties of superposition and interference, the very cornerstones of

Young's experiments and of his theory of diffraction of light waves, a theory which Young saw as a mere development of Huyghens' idea of a progressing wavefront. Young's contribution went further, however. He introduced as well the concept that, unlike the longitudinal vibrations of sound waves, light consists of transversal vibrations of the aether, as though the aether were an elastic solid, rather than a fluid. Young could not conclude this from his own experiments with interference and diffraction because longitudinal waves, such as sound waves, also show the same effects. But based upon the results of D. Arago and A. Fresnel's experiment, which showed that one could produce two separate and coherent light beams without interference fringes when a light beam passed through a calcite crystal, Young deduced that light must be a transverse wave because the two planes of vibration of the emerging beams had to be at right angles to each other. He proposed the term polarization of light to describe the phenomenon.

1.2. Rise of the classical electromagnetic theory

Further development of aether theory would come from Faraday's experimental work on magnetism which suggested to him that, in distinction from the luminiferous aether, there was also a magnetic aether composed of magnetic lines of force distributed in space. Faraday proposed that 'magnetic propagation' took place at the speed of light, but a synthesis of the magnetic and optical properties of the stationary aether would have to wait for Maxwell's electromagnetic field theory. Maxwell mathematically demonstrated how the aether properties of magnetic and luminiferous propagation were identical and equally explained by his concept of light as consisting of an electromagnetic disturbance propagated through the electromagnetic field. An important consequence of Maxwell's theory is that it predicted that any radiative disturbance of the electromagnetic field would have to propagate through Space with a definite velocity, the speed of light c, calculable from 'nonkinematic' and 'nonmechanical' parameters.

Maxwell's contribution of the electromagnetic wave theory of light consolidated classical Physics into an impressive theory. But it also created much controversy within XXth century Physics. For some, Maxwell was simply crediting the stationary aether with consistent properties that permitted synthesis of optical and magnetic phenomena. For others, the introduction of the field concept already replaced the classical notion of the static aether. In their defense, the latter often cite how Maxwell's electromagnetic properties (permittivity and permeability) replaced the mechanical properties of mass-density and elasticity of the quasi-solid luminiferous aether. Maxwell himself contended that the electromagnetic field was non-material in nature and filled all space, the constant speed c being solely referred to the space frame of this radiation. However, in distinction from

modern treatments of the electromagnetic field which proceed as if radiation were a substance comparable to, but different from, matter, and able to exist by itself in Space empty of matter, Maxwell viewed the optical, electric and magnetic disturbances as properties of a pervasive aether medium. Some physicists, like Einstein, later considered that Maxwell's theory marked the actual break with the old Newtonian notion that light was composed of particles of matter in motion across space, and thus that it constituted the beginning of a theory of 'continuous fields' governed only by partial differential equations and free from mechanical constraints. This is an important aspect of this entire story, in that it would be Einstein who would reintroduce the notion of light corpuscles, in the form of photons, back into modern Physics, in the context of their compliance with a quantum of action; these being the same photons which de Broglie's theory of 'matter waves' would predict to have inertial mass, even if minute. But Einstein would never thereby cease to search for a theory of the continuous field that would satisfy Maxwell's intuition of a non-mechanical field action.

However, in a very real sense, Maxwell's synthesis represented the final development of the theory of the luminiferous aether dating back to Young and Huyghens. In Maxwell's theory, radiant energy transfer was still linked to the properties of an imponderable medium and subject to continuous action. Mechanical notions could not be completely abandoned, and today's 'electric permittivity' was called by Maxwell himself 'electric elasticity', in order to relate it to Couchy's notion of mechanical elasticity. Moreover, Maxwell upheld the wave theory of light as the basis for the synthesis with magnetism and electricity. This coherent position directly led him to stress that what Faraday conceptualized as 'magnetic lines of force' should not be regarded as 'mere mathematical abstractions', but rather should be considered to constitute real 'directions in which the medium is exerting a tension'. Some, like Theocaris in 1983, have suggested that Maxwell's treatment of the electromagnetic field as occupying the space that 'contains' and 'surrounds' material bodies subject to electric and magnetic conditions, should have had the *dual* result of leading Maxwell *to reject* the theory of the luminiferous aether, and in particular the 'aether wind' notion originally proposed by Young, and *to put forth* instead the only view consistent with Maxwell's own theory, specifically, an 'electromagnetic aether drag model' based upon the notion that the earth generates its own 'electromagnetic aether field', and thus that the velocity of light constant is referred to the 'earth's geofield' and not to any other frame.

Theocharis' argument is a very interesting one. He reproaches Maxwell for being inconsistent with his own theory and for ignoring therefore the earth's Coulomb field that actually anchors the Maxwellian electromagnetic waves and remains attached to the planet such that it prevents thereby any possibility of an electromagnetic wind. Denoting all the

short-range interaction fields (Coulomb, Ampère, Faraday) as radiative I-fields, and all the long-range electromagnetic interactions (light, X and gamma rays) as radiative R-fields, Theocharis holds that Maxwell should have concluded that the I-fields, specifically the Coulomb I-field, serve as reference for the displacement of the R-fields, even though Maxwell did not know that only R-fields consist of photons. Effectively, Theocharis' relation highlights how Maxwell's theory was unable to overcome the theory of the stationary luminiferous aether, which had disregarded how the propagation of light requires an electric frame of reference that happens to be connected to the inertial frame of reference of the laboratory by virtue of the generation of this electric frame by the earth's motion itself.

However, irrespective of any inconsistency, Maxwell predicted that it should be possible to determine the velocity of the 'aether wind' with respect to the earth by using the interferometric methods of Fizeau. He had calculated that detection of a second order effect in the v/c ratio was a likely outcome, and this required a $1/10^8$ resolution to carry out the experiment. It is here that Michelson's 1881 quest begins, as he sought to take up Maxwell's challenge and determine by optical means, and with reference to the undisturbed aether of 'absolute Space', how fast and in what direction the earth is travelling.

1.3. The 1887 Michelson-Morley experiment

Following Lorentz's suggestion, the set-up of the classical 1887 MM experiment involved a rotating interferometer which would measure the speed of two light beams travelling in orthogonal directions (**Figure 1**). The intention was to measure the degree to which the observed interference pattern would be shifted as the interferometer was rotated through 90°, and thus calculate both the velocity and the direction of the earth's motion in space. The essential expectation assumed that, as the apparatus rests on the earth and thus partakes of the motion of the earth through the aether, and as the earth moves in the direction of one of the beams- let us call this the A-B direction- the ray that travels along this direction and back from the mirror reflecting it, and thus executes the A-B-A path, must return to the starting point somewhat *later* than the light beam traveling perpendicularly to the first beam along a A-C-A direction. The delayed arrival of the A-B-A ray would then be proven by the displacement of the interference fringes of the two light rays.

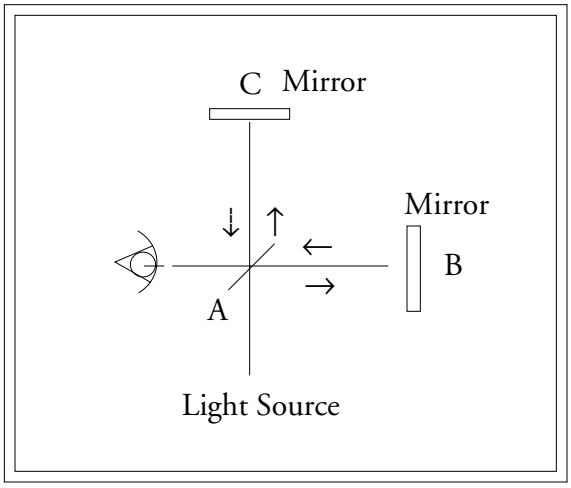

Figure 1: The Michelson Morley Interferometer

If the aether were stationary and occasioned an 'aether wind' effect due to the motion of the earth in Space, and based upon (1) Fizeau's confirmation of the Fresnel formula, (2) the Newtonian theorem of the addition of velocities, and (3) the dependency of the speed of light upon the velocity of the material bodies through which it travels, the expected result of the MM experiment for the speed of light in the direction of motion of the earth and with respect to the laboratory frame of the observer should obey the Fresnel formula

$$c_{2B} = c_2 + v_1 (1\text{-}1/\mu^2) = (c_1/\mu) + v_1 (1\text{-}1/\mu^2)$$

The unexpected finding of the MM experiment was its total failure to detect any fringe shift and thus failure to measure any and all of the motional components of the translation of the earth 'through the aether'. The average speed of light for a round trip in either arm of the apparatus appeared to be identical within the apparatus' resolution limits, and thus independent of the motion of the earth through space. No retardation commensurate with the expected result required by the hypothesis of a stationary aether could be found. The results confirmed Michelson's 1881 experiment which had led him at that time, and in disbelief, to conclude what had become apparent: "the hypothesis of a *stationary* aether is erroneous" (2).

We should pause at this point and take stock of the problem. Assuming that the speed of light is a constant only with respect to the undisturbed aether of space, the MM experiment should have detected the ~30 km/s translatory motion of the earth around the sun. But it did not, and subsequent repetitions with the same method and down to a resolution of 1.5 km/s failed to detect any aether wind, unlike what was supposed by the theory of the stationary luminiferous aether. This failure would be determinant of the aether wars of the XXth century, as it would suggest that only Relativity could account for the

observed result. Yet, as indicated by Theocharis and already mentioned above, there was an alternative interpretation consistent with a theory of partial drag, such as Stokes' theory, including his notion of an aetherosphere shielding the motion of such bodies as the earth: if the frame of reference for the propagation of light in the laboratory is taken to be the electric field of the earth, attached as it is to its inertial frame and being responsible for the earth's geomagnetic field, no shift of the interference fringes should be anticipated. In a letter to Alexander Bell, on April 17, 1881, Michelson expressed the essence of this view by concluding from his 1881 experiments that "the question is thus solved in the negative, showing that the aether in the vicinity of the earth is moving with the earth; [this is] a result in direct variance with the generally received theory of aberration" and the notion of an aether wind resulting from compression of the wave front in the direction of motion.

But the century would not remember these courageous words of Michelson, nor would Michelson repeat them on the occasion of the 1887 experiment and subsequent ones. Indeed, the negative result did not imply that there was no aether filling space; only that the stationary model of the luminiferous aether and Young's aether-wind effect were erroneous hypotheses. Instead of physicists heeding Michelson's early conclusion, the bells tolled for any and every aether theory. It was the entire foundation of Physics for over 300 years which was shaken to the core. H. Poincaré, French philosopher and scientist, was probably the first one to suggest the need for a new physical hypothesis capable of accounting for how optical phenomena depend solely on the 'relative motions' of material bodies with respect to other material bodies, luminous sources or optical apparatuses, confirming therefore Mach's contention of the relativity of all motion. No absolute motion in space could be detected in principle, there was no absolute observer at rest in a stationary medium. With Poincaré the question of the electric frame which serves as reference for the propagation of light in the laboratory frame had already been reduced, and precociously so, to the question of the reference frame being an inertial one. Only for inertial frames was the speed of light constant, this forming the basis for all relativistic theories. By 1899 Poincaré had enunciated the fundamental postulates of what will later become Special Relativity: (1) the null result of the MM experiment indicates that the aether does not exist; (2) physical laws must be the same for a fixed observer as for one in uniform motion of translation relative to one at rest; and the principle of the 'new dynamics' would be that no velocity can exceed that of light.

As E. Whittaker observed in his voluminous history of the theories of the aether, the real inventor of the Principle of Relativity was Poincaré and not Einstein. With Poincaré, an epistemological break occurs with classical Physics which would forever change the conceptual framework of physical theory and condemn the concept of the stationary aether to the dustbin of history. Be that as it may, as Essen has pointed out in his scathing attack

on Relativity, the 'new dynamics' which Einstein would formalize could never pretend to find proof for its axioms in the MM experiment because it arose precisely to explain the null result of the experiment. The results of the MM-type experiments conform to the notion that none of the translatory components of the earth's motion can be detected optically or electromagnetically by reference to a stationary aether. They preclude therefore the existence of an aether wind caused by translation-induced compaction of a stationary aether.

1.4. Lorentz's ad hoc hypothesis of contraction

In the wake of the MM experiment, perhaps no theory ushered in Relativity faster than Lorentz's efforts to salvage the old model of the stationary aether by suggesting that the impossibility of determining absolute motion simply resulted from a change in length that took place for every object in a state of motion. Lorentz's hypothesis of a contraction of length in the direction of motion was solely an ad hoc theory which led him to stress his main thesis regarding the fundamental separation of the aether and matter. Only ponderable matter was subject to the contraction hypothesis, and this therefore precluded us from measuring its inertial speed with respect to the imponderable aether of space.

Lorentz's transformation indicated that the length of an object, be it a pencil of light, as measured with respect to a system of reference in relation to which it moves with velocity v, was proportional to the second order ratio $[1-(v^2/c^2)]^{0.5}$. Lorentz effectively proposed what would later become the cardinal point of Special Relativity [(3)], viz that mass or length in the direction of motion contracts with increasing speed. With reference to **Fig. 2** and the MM experiment, specifically, he postulated that the beam in the direction A-B became shorter both in length and in time as it moved against the aether, thus shortening the A-B-A pathway. Hence the A-B-A ray returned just as fast as the A-C-A ray did. In Lorentz's view, the co-contraction of time and of mass or length (extensivity) was a property of the aether itself, the aether exerting "shortening forces upon the moving bodies in such a manner that the differences in the velocity of light connected with motion cannot be demonstrated" [(4)].

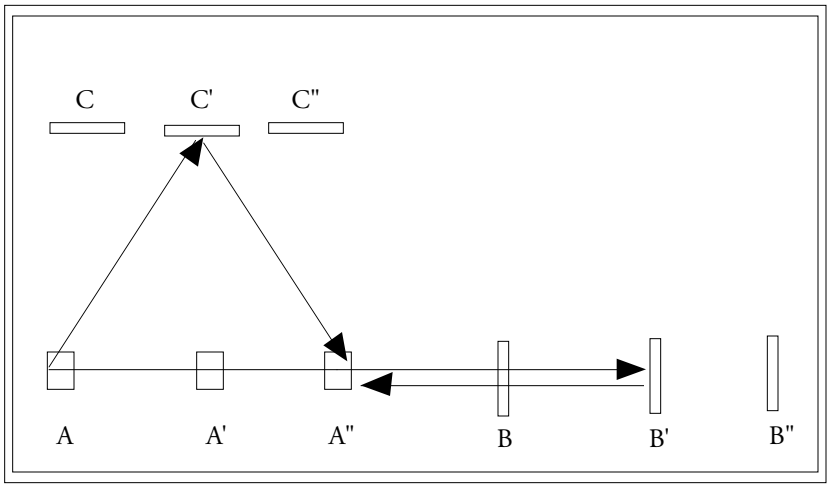

Figure 2: The Michelson-Morley Experiment

G. FitzGerald had suggested a similar hypothesis in a 1889 letter to Michelson, predicting that the contraction of the length of material bodies would vary by an amount given by the square of the ratio of their velocity to that of light. The Lorentz-FitzGerald contraction, as it became known, would constitute the cornerstone of the theory of Special Relativity, despite its intended objective of salvaging the static aether concept. Integration of the Lorentz-FitzGerald contraction theory with Maxwell's equations would essentially be the work of Poincaré, rather than Einstein's.

To be consistent with the hypothesis of length contraction in the direction of relative uniform motion, there should also be a reciprocal co-variance of time, of flow of time. This is the basis of the fourth equation of Lorentz - as it yields a transformation which will become one of the fundamental tenets of Relativity, both Special and General: the dilation of time proportional to increasing speed [(5)]. To the aggregate of all four co-variant equations of Lorentz, Poincaré gave in 1905 the name of 'Lorentz transformations', which are expressed as follows:

$$x' = (x-vt)/ [1-(v^2/c^2)]^{0.5}$$
$$y' = y$$
$$z' = z$$
$$t' = [t-(v/c^2)x]/ [1-(v^2/c^2)]^{0.5}$$

as opposed to the old mechanical equations of the Galilean transformations:

$x' = x - vt$

$y' = y$

$z' = z$

$t' = t$

Lorentz's transformations were one last ditch attempt at preserving the romantic belief in the stationary aether, as one would *otherwise* have to assume that no proof of the existence of the aether would ever be possible. Akin to the actual impossibility of demonstrating the metaphysical dogma of the existence of God, which is therefore said to be a matter for faith alone, the aether - in a Lorentzian universe - could only *be inferred by its very absence*. Lorentz's contraction of time in the direction of motion was a stratagem to preserve our scientific belief in a God for physicists. But, thanks to Poincaré and Einstein, this would not last long, even though, in a very real sense, just as Maxwell inconsistently preserved the luminiferous theory of an aether wind, so did SR preserve the Lorentzian notion of a stationary aether that escapes detection, to the point that the physicist can go about his calculations as if the aether did not exist, the matter of the aether being relegated into a domain of metaphysical credo as both belief and disbelief appear to have effectively become phenomenologically compatible and indistinguishable.

"The result of the famous Michelson Morley experiment was a verdict of 'death' to the theory of the calm ether-sea through which all matter moves. No dependence of the speed of light upon direction could be found"

A. Einstein & L. Infeld, "The evolution of Physics", 1938, p.174

2. Special Relativity and the death of the stationary aether

2.1. From a heuristic hypothesis to Special Relativity

The initial epistemological problem with the relativistic interpretation of the negative results of the MM experiment is that it erased the physical basis for the concept that light waves were analogous to water waves, transversal waves in a medium, waves *of* a medium. If light consisted of waves, these waves had to be waves of something, of something like water, waves *of* the aether. But, if the aether did not exist, *light waves were waves of what*?

At first, Einstein's theory of Relativity did not so much appear to be concerned with an answer to this question, as it was with establishing the basis for the equivalence of all inertial frames of reference in uniform translation. As Poincaré had previously pointed out, this alone would provide the physical basis for the relativity of all motion and the universality of the Lorentz transformations. Einstein's approach was mindful of the possibilities of an eventual theory of 'continuous field action', but it would be precisely at the heart of such theory that he would strike, first by proposing that one should conclude from the MM experiment that there is no stationary aether, and thus that the transformations proposed by Lorentz were not mere optical aberrations or, as in the case of Time, mere mathematical conversions, but were actual physical changes; secondly, by arguing that there is no need to take recourse to an aether in order to explain the propagation of light *in vacuo*; and thirdly, outside of the Special Theory proper but yet in a manner designed to complement its framework, by his theory that light was made up of particles (quanta) associated in bundles and emitted with a speed that was invariant for all frames of reference.

Hence, Lorentz would state in 1927: "I considered my time transformation only as a heuristic working hypothesis. So the theory of relativity is really solely Einstein's work" (6). In Einstein's special theory, there is no medium for light to travel 'in' or 'through', there is no fixed Space frame of reference for the propagation of light, its transmission being always effectuated at the same speed in all directions of any and every uniformly moving frame of reference. It is important to note at this conjuncture that the MM experiment could be 'ideally construed' as a test of the Lorentz contraction theory, given that, in the absence of any relative motion between the apparatus and the observer, length contraction with respect to an ideal stationary aether could be said to occur - amongst other alternative

interpretations. The same, however, cannot be said with respect to the MM experiment serving as a test for Special Relativity. Such a test would in fact *require relative motion of the apparatus with respect to the observer*, and this is not what the MM experiment involved.

In his later years, Einstein would describe the theory of Relativity as a theory of principles that utilized the analytic method and stuck to empirical observations. The empirical reference for such a statement when it comes to SR can only be that of the MM experiment, and yet all that SR can claim in this respect is that it does not conflict with this empirical result, *not* that it can validate its analytical method by the MM experiment. Einstein enunciated the two critical principles of SR as being the equivalence of inertial frames of reference and the constancy of the velocity of light in a vacuum. Few realize the paralogical assumptions that each of these two principles entail.

The **first principle** of SR, which Einstein traces back to the ancient Greeks, requires that the motion of every material body be referred to another body which, in the context of Galilean-Newtonian mechanics, serves as a spatial system of coordinates. This principle can be formulated as: there is no absolute motion, no absolute observer at rest in the inertial frame of Space, since all motion is relative to an observer at rest in an inertial frame of reference. There are plenty of both apparent and hidden assumptions in this principle, and even more when it is wielded by SR.

1) The first hidden assumption is that the Galilean system can be mathematically *and physically* extended to a flat Minkowski four-dimensional Spacetime continuum, where Time is first reduced to a length of Space and next all lengths are treated as co-variant intervals. The net result is that SR's concept of the continuum corresponds essentially to a 4D pseudo-Euclidean Space. The assumption of a Minkovski Spacetime solution implies therefore a spatialization of Time.

2) The second hidden assumption is that SR holds that simultaneity is impossible because it is relative to 'relative position'. As there is no "Space at a Time", the simultaneity of events is no longer invariant, nor for that matter is the notion of spatial coincidence. The notion therefore of a spatio-temporal location itself becomes a 'fuzzy' one.

3) Diachronic separation of events in Time has no absolute reality, being exclusively relative to the state of motion of an observer.

4) The definition of the valid frames of reference rests on the definition of inertia, or the uniform motion of inertial frames, and inertia is essentially defined in a Newtonian fashion, by the resistance to acceleration or to change in direction. This implies that a valid reference frame must be substantially free from rotation, twisting and acceleration. That is what Einstein meant when he formulated his basic principle of SR as-

"Every law of nature which holds good with respect to a coordinate system K must also hold good for any other system K' provided that K and K' are in sufficient movement of translation."

It is this tenet which serves as foundation for the relativistic equivalence of all inertial frames of reference. Yet it is also clear that such a principle makes some further axiomatic suppositions:

5) The first implicit reduction is that *all translatory motion* not subject to changes in acceleration *is inertial motion*. Inertia then, is the property of mass in translation.

6) Therefore, the valid SR frames of reference are necessarily limited to those which are axed on mass-energy that has constant kinetic energy associated with it.

7) Finally, implicit on all this, but unmentioned until the advent of General Relativity, there is a definite assimilation of inertial motion to the gravitational motion of free fall, as the latter constitutes the very model for substantial translation devoid of rotary components. This hidden axiom postulates that inertial motion and "gravitational" motion are one and the same type of motion.

The **second principle** of SR is that the speed of light is a constant for every inertial frame of reference, that is, the same in all directions and for all observers, as well as independent of the motion of the source of light or the motion of the receiver, for as long as we are considering solely 'substantial translatory motions' in 'empty space' (7). The constancy of the speed of light means that "in a system of reference rotating with respect to an inert system" (eg the axis of the earth) "the laws of disposition of rigid bodies do not correspond to the rules of Euclidean geometry on account of the Lorentz contraction", to quote Einstein's words in "Sidelines on Relativity". Einstein himself acknowledged that this principle was implicit to 'the Maxwell-Lorentz theory of electrodynamics', this being perfectly sufficient for him as a basis for its validity. Hence, one can say that SR satisfies Machian relationism by positing all electromagnetically valid observers as being at rest in inertial frames of translation, their *speeds being all relative and none absolute*. But SR recognizes some form of *absolute velocity*, strictly speaking not for a particle-photon, but for light waves in a vacuum and in the absence of matter. Hence, by virtue of the reference to an *absolute speed* of radiation *in vacuo* which is *constant* for all inertial frames in 'sufficient translation', we can determine the *relative speeds* of translation using any inertial frame as their reference.

It is apparent that Einstein's contribution, beyond the theories of Lorentz and Poincaré, was not so much the enunciation of new principles, but the axiomatic synthesis of principles which up until SR seemed to be logically incompatible. This reconciliation of opposites, as Einstein himself once described it, led to a 'new kinematics' which proscribed

any form of simultaneity and, at the same time, prescribed a time-dilation function. The Time transformation previously suggested by Lorentz to be a mere phenomenological barrier to our detection of nature, becomes with SR a physical reality that permits the existence of separate times ruled by the ratio of the inertial speed of their rest frames to the speed of light. Einstein's procedure has in fact substituted any observer "in sufficient translation substantially free from rotation" for the stationary aether of XIXth century physics, with the result that motion, with respect to the inertial frame of the observer, retains all the elements which it had when considered as motion with respect to absolute space, the inertial frame of the aether. This then is taken as the necessary price one must pay in order to consider that all valid observers are absolutely in a state of translation!

SR's second principle, relating the absolute speed of light as invariant for all frames of matter in translation, indicates that neither in electrodynamics nor in mechanics are there properties 'corresponding to the idea of absolute rest'. But since this invariance only applies to inertial frames, it is in fact made relative to a state of motion - that of translation. Therefore, there exists this deep connection behind the apparent disconnection of the inert frame of moving matter and the invariant propagation of light: if the reference is mass in translation, the frame is validated. This link between electromagnetic energy and the inertial frame of mass is complementary of the principle of equivalence of mass and energy, such as Einstein understood it. But here, too, we have a tremendous paralogical leap of faith, one that requires our understanding of the equivalence of mass and energy to be a one-way street: mass is equivalent to electromagnetic energy, because it converts into the latter. But when the physicist is concerned with the reverse process, the only empirical evidence he can adduce is the relativistic interpretation of an increase in mass for particles accelerated to near-luminal speeds, which he obtains by applying c as a constant (petition of principle), and which appears to confirm that (1) kinetic energy is electromagnetic energy, and (2) electromagnetic energy can be converted into mass. Yet, the electromagnetic mass-energy equivalence thus 'adduced' by effective petition of principle is unable to explain the creation of matter, ie the creation of inert mass-energy; it is only capable of explaining the *addition* of mass, and that, too, only in principle. The obvious assumptions, in this respect, subjacent to SR's second principle are that: (1) kinetic energy can only exist in association with, and with reference to, inertial mass; (2) all energy is electromagnetic energy.

Philosophically speaking, Einstein's démarche is tantamount to overcoming the old 'thesis' denied by the MM experiment (empirical antithesis) by recuperating the old 'thesis' under conditions that make it appear to be a 'new' thesis, a 'synthesis'. But the 'old' shines through the 'new', as it is still to the idealized notion of a stationary state of matter ('at rest in its own inertial frame of motion') that all motion is referred. Einstein had just replaced the

'inertial frame of reference of the aether' with the inertial frame of reference of any material body in a state of substantial translation. Some have argued that Einstein's observer is a microphysical reality beyond human perception, void even of any real senses. As an observer, not only does he appear to lose the sense of real irreversible Duration (through the mathematical fiction of *a Time in extension*), but what is still more fundamental for a microphysical perspective, he loses the sense of simultaneity because of his 'heavy' condition, as if his perspective was forever that of inertial mass in free fall.

The price for SR's synthesis was therefore the introduction of 'actual' time-dilation; thereby, the timing clock of the observer's laboratory ceases to be the actual rotation of the earth (which can even be ignored from the viewpoint of SR), to become the clock of the propagation of light. In doing so, Special Relativity treats the spatial figures of light lines in Space as lines of Time, as if they were actual lines of time [(8)]. From Lorentz's heuristic time transformation, Special Relativity extracts the transformation of length, the contraction of extensity, and thus of matter, as a function of addition of inertial mass with increasing speed:

$$l' = l\,[1-(v^2/c^2)]^{0.5}$$

and its corresponding time-dilation functions for two interchangeable frames of reference:

$$\Delta t' = \Delta t\;\; [1-(v^2/c^2)]^{0.5}$$
$$\Delta t = \Delta t'\; [1-(v'^2/c^2)]^{0.5}$$

Hence, in the context of the Michelson-Morley experiment, the two light-time lines, with longitudinal and transversal paths, must remain identical with respect to the length of the complete circuit (emitted and reflected arms). And it was to obviate the objection that Newcoomb had already addressed in 1881 to the Michelson experiment, that "when a ray returns on its own path the retardation in one direction is compensated by the acceleration in the other" [(9)], and hence that there is no way to determine whether the velocity of the light beam along the AB direction was greater or smaller than in the BA direction, that Einstein put forth the Special Theory's view of the Relativity of simultaneity. It is this component of Relativity that will fragment Time and transform Duration into a fourth dimension of Space, the *sine qua non* of replacing the aether by the observer at rest in his inertial frame. In Einstein's view, simultaneity close by, in the same frame of reference, is not the same as simultaneity at a 'distance'. Michelson could not determine the velocity of light in a single direction, eg in the emittive direction alone, he had to reduce himself to the average of the velocity in both arms, emittive plus reflective. But Einstein argued that

determination of the velocity in a single direction would be useless because the difference would appear as a null one: even if we were to use two clocks at different points, we would still have to determine whether or not the clocks would show the same values at the same time. In other words, simultaneity itself is relative to the selected inertial frame. As Reichenbach described it: "We find ourselves in a vicious circle: in order to determine the simultaneity of distant events, we must know a velocity; and in order to measure the velocity, we must be capable of judging the simultaneity of events separated by distance" (10). This is the very fundamental *fuzziness or undecidability* of relativist science.

Provided that the speed of light be considered a constant, we may define simultaneity consistently, *without ever being able to verify it*. Such is the tenor of Einstein's Special Relativity. And provided we define simultaneity in the same relative way as we defined the speed of light constant for all inertial frames in substantial translation, we may introduce into the universe of experience a method to determine a spatio-temporal order. As Reichenbach also succinctly puts it: "Einstein's theory of simultaneity has a presupposition without which it could not be maintained: it is nothing other than the assumption that no velocity greater than the velocity of light can occur in nature" (11). As long as we do not assume that electromagnetic energy may travel faster than the speed of light constant *in vacuo*, the relativist hypothesis applies. As we shall see ahead, with the generalization of the relativistic principle to the 'gravitational field', the light speed limit will be applied to both electromagnetic and gravitational waves, with no other basis than an axiomatic one.

Finally, the change of mass due to relative velocity is given by SR as

$$m' = m / [1-(v^2/c^2)]^{0.5}$$

which means that mass increases with the velocity of a body relative to an outside observer's system of reference. Even in relativistic terms, this statement may have solely a heuristic value, in principle telling us nothing about actual addition of inertial mass. In fact, aside from the obvious unwitting contribution to SR on Lorentz's part, both in terms of electrodynamics and the contraction hypothesis, classical theory had already made a distinction between *proper mass*, which was velocity-invariant, and *electromagnetic mass*, which was velocity-dependent, and this in fact was the pre-relativist interpretation of Kauffman's original 1910 results with particles accelerated to near-luminal speeds.

2.2. SR and the Einstein-Planck theory of quantum discontinuity

In 1901, Planck proposed the notion that electromagnetic radiation (such as light or heat) may be emitted by a black body in small, discrete steps, rather than continuously (note that Planck's original theory did not involve quantization of absorption, a question which was only resolved later, in 1913, with Bohr's model of the hydrogen atom). In 1905, following his studies of the photoelectric effect, Einstein extended Planck's notion of discontinuity by proposing the concept that light had a granular structure, consisting of discrete elements, quanta, later termed photons. While the classical Rayleigh-Jeans distribution had predicted infinite energy in the radiation field for low-intensity (high frequency) black-body radiation, Einstein mathematically demonstrated that this prediction was in error due to the fact that the classical distribution had not taken into account how the entropy of radiation behaved at low intensity (high frequency) as the entropy of particles, that is, how it behaved differently from the high-intensity (low frequency) entropy of waves.

From the same set of equations, Einstein then showed it was possible to produce both the continuous Rayleigh-Jeans distribution and the discrete Planck distribution. In treating high frequency radiation as bundles of discrete elements, the photons, Einstein was demarcating the singularities of the field, its particle-like behaviour, from the energy fluctuations observed at high intensity resulting from the interference of waves, thus effectively deriving the Rayleigh-Jeans distribution from Planck's law itself, to the detriment of the 'fluid aether' theory of Jeans.

This shattering of the classical perspective of a continuum of radiation inherent to the very notion of field would introduce a profound theoretical break that also marked the beginning of the quest for a unified field theory - which so occupied XXth century physicists. But until today, the fragmentation of the notion of field by quantum singularities has effectively preempted any successful theory of a continuous field. Einstein would go on to search for a set of non-linear field equations that would reduce to Maxwell's electromagnetic field equations at high intensity, where statistical processes predominated, but would present "discontinuities as singularities of the field" at low intensities. With Einstein's concept of discontinuity, electromagnetic theory not so much stood on its own feet, as it stood on mere phenomenological grounds, due to statistical considerations: "Although Maxwell's theory is not applicable to elementary resonators, the *average* energy of such a resonator in a radiation field is the same as that which one would compute from Maxwell's theory" (12).

Even though it is apparent that, until the end of his life, Einstein was not satisfied with the answers provided by quantum mechanics or even wave mechanics, because a theory of continuous fields remained effectively precluded, there is no denying that SR's concept of Spacetime as an empty and flattened container (very much a Euclidean inheritance), as well

as its assimilation of Time to this geometric concept (arrived at by adopting Minkovski's notion of Space-Time), melded easily both with his and Planck's theory of electromagnetic field discontinuity, as well as with the finding that at high frequency the entropy of electromagnetic radiation behaved like that of particles.

Many have sought to relate Einstein's thought to that of Descartes, or even more tenuously, to that of Spinoza. But the real connection to be made in this respect is with Newton, and not Descartes or Spinoza, as Einstein and Infeld pointed out (13). For, just as in Newton's theory we have an absolute 3D-Space which is an empty locus (the Vacuum) and a pure geometric form populated by material light corpuscles hurled at a distance across space, so is Einstein's Space-Time a pure four-dimensional geometric form, void of energy where it is void of matter, and populated by bundles of photons, that is, effectively populated by discrete light corpuscles. In this quantum-relativistic scenario, once again, as in Newton's scenario, we do not need to worry about what it is that waves wave *in*. Light may have wave-like properties but is quantized as a function of increasing quantum frequency. In a real sense then, Einstein's theory of discontinuity returns a re-interpreted Newtonianism back to the throne of official physics. In the old Atomistic tradition of science, Einstein's photon - the atom of light - stands in a long line of atomistic quests for the ultimate elements of matter: the atom for chemical reactions, the electron for electric reactions and the photon for electromagnetic reactions. Even if Einstein was not and could not be satiated with this quantum-Atomistic picture, he could neither set it aside nor reconcile it with a theory of energy continua.

One may deepen this link further - as it presents the roots of that other great dilemma of XXth century Physics: are there wavicles? What are particle-waves or matter-waves - are they just misnomers? The very notion of a wave-particle couple, a form of synthesis of Cartesianism and Newtonianism, goes back to the XIXth century theories of the luminiferous aether, if not to Newton himself who actually had tried to conjugate the notions of waves and corpuscles. William Thomson, staunch defender of the stationary aether concept, would write - "You can imagine particles of something, the thing whose motion constitutes light. This thing we call the luminiferous ether" (14). In fact, the notion that such particles might be material, in the sense not of their physical reality, but in the sense that they might partake of some of the properties of ponderable matter or inertial mass, though a specifically mechanistic view, is not however foreign to the theory of the luminiferous ether. The differentiating concept implicit in Einstein's concept of the photons is the quantum of action later denoted by the Planck constant h, that is - the new idea of discrete or discontinuous energy emissions: that light-waves consisted of *discrete* particles, that discontinuity was quantized, *was* the new insight which *in practice* did away with the old

notion of the aether. The notion that the energy stored in any resonator does not vary by gradual changes, but by whole units of energy, became the backbone of a modern physical theory that, at the limit, could describe physical forces and interactions without taking recourse to the Romantic notions of absolute Space, absolute Time, absolute speed, and absolute motion. But does this mean that modern Physics had shed all metaphysical prejudices?

To keep this problem in perspective, we should realize the import of Einstein's designation of the "Maxwell-Lorentz electrodynamics" as the basis for a 'new kinematics'. For the very notion of particles of light did not necessarily entail that all adherents of the luminiferous aether which shared with the Newtonians this concept, considered these particles to be *inert mass bodies* - as the corpuscular theory of light held. Indeed, here is where the cleavage between the mechanical theory of Newton and the undulatory theory of Young becomes the starkest. The champion of this realization must be found in Maxwell, to the very extent that he searched for the non-mechanical and non-material properties, the electric and the magnetic properties, of light. But with Lorentz a new proviso arises, that length contraction and associated transformations must refer solely to the motion of ponderable substances, and *not to the motion of the imponderable aether*. Einstein, having operationally discarded Lorentz's stationary imponderable aether with the SR theory, could now apply a relativistic treatment of Lorentz's electro-mechanical principles to electromagnetic radiation, by assuming that all charge is associated with inert mass - even though the electrodynamic effect caused by different masses of charge carriers is entirely ignored by Lorentz's electrodynamics of ponderable matter. One might object to this contention of ours by arguing that, initially, Einstein's demonstration that light must assume resonator energies restricted to integral multiples of $h\upsilon$, was perfectly compatible with the notion of *massless photons*, and hence, that it was not until de Broglie's formalization of matter wavicles that the modern concept of a mass-carrying photon emerged. But the fact is that, in SR, no form of energy is exempt from relativistic constraints (c being a constant is the form of the constraint such as it applies to photons in their inertial frame of reference). It is therefore implicit that light itself, photons as constituent elements of light, must have a quantum of inertial mass, no matter how tiny. It is in this very sense that the concept of mass-energy is today applied to all forms of electromagnetic radiation, and that the bending of light in gravitational fields is explained: the deviation of light in the Doppler effect, said to be caused by the curvature of nearby Spacetime, is simply a geometric expression for the supposed inertial mass of the photon in a gravitational force-field.

We shall see how this link of the photon to inert mass becomes critical from the vantage point of Einstein's enunciation of the theory of General Relativity (GR). By

acquiring mass, the Einsteinian light particles (the photons) made a full return to the Newtonian universe of mechanical forces between units of matter, atoms and granules of ponderable mass.

"Are not gross Bodies and Light convertible into one another(...)?"
I. Newton, Opticks, Ch. 8.

3. The primacy of inert mass and electromagnetic energy and the question of a non-mechanical, non-stationary aether.

If the equivalence of inertial mass and electromagnetic energy was ascribed by Einstein to his SR theory, nevertheless the relation $E = mc^2$ had already been proposed by Jeans in 1904, in the context of Jeans' own aether theory of transmutation of mass into energy, and still before Jeans, by Poincaré in 1900 (how ironical it is that Einstein is most remembered by this relation which he did not even discover!). But Einstein explicitly wanted it to be understood as a logical consequence of the first principle of SR:

"The most important result of the special relativity system concerned the inert mass of a material system. It became evident that the inertia of such a system must depend on its energy content, so that we were driven to the conception that inert mass was nothing else than latent energy" (15).

But how are we to understand inert mass as latent energy? It is only latent from the viewpoint of a theory that pretends that all energy transfers are electromagnetic (and at that, only in the epiphenomenological sense that the average resonator is Maxwellian) and which, furthermore, holds as exclusive the viewpoint of electromagnetic energy converted from disintegrating mass. But as inert mass, *qua* mass, what exactly is the form of the energy that yields the effect of the identity of inert and heavy or weighty masses? That is the question that neither Relativity nor quantum or wave-mechanics ever was able to answer. The problem ties in directly with the lack of understanding of the physical processes responsible for the creation of mass-energy. One may well liberate photon energy from the disintegration of matter, or mass-energy, but can one hold as a fact that, if all mass is congealed energy, so is all energy liberated matter? SR tells us that we must. But must we? For how are we to prove that it is from electromagnetic energy that mass-energy arises? If pair-creation were the only way to produce electrons, why does nature present us with such an unbalance between negatrons and positrons? And are all the manifestations of electric charge necessarily associated with mass and its inertial effects? If massless charges exist, then, at the very least, we cannot assume that all energy is derived from matter, just because all matter is necessarily derived from energy or better, itself a form of energy.

Even with respect to the question of the mere addition of mass as a function of increasing speed of a body relative to the inertial frame of the observer's laboratory, it is doubtful whether this should ever be taken to imply an effective increase of the mass of the

body in relative translation. For it is at least admitted that in its own inertial frame of reference, the mass of the body would appear to be constant. Yet, this is the only basis that Relativity has at its disposal in order to establish the increase in mass of particles with increasing speed of motion or acceleration, or increasing kinetic energy. Moreover, the reader should note the relation between the length contraction in the direction of relative uniform motion, which implies a contraction of extensity, and thus a compaction of mass in the direction of motion, and the 'new kinematic' increase of mass at relativistic speeds. Relativity does not differentiate completely between these two aspects- given that reduction of extension in the direction of motion invariably reduces the volume of a body and thus increases its mass density. When coupled to the increase in mass with increasing relative speed, Relativity is in fact holding two distinct propositions: that mass is catalyzed from energy with increasing speed, and that its density increases by volumetric contraction with increasing speed. The former depends upon there being no energy loss by radiation, so that effectively it is kinetic energy that is condensed into mass, whereas the latter is a geometric constraint imposed by the Lorentz-Fitzgerald transformation.

With SR, the kinetic energy of a body of mass m is no longer given by the Leibniz formula mv^2, modified by Newtonian mechanics into $0.5\ mv^2$, but as

$$E_0/\sqrt{(1-\beta^2)} = 0.5\ mv^2/\sqrt{(1-\beta^2)}$$

where β stands for v/c. Likewise, the inertial mass of a body is not deemed to be a constant, but to vary in accordance with the state of motion of the body and thus with the change in the energy of a body. Hence, the mass-energy of a body is a variable defined by:

$$mc^2/\sqrt{(1-\beta^2)}$$

It follows that if we are to consider the total energy of a body, E_T, it is not simply given by

$$E_T = mc^2 + 0.5\ mv^2$$

but by

$$E_T = (mc^2 + 0.5\ mv^2)/\sqrt{(1-\beta^2)}$$

But this relativistic increase in mass with increasing acceleration follows from a poor understanding of what exactly is happening in the Kauffmann-Bertozzi experiments: it is

massbound charge that, by asserting and conserving its inertia in linear motion, increasingly resists addition of kinetic energy that approaches the magnitude of its rest mass-energy, with the result that what is deemed to become the kinetic energy of the moving massbound charge, and deemed thereby to increase its inert mass, is nothing short of wasted energy thermally radiated from the recalcitrant charge wanting to preserve constant its mass-energy. All happens as if the linear inertia property of the electron and the electrical properties that it entails, are by design inefficient at acquiring kinetic energy, when inertially accelerated. The Argentinean physicist R. Carezanni has poignantly drawn attention to this problematics, and elsewhere we have proposed our own aetherometric analysis of this type of experiments, where it is shown how the experimental velocities of the massbound charges are predicted by a theoretical model that does not take recourse to any of the Lorentz transformations. That means - no time dilation and no relativistic mass increase with acceleration of inertial mass. The inertial mass of a system is only a measure of its rest energy, unlike what SR proposes it is.

These questions surrounding the relativistic treatment of mass-energy with respect to states of motion, and the companion treatment of mass-energy as latent electromagnetic energy, raise the problem of the integration of gravitational and electromagnetic energies and even further, the problem of the energy structure of mass-energy or, in stricter terms still, the problem of what is *the internal motion of a body in a state of rest* with respect to its inertial frame of reference. Specifically, the difficulty resides in the problem of rotation and periodic acceleration, such as these are per force implicated in the actual (intrinsic) motions of material bodies, and most obviously in the ostensibly perpetual motions of astrophysical bodies and atomic electrons. These questions raise the spectrum of GR, that is, the problem of how Relativity had to become a generalized theory that encompassed the laws of gravitation, before a unified theory of Special and General Relativity, of electromagnetism and gravitation, could even be sought.

Einstein's first answer to these problems attempted to deal with the problem of rotary motion by considering that "a system of coordinates in stable rotation relative to a system of inertia in the Newtonian sense" yields the identity between gravitational and centrifugal forces proscribed by classical mechanics: the radial force which an observer at rest interprets as a centrifugal force, as an effect of inertia, an observer 'immobile' on a rotating system may interpret - by GR's principle - as an effect of a gravitational field. This, of course, was not a legitimate transformation from the viewpoint of Newton's theory of gravitation, since the latter required the field both to vanish at the center of mass and increase radially as a function of the distance, though unaffected by latitude. With GR, Einstein claimed that Space everywhere presupposed a gravitational field - without which, "nothing would remain

of Space", not even "a topological Space". This abrogated any independent existence of Space (or Spacetime), but not to the benefit of understanding how multiplicities (that differ in nature and also in metric) are constitutive of energy. Instead, GR's connection of a (spherically flattened) Spacetime continuum to a gravitational aether caved in to mechanistic considerations by making the latter dependent upon matter: "once matter is found in the domain under consideration, only its inert mass [and thus] (...) its energy alone need be considered as actively producing a field". Or, in still more general terms -

"In the generalized theory of relativity, the doctrine of space and time, kinematics is no longer one of the absolute foundations of general physics. The geometrical states of bodies and the rates of clocks depend in the first place on their gravitational fields, which again are produced by the material system concerned." (15)

One may well wonder whether this was the valid route one should take to establish the existence of a non-electromagnetic aether responsible for the gravitational phenomena. For material systems are conceived by GR merely as electromagnetic energy systems that are artificially flattened onto an imaginary topology. Further, this impeded any understanding of mass not just as latent energy, as potential electromagnetic energy, but as *actual* electric energy in a peculiar state of rotary motion. However, at the time of Einstein's first enunciation of the GR theory (1913), there was still an opening left in Relativity with respect to the question of the aether, and specifically, of a massless aether. Certainly SR assumed that the stationary aether was precluded by the results of the Michelson-Morley experiment. But, by the same token, there was no implicit assumption that a *dynamic aether* could not be at work, nor, for that matter, that a non-mechanical *massfree aether* could not exist. Even in this sense, the words of Reichenbach echo those of W. Reich: "(...) Light is an electrical process rather than a mechanical one. (...) With such a statement, it is true, the question of the existence of the aether, assumed formerly, is not yet answered in the negative. *All that is proved is that the aether is not a substance, in the mechanical sense of the word, comparable to what we call matter.* The question remains: (...) Can't there possibly exist a particularly fine [massless] substance underlying electrical fields and related to them as water is to water waves?" (16).

Most physicists today regard these words of Reichenbach as merely part of the wavering of Relativity in its early days. With considerable confidence, modern physicists assert that waves wave in probability and nothing more. Having become the official logico-mathematical theory of Physics, relativistic orthodoxy, as much as quantum and wave mechanics, refuses to conceive of any form of energy that is not electromagnetic or associated with mass-energy. To speak of the aether these days only brings smiles of contempt from institutional physicists - they have already found something better: the intangible 'swarming

of virtual particles'. Today, the problem of the aether is considered merely one of the great false problems of science and is dismissed outright by slight of hand. Yet, Einstein himself did not consider that his theory of Relativity, in either the Special or the General formulations, precluded the existence of *an* aether. Bergson commented on this essential element of Einstein's Relativity - emphasizing the fact that when Einstein declared that there no longer was an aether, he obviously meant that the hypothesis of a fixed, stationary aether, "a unique and absolutely privileged system of preference", was no longer tenable, *not* that a non-stationary aether *could not, or did not,* exist: for, writes Bergson, "the hypothesis of the aether, suitably amended, may quite well be retaken by the theory of Relativity" (17). In his famous talk on "Aether and Relativity", in 1920, Einstein was clear about the fact that, if space has physical qualities which are not mechanical, then there is an aether which must be compatible with Relativity:

"Most careful reflection teaches us, however, that the special theory of relativity does not compel us to deny the aether. We may assume the existence of an aether; only (...) we must by abstraction take from it the last mechanical characteristic which Lorenz had still left it (...), namely, its immobility. (...) To deny the aether is ultimately to assume that empty space has no physical qualities whatever. (...) Recapitulating, we may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an aether."

It is a disservice to Einstein's theory to present it as if it had, once and for all time, laid the ground for the final dissipation of any 'aether illusions'. Not only through the back door, the theory of SR as a whole, introduces elements of the old stationary aether theory (the equivalence of all motion, be it rotary or translatory, with inertial motion; the privileged role of the speed of light; the actual extension of Euclidean Space to encompass Time, to name but a few), but Einstein is quite explicit with respect to the fundamental physical characteristic of the aether which Relativity can exclude: absolute immobility. After SR, it was the static aether concept which was no longer tenable; not every dynamic concept of an aether had become outlawed. Yet, this was not the conclusion arrived at by XXth century Physics and the inheritors of Relativity. Einstein's failure to formulate a unified relativistic theory was germane to this posterior switching in the interpretation of Relativity.

One might tend to view Einstein with a somewhat cynical attitude - for, at times he appears to be a traveling road show, gathering theoretical pieces wherever he can - the mass-energy expression from Jeans, the Relativity principle from Mach and Poincaré, the four dimensional Spacetime from Minkovski, the tensors from Riemann, the primacy of electromagnetic energy and its non-mechanical effects from Maxwell, the dimensional transformations from the Lorentz-Fitzgerald contraction, the theory of photons from Planck

and the electrodynamics from Lorentz. But the fact was that he alone synthesized all these views, up until then incompatible with one another, into one congealed theory which, nevertheless, *did not forbid a dynamic model of the aether*. Had anyone enunciated such a theory before the MM experiment, one might have realized how the premises of the experiment itself were faulty. From such a perspective, one might well have proposed that there is no aether drift to be expected if the aether around the earth *moves with the earth*, *in the same direction as the earth's rotation*. In fact, if it moves *with* the earth it is *likely* that it is *what makes the earth itself move.* From such a perspective, a null result of the MM experiment would be just as well the predicted or required finding, without any resort to relativistic assumptions. Remarkably, this was precisely the viewpoint that W. Reich would take with respect to the MM experiment: as he suggested, the null result is compatible with the notion that the earth is surrounded by a rotating (massfree) aether energy envelope that moves from West to East, in harmony with the direction of the earth's rotation, but slightly faster than the speed of rotation of the planet. The argument has failed to capture the attention of physicists. Yet, it really is not a new idea. Michelson himself had once objected to the relativist interpretation of the null result precisely with the suggestion that his own premise, viz that the aether, if it existed, was stationary, could be wrong: the aether could actually contain moving frames. That was the essential thought behind these explicit words of Michelson -

"[the MM results] could still be accounted for by the assumption that the earth drags the ether along at nearly its full speed, so that the relative velocity between the ether and the earth at the surface is zero or very small" (18).

Michelson's point is that, for as long as the motion of the aether, on the surface of the earth, on the horizon system or the rotating frame, is synchronous or nearly synchronous with the rotary motion of the earth, we should not expect a phase difference between the light pencils oriented parallel with, and those perpendicular to, the "aether drag". If we can talk of a scientific repressed with respect to the MM experiment, this is its content - that, if we assume that the local aether is not stationary but in motion parallel to the motion of the laboratory locality on the earth's surface, we cannot conclude from the null result of the MM experiment that the aether does not exist, or cannot exist. Only the classical fixed or stationary aether is ruled out of existence, not a dynamic aether, and specifically not one that may be intimately connected with the rotation itself of the planet.

"(...) It became clear in the later revision of the [SR] theory that light may be used for all measurements of time, for the designation of the measure of time (...)Clocks and yardsticks (...) have only a subordinate function. They adjust themselves to the geometry of light (...)"

H. Reichenbach, "From Copernicus to Einstein", p. 69, 1942

4. Relativistic fragmentation and spatialization of Time

In our estimation, SR went astray not because it denied the stationary aether, but because, under the influence of Lorentz's tranformations, it negated the physical reality of simultaneity with its concept of Time-dilation and the concomitant inverse correlates of length contraction and relativistic mass increase. Here is where the most intense point of rupture with the romantic and classical notions of Time took place - the rupture with the classical view of a universal Time, a single Duration.

Certainly Relativity compensates for the resulting fragmentation of Time into timelines that can enter only into relativistic quasi-'simultaneity', by integrating these timelines in the Spacetime continuum - by making them into reversible and extra dimensions of Space. But in doing so, all simultaneities are distorted, because the real compensation for the introduction of multiple times is the acceptance of the dilation or transformation of time along any and every line, as a function of relative wavespeed having a uniform limit. The unity of the world is then to be found not in its content, but in its empty and fuzzy form. The reign of the Form in Relativity is also a return to Plato, not Spinoza. It is in this sense that Relativity actually treats the speed of light in vacuum, in Space empty of matter and electromagnetic interactions, as an *absolute* speed, an invariant from which it deduces the pure Form of Spacetime. In the second principle of SR, which serves as postulate for the motion of gravitational waves in GR, we have a *residual notion* of absolute velocity. It is this residue of metaphysics which leads SR to accept that acceleration, irrespective of an inertial frame, has an absolute value of nonzero magnitude. Hence, Sklar wrote-

"If we refuse to adopt a particular inertial frame of reference, the only invariantly characterizable magnitude of acceleration is the zero magnitude. It is [therefore] meaningful to ask, 'Is this particle suffering no absolute acceleration at all?" It is not meaningful to ask, "what is the (nonzero) magnitude of the absolute acceleration of this particle?" So we are left [in SR] with a residual part of the notion of absolute acceleration." (19)

Sklar concludes that "in the special relativistic spacetime (...) there is no such thing as (...) the absolute magnitude of nonzero accelerations", as all other speeds but the speed of light in vacuo are relative speeds.

The absence of a universal Time opened the door for a multiplicity of times: everywhere a plurality of speeds for the passage of Time appears to be "affirmed" by SR. Einstein concluded that there was a displacement of every and any simultaneity - that which was simultaneous for a fixed system ceasing to be so for a mobile one - and therefore, he postulated a plurality of times with different speeds of "passage", all real and each characteristic of a particular system of reference, to arrive at his conception of a spatialized unity of Time, this unity consisting in Time simply forming one more dimension of Space. One might say that Relativity experiences the diversity of durations for a multiplicity of observers as a requirement that only partial times can be real:

"In this sense there would be a multiplicity of times, a plurality of times, with different speeds of flow, all real, each peculiar to a system of reference. And as it becomes necessary, in order to situate a point, to indicate its position in time as well as in space, the only unity of time is in a fourth dimension of space." (20).

What Bergson reproached Einstein for, was the latter's implicit confusion of the two terms characterizing the Riemannian distinction between actual, quantitative and discontinuous multiplicities (the domain of the differences in degree) and virtual, qualitative and continuous multiplicities (the domain of the differences in nature). Einstein proceeds as if there existed only one type of multiplicity, discontinuous multiplicities, condemning himself from the start to never be able to seize the real nature of the continuum. Due to this shortcoming, Einstein will have to invoke notions such as time dilation, the plurality of times of passage and the false unity of a spatialized Time.

Time is not treated by Relativity as distinct in nature or in quality from the set of topological locations or lengths between points. Whether in the SR form of a flat Minkowsky Spacetime or in the GR form of a curved Riemannian Spacetime, the essence of Relativity lies in its treatment of Time as the fourth length of a four-dimensional Space. As the actual metric of a length of time is not fixed, only the intervals being invariant, one can no longer speak of the reality of timelines or of synchronicity. Let us consider this fragmentation of Time in some detail.

In Newtonian theory, events take place in absolute Space conceptualized as Euclidean 3D-Space. The set S of spatial locations of an event is given by the three lengths of Space -

$$S = x^3$$

whereas the set T of temporal moments of an event, ie the location of the event in Time, is only the one-dimensional timeline t^1, such that the structure A of Space and Time is simply the Cartesian product of Space and one-dimensional Time:

$$A = S\ T = x^3 * t^1$$

Two events are defined as simultaneous, or are said to belong to the same class if, and only if, they have the same temporal location, ie occur at the same time, with the result that one differentiates between them solely as a function of the structure x^3. Similarly, diachronicity is simply defined as the reverse procedure whereby events having the same location x^3, may establish diachronic series or collections of events as a function of the structure t^1.

Minkowsky Spacetime underlies all relativistic transformations, whether for a special or a general observer. It differs from Newtonian Space and Time in that it is not the Cartesian product S x T = $x^3 * t^1$, but a Euclidean Space in four dimensions with respect to *topology*, with a non-Euclidean *metric* defined not by the distances between events but by their *intervals*. This is an essential condition for SR, as two observers in motion will in general disagree about the sizes of the spatial and temporal lengths separating two events, but can agree about the interval between events. The pseudo-Euclidean Space (21) is defined as -

$$S = x^4$$

but the spatiotemporal structure is given by the interval A along any curve L, defined as -

$$A = \int_L dS$$

or, retaining the formalism of length connoted by x and time connoted by t, we have for four dimensional Spacetime-

$$dS^2 = dx_1^2 + dx_2^2 + dx_3^2 - c^2\ (dt^2)$$

If we take c as unity, and write the timeline strictly as the length, $t = x^4$, which it corresponds to in Minkowsky Spacetime, we have -

$$dS^2 = dx_1^2 + dx_2^2 + dx_3^2 - dx_4^2$$

Here, at last, it becomes evident how timeline dx_4 has become reduced to a negative length of four-dimensional Space. Once the metric is chosen, this is still the same notion of an envelope, a container of events separable from the events themselves that was intrinsic to the concept of Euclidean Space, except that it is a four-dimensional pseudo-Euclidean Space. The functional correspondence between a 4D-Space(time) and the Minkowsky metric of intervals between paired events, can be functionally written as-

$$S = x^4 \text{-}\int\text{-}\, dS^2 = dx_1^2 + dx_2^2 + dx_3^2 - dx_4^2$$

As time is turned into just another length, it too becomes subject to a Lorentz transformation, the result being dilation of Time as a function of increasing relative speed. The interval between any two events along any Spacetime curve is a quantity and an invariant property of Spacetime. Unlike distances, which are always non-negative, the intervals of Minkowsky Spacetime can be positive, zero or negative, originating different kinds of separations between events. If the interval is positive, a spacelike separation between events takes place; if the interval is negative, a timelike separation occurs, and if it is zero, a lightlike separation is said to occur. The set of events that have lightlike separation from any given event *a* is denoted as the light-cone of event *a*. Only for events that have a timelike separation can a causal signal be established for propagations *slower* than c. Given the invariant role of c, there can be no causal signal linking spacelike-separated events, which would require propagation velocities *greater* than c.

Minkowsky Spacetime is an essentially flat structure that dissociates into Space and Time only when the state of motion of the observer in an inertial frame is specified. That is what gives it its Euclidean or quasi-Euclidean characteristic, by permitting the application of Cartesian coordinates. Hence its employment by SR, where only the special observers in uniform or inertial motion belong to valid frames of reference for the actualization of a system of coordinates. This is what Sklar terms the 'preferential coordinatization' characteristic of SR.

Like the flat Minkowsky Spacetime of SR, the curved Spacetime of GR is a 4D-manifold with an interval metric and a system of geodesics ("the straightest curved lines"). Just as the Minkowsky Spacetime becomes a 4D Euclidean Spacetime once an inertial frame is specified, so does the curved Spacetime of GR become a Riemannian relativistic Spacetime that employs the ordinary Gaussian-Riemannian distance metric but treats not curved n-dimensional Space, but curved 4D-Spacetime, once a general observer is defined by a set of functions. The Minkowsky metric of intervals which we wrote above as $S = x^4 \text{-}\int\text{-}\, dS^2$, can

be treated as an example of a flat n-dimensional Riemannian Space, and with n=4, the metric lengths become replaced by Riemannian interval g-functions, to yield-

$$g_{11} = g_{22} = g_{33} = -g_{44} = 1$$

where $-g_{44}$ is now the interval of time between two events, and $g_{ij} = 0$, $i \neq j$.

The relativistic pluralism of times is in the ultimate analysis just a pluralism of intervals, all of which are reduced to lengths of value 0, +1 and -1, such that only 0, x and -x exist as metric realities. Inevitably, the introduction of negative directions in Time results from the assumed structure of Spacetime, with the result that Spacetime is only irreversible as a process because of the physical limit posed by c.

This relativistic fragmentation of a root-Time into rootlet times, all spatialized and each peculiar to a system of reference, requires a *totalizing unity,* all the more despotic and gratuitous as it empties Space in order to establish itself: it is in the invariant propagation of electromagnetic signals that Relativity finds its fundamental principle of unification, beginning with the reduction of all energy to electromagnetic energy. The unifying element that serves as complement to the dominant reality of "empty space" is the luminal limit to the transmission of energy, which is now exclusively conceived as electromagnetic energy. But this effective dogma-limit of Relativity is a shallow river with a comical effect: four years after Einstein's death, Cerenkov would publish his papers showing the presence in an aqueous medium of *electric* waves traveling faster than the speed of light in the same medium. Much has been made of the fact that Einstein's second principle only applied to the medium of the vacuum. But it would not take long for the founders of QED, Feynman and others, to circumvent the relativistic limit with spatialized fictions of particles actually moving back in time, in their atomicized time. The theory of *anti-matter* finds its rootlets here - from theoretical tachyons that move faster than the speed of light in vacuo, to positrons which are taken as electrons moving *backwards in time*. With QED, even irreversibility would be lost from Time. But the unifying Atomistic taboo remained - it is in the Void, in the n-dimensional Space empty of energy because it is empty of matter, that the absolute limit and reference of c lie.

What Relativity, no less than any other theory since Relativity, has been missing is an energetic theory of the continuum, where the manifolds of Space *and* Time would remain mutually irreducible as distinct properties of energy. But to enunciate such a theory, Time itself would have to be understood as having its own universal metric, irreducible to that of Space, and comprising more than one timeline. This requires such a theory to be able to place simultaneity at the heart of the concept of energy, in the domain of resonant

synchronization of wave functions. Then maybe one might find that the adequate correlation of dimensions is not additive, but one of superimposition, and thus that the manifolds of Space and Time are themselves directly the product of a constant flux of energy.

"It was the advent of modern quantum theory (...) that established the quantum vacuum, so-called empty space, as a very active place, with particles arising and disappearing, a virtual plasma, and fields continuously fluctuating about their zero baselines. The energy associated with such processes is called zero-point energy, reflecting the fact that such activity remains even at absolute zero."
H. Puthoff, "Can the vacuum be engineered for spaceflight applications?", IE, 15-16:72, 1997

5. Einstein's and Stern's proposal of a Zero-Point Energy and its legacy

Originally, the theory of the ZPE was a component of Planck's second theory (1909), when Planck actually took discontinuity explicitly into account, albeit still having reduced it to emission processes (absorption of energy from the aether being seen as a continuous and slow process). To understand the ZPE model we must backtrack to the origins of Planck's thought. Unlike Boltzmann's phase-space cell domains, which encompassed a number of molecules, Planck's original search targeted the units of a continuum, his theorized phase-space cells accordingly having to be *quite small domains of space.* Planck proposed that these phase-space cells are electromagnetic oscillators (resonators) which may possess all possible energy levels of the spectrum. The physical cells of space would contain discrete elements describing in two dimensions cyclical ellipsoids such that, once an oscillator crossed the nth elliptical boundary in the phase plane, it would radiate n quanta by emission, and would finish radiating once the ground state of zero energy was reached. Even at absolute zero temperature, the oscillators would possess finite energies randomly distributed between zero and $h\upsilon$. This, however, only becomes clear with his second theory. There, he added another element: the presence of a residual randomistic energy near absolute zero temperature which suggested to Planck that the energy of an oscillator, set in a weak, fluctuating stochastic 'field', could easily be brought to the point of electron emission and converted into the translatory kinetic energy of an emitted electron. This had direct application to the understanding of the photoelectric effect and formed the basis for Einstein's demonstration that the electromagnetic energy of photons would become transformed into the kinetic energy of the emitted electrons. But Planck's second theory postulated that only the number of electrons emitted could vary, *not* their energy, suggesting therefore that, if Einstein's law of the photoelectric effect was correct, there was no need to assume that these electrons were emitted from the light-particles themselves.

According to Planck's second theory, the submicroscopic oscillators were described with an additional term, $h\upsilon/2$, to denote the energy present when all thermal oscillation had ceased, but which was absent from the distribution law for radiant energy (being negligible

for $h\upsilon << kT$) though it would be accounted for, in principle, by finding that the frequency of all motions contributing to the specific heat of a gas was independent of temperature.

Paradoxically, it was Einstein and Stern in 1913 who set the ZPE theory on an independent course, when they demonstrated that while this foundation for the additional term might well be appropriate for Planck oscillators, and even possibly for the vibrations of atoms in solid lattices, *it could not be applied to the rotational frequency of a diatomic gas molecule* (which Einstein and Stern treated without quantizing rotational energy). Based on then recent measurements of the specific heat of hydrogen at low temperatures, they concluded that existence of zero-point energy on the order of $0.5h\upsilon$ was most likely. In the second part of their paper, however, they provided a derivation of Planck's Law without taking recourse to discontinuity, by assuming that the value of the ZPE was simply $h\upsilon$. It is worth noting that Einstein had already in 1905 [(22)] framed the problem of discontinuity, even if only heuristically, as one of placing limits upon the infinite energy of the vacuum state predicted by the Rayeigh-Jeans dispersion law. According to Einstein, the Rayleigh-Jeans law would result in an impossibility, the existence of infinite energy in the radiation field, and this was precisely incompatible with Planck's discovery - which suggested, instead, that at high frequencies the entropy of waves was replaced by an entropy of particles. Einstein, therefore, could only hope for a stochastic validation of Maxwell's equations at high frequencies "by supposing that electromagnetic theory yields correct time-average values of field quantities", and went on to assert that the vibration-energy of high frequency resonators is exclusively discontinuous (integral multiples of $h\upsilon$).

Since then, the ZPE model evolved as an experimental physical theory independent of Planck's second theory, the latter having faded away, largely because of the Bohr theory which postulated identical discontinuous processes at work *in both absorption and emission of energy*. Confronted with the Stern-Gerlach experiment of 1922, Planck too would accept the stationary states and the quantization of energy proposed by the Bohr theory. Hence, for modern physics, the lowest energy of any harmonic oscillator, or any particle in a given parabolic trajectory, cannot have less than this zero-point energy, defined for quantum mechanics as $E_0 = h\upsilon/2 = h\omega_0/4\pi$, where ω_0 is the angular frequency of the quantum harmonic oscillator which, unlike the classical harmonic oscillator, is not independent of the amplitude of the oscillation, and thus is not independent of energy. The ZPE was treated as a completely nonclassical phenomenon and led, in a very real sense, to the creation of quantum mechanics.

That this definition of a 'new aether' was in Einstein's mind is proven not only by his conclusions from SR and GR, and his joint proposal of the ZPE of space, but also by the explicit proposal that he made in 1925, when commenting on (and commending) de

Broglie's theory of matter waves, for a universal electromagnetic limit frequency of this 'motile' or nonstationary aether, to be determined as:

$$\upsilon_\delta = m_e c^2 / h = 1.2353*10^{20} \text{ cps}$$

This would have the result of giving E_0 as half the mass-energy of the electron-

$$E_0 = h\upsilon_\delta/2 = m_e c^2/2$$

Einstein's proposal, similar to others made by Dirac and Schrödinger, would later become one of the cornerstones of Aspden's theory of aether spin. These facts demonstrate the length to which Einstein went, up until 1925, in admitting a compatibility between Relativity and a theory of a minimum continuous moving field responsible for electromagnetic quantization and for gravitation.

In more recent decades, different approaches to ZPE theory have ignored these elements of Einstein's work and have gone on to characterize the 'new aether' as a 'free field' (the ZPF) of electromagnetic radiation present in space devoid of matter. Since the 1970's, stochastic electrodynamics (SED) has developed as an alternative interpretation of quantum mechanics, designed to treat quantum field-particle interactions in accordance with classical physics. SED theories retained the probabilistic approach that characterized Planck's and Einstein's early efforts by positing that the "vacuum state" is actually a field formed by a collection of classical electromagnetic radiation modes with random phases, present even at absolute zero temperature, the ZPF being homogeneous, isotropic and subject to Lorentz invariance [(23)]. A real electromagnetic field is supposed to define the "vacuum" state as a background of classical radiation modes, while ZPF-induced motion involves a free energy exchange between the field and the particle with no average transfer of energy in any direction at any frequency [(24)]. From this vantage point, heat has two forms: (1) as thermal energy, which is but a form of electromagnetic radiation that flows from the regions of space surrounding the system undergoing a temperature increase, *in a reversible process*, such as displacements driven by van der Waal or Casimir forces (if temperature $T \neq 0$); and (2) as emitted radiation from the system to the ZPF, resulting from conversion of the kinetic energy of two colliding particles or molecules, *in an irreversible process* obeying a positive net entropy change [(25)].

It is fascinating to see the unresolved problems of contemporary physics dredging up the sediments of forgotten disputes, returning incessantly to their grounds. If there is energy in space even at absolute zero, this energy flux, this motion, cannot be due to thermal energy,

to sensible thermal energy, but the cause of it. And if this motion exists even for space devoid of matter, then the question becomes - what moves if it is not matter? What energy is it? If what moves are *actual waves of energy* that account for the translational and rotational energies of atoms and molecules at low temperatures, the primary motion of these waves must clearly be distinct from the secondary motion of the molecules it gives rise to, the Brownian motion of the latter being a particular consequence of the 'random phase' motion of the former. These questions are distinctly reminiscent of the problems associated with determining the nature of Planck's oscillators. Just what exactly were they? Were they elements of matter or elements of the (imponderable but stationary) aether? Could they have been the elements of an imponderable and moving aether? Certainly their behaviour was particulate and, for as long as we relate particulate nature to mass, the difference between matter and the aether is not very significant, as the aether in a classic sense was considered to be a material substrate (with, as we have argued, Maxwell's non-material, non-mechanical 'field aether' being the partial exception to this statement). Because this difference indeed has not been properly considered by modern physics, quantum electrodynamics (QED) has suggested that space is filled with virtual particles fleeting constantly in and out of existence - a domain that has become the impregnable realm of imaginary matter and anti-matter couples that fill up the quota of 'dark matter' which is missing from the relativistically-revised electromagnetic Weltanschauung. In fact, it is here that SED deviates from QED to posit instead a random phase of electromagnetic wave continua. The question then is - just what are these space elements, nodes of electromagnetic waves or virtual particles, or neither?

Already at the dawn of Planck's first theory, Ehrenfest had proposed a duality of oscillators, molecular resonators and aether vibrators. Resonators were said to be the ultimate elements of matter and were conceptualized as being interconnected by a network of springs or vibrators representing the aether in different states of oscillation. Even though Ehrenfest's early interpretation of the need to introduce discontinuity - to reach Planck's goal of determining a unique distribution function - suggested that non-colliding molecular motion was a form of energy transmission which betrayed modes of free aether vibration in the absence of increase in entropy, it was Einstein's statistical approach to the thermodynamics of mechanical systems which would triumph on the very basis that the fixed size h should not be attributed to phase-space cells, *but only to the probabilistic behaviour of every physical system as it inevitably tends over time towards a more probable stationary state.*. Planck's hope for a theory that would keep constant the size of phase-space cells fell by the wayside, as it violated the very probability ruling the transformations. But, as we have seen above from Reichenbach's words, Special Relativity also introduced a new element when it drew the conclusion that the stationary aether of the wave-theory of light could not, and did

not, exist. If the aether existed at all, it could not be a material medium; its physical nature would demand precisely that it be massless and non-mechanical. Yet, Special Relativity had made the aether vibrators irrelevant, even as it decoded the nature of the aether one step further.

The only connection that mattered for Einstein at this conjuncture was the relation of any system to that 'infinite heat bath' with which it is in constant communication. Indeed, having arrived at this very point, Einstein focused on the phenomenon of energy fluctuations, to posit that the only system where energy fluctuations are presumed to occur is "empty space filled with thermal radiation". And this then throws us right back to the very same problem: if it is not thermal energy resulting from the radiative transitions of decaying high-energy matter, as Einstein would later hold, just what is the nature of this radiation? Current SED theorists propose that its nature is electromagnetic, and that the ZPF is Lorentz invariant. As Aspden has quite appropriately commented, this "fits too closely in the Einstein mould and accounts for his failed attempts to explain inertia" (26).

"After such bad experiences, this is the moment to forget the ether completely and to try never to mention its name. We shall say: our space has the physical property of transmitting waves, and so omit the use of a word we have decided to avoid."

A. Einstein & L. Infeld, "The evolution of Physics", 1938, p.176

6. Conclusion: how SR voided a Physics of Energy

One could suppose Relativity to be the only quasi-comprehensive theory of Physics that first put forth an energetic argument. Yet, energy only figures in Relativity as a manifestation secondary to the structure of the Spacetime manifold, and subject to relativistic constraints, by its reduction either to electromagnetic or mass-energy. If Relativity were to be an energetic theory of Physics, it would have to abandon the very canon of the 4D-Spacetime manifold, and realize that the dimensionality of any continuum would be the dimensionality of massfree energy. As it stands, Relativity is not an energetic theory but a formalistic or geometric theory of nature, where energy is dissociated from the structure of Space to the exclusion of Time.

Several steps are required to form the relativistic argument that finally *severs* Space and Time *from* energy and motion, to make of the block Space-Time a mere geometric construct. They are -

a. Time is a property of space as energy is a property of matter.

b. Space empty of matter is empty of energy, as it is empty of matter waves (even the photon must have weight, like the atom, because of a postulated inertial mass).

c. Space empty of mass-energy is space empty of motion: kinetic energy only exists as energy associated with a body, energy of the motion of a body.

d. Space exists therefore independently from matter, energy and motion: it is an empty geometric form, and it is this form that explains gravity. Space is the scheme of matter and renamed Spacetime.

Only the mathematical and geometric evolution of form determines the function and the codistortion of Space and Time. It is Space which is the form of both matter and energy, their scheme. As Spacetime it is Space that exists as pure form, at the cost of eliminating a dynamic and economic aether - and at the cost of eliminating singularities:

"A field theory is not yet completely determined by the system of field equations. Should one admit the appearance of singularities? (...) It is my opinion that singularities must be excluded" (27).

At the end of his life, Einstein was still searching for a theory of the continuum that would eliminate singularities - caught in the same problem that prevented de Broglie from succeeding in integrating wave and quantum mechanics in his wavicle theory of matter

waves. And why? The simplest answer is - because of the classical electromagnetic ignorance of longitudinal electric waves. In fact, the adoption of Maxwell's theory of transverse, homogenous electromagnetic disturbances to establish a bridge between quantum and wave mechanics prevented any synthesis with the behaviour of quanta. De Broglie summarizes the difficulty -

"In the theory of waves, the magnitudes of fields which are propagated by undulations are distributed in space in a continuous manner; the different points of the wave do not differ essentially one from the other, which can be interpreted in the language of mathematics by saying that the waves of the usual undulatory theory do not present any 'singular' point" (28).

Several barriers prevent any filiform treatment of wave functions by current electromagnetic theory: the conceptualization of the propagation wave as a constant transverse wave which precludes singularity; the notion that the wave function can only achieve a filiform solution if its frequency is infinite; and the notion leftover from Einstein, Podolski and Rosen, that nonlocality can only invoke "spooklike actions at a distance". To us, it is apparent that not all hidden variables are local, but just as well that nonlocal variables are only relevant if they affect local ones (relativity of nonlocality). Quantum mechanics has remained to this day incomplete, and this is the source of the paradox. It would suffice to explain how electromagnetic quanta are locally generated with distributions dependent upon the motion of continuous, nonelectromagnetic, longitudinal waves, for the seemingly impossible integration of quanta with an energy continuum to reveal itself as a shallow problem. Instead, modern Physics is stuck with the quasi-filiform relativistic solutions of Sommerfeld and Schrödinger, trying to insert a singularity into a probabilistic wave that approaches the Maxwellian envelope.

Furthermore, experimental findings of nonlocality employing anomalous dispersion techniques that exploit stimulated emission (29) are easily explained by precisely the assumption that the stimulus is propagated supraluminally because it is not an electromagnetic stimulus to begin with. The NEC researchers have wrongly contended that 'time and the group velocity being negative', the photon pulse arrives before it departs (a nonsense even for relativists), but in fact all that the nonlocality response demonstrates is that the shortened, though positive, time of propagation is not due to electromagnetic factors. In fact, the symmetry of choices made by synchronized photons in Franson-type experiments should be read as proof that microscopic simultaneity does exist. What the researchers interpret as 'photon choices' is in fact an implicit admission of a synchronization phenomenon. If the light stimulus can propagate at speeds greater than those of light, as Cerenkov first found out, then what propagates is not light at all, and thus certainly not

energy configured electromagnetically. Light consists solely of a local production of photons in response to the propagation of a stimulus that itself is not electromagnetic. The aether is not about words (nor about blocking out the infantile trauma of 'bad experiences'...), but about a Physics of massfree energy and Time, that is, about simultaneity and the paradoxes of synchronicity. Only deluded fools believe one can mathematically omit *that* by playing with a metric of intervals, simply because the notion of the aether as a static mechanical medium proved to be false.

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