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ABSTRACT

In the history and theory of Physics there are accursed experiments voted to systematic oblivion. Two such examples are the 1913 Sagnac and the 1925 Michelson-Gale-Pearson (MGP) experiments, which, to this day, remain welded together as the repressed of General Relativity (GR).

That the MGP experiment was voted to oblivion is all the more glaring an omission, since it was supposed to provide a test for Einstein's "principle of equivalence" of inertial and gravitational masses, the actual basis for GR. The relativistic expectation sanctioned by Einstein in 1924, was that the MGP experiment should detect a full fringe shift in order to confirm General Relativity, whereas a null result would have been compatible with the notion of a partial aether drag. Note that the expectations regarding the null result had now been inverted with respect to the MM experiment, because the MGP experiment tested for rotation and not translation of the earth. So argued Einstein.

In this context, the authors wonder why should *rotation be measurable* because of a Space-Time drag of inertial frames in rotation, and *translation remain unmeasurable* and unable to elicit the dragging of its own inertial frame, when translation is also a gravitational motion and there must be equivalence in principle between inertial and non-inertial frames? The problem is further highlighted by GR's later confrontation in the early 1930's with the 1913 Sagnac effect, because GR is here constrained to admit that, 'for non-inertial frames', the speed of light is no longer constant. After all, to be consistent with itself, as Aspden has pointed out, Relativity should have followed Mach's lead and proposed that one should not be able to electromagnetically measure any speed of rotation with respect to Space. To achieve this somersault, Einstein adopted the relativistic dragging of inertial frames from aether drag theory, and even went as far as claiming in 1920 that with GR, "the conception of the ether has again acquired an intelligible content, although this content differs widely from that of the ether of the mechanical undulatory theory of light".

But did Einstein's trajectory remain loyal to this program? The authors contend that it did not. Central to the GR paradox was the *axiomatic assumption that gravitational field energy can be treated as reducible to the interval metric structure of Space-Time itself*. From an energeticist perspective, this was an essential metaphysical lapse - emptying gravitation of its energetic content and replacing it with the structure of a manifold that is susceptible to the criticism that it essentially confuses Time with Space. Moreover, there is no intrinsic or heuristic requirement on the part of the Sagnac effect for any time-dilation transformations. Einstein was in fact obliged to treat the continuum as a pseudo-Riemannian manifold that had a *separate physical reality distinct* from the spatiotemporal relations between material

objects. This clearly introduced substantivalist considerations into what was originally deemed to be a relationist project.

These considerations lead one to become suspicious of Einstein's utterances about *an aether compatible with* Relativity. The problem is that the 'aether' that Einstein increasingly appeared to have in mind, rather than becoming, as promised, a 'non-material, non-mechanical and gravitational aether', turned instead into a pure *metaphysical fiction*; a disembodied Spatial reality endowed solely with a mathematical existence and barred from any access to Time and synchronicity. *Einstein operated a reduction of gravitational theory to geometry, and ultimately precluded therefore any recourse to the notion of gravitational energy*. With this mystification, rotation was indeed made to appear as a mystery of nature.

Subsequent evolution of relativistic cosmology at the hands of Einstein's successors has resurrected the problem of absolute motion in the measurement of peculiar velocity with respect to the CBR. A cosmic universal frame of reference for the propagation of electromagnetic energy has been found, in direct contravention of Special Relativity - yet, as soon as it was made, this discovery was co-opted by Big-Bang ideologists as evidence for a cosmic entropy. Relativist metaphysics succeeded in keeping its cake and eating it too. Such are the privileges of theories that become part of the organon of royal science.

"(...) Classical theory tends to start out with charge as the source of electric fields, whereas Relativity pulls field out from nowhere by the magic of abstract transformations of reference frames"

H. Aspden, "Modern Aether Science", 1972, p. 85

1. The MGP experiment as a test of General Relativity: Einstein's ambivalence.

There are some experiments in the history and theory of Physics which are systematically ignored. One such glaring omission is the 1913 Sagnac experiment, whose principle and effect are today used in the ring laser gyro applied to submarine and satellite navigation, and another significant omission is the Michelson-Gale-Pearson (MGP) experiment which was supposed to provide proper verification of Einstein's GR, in accordance with Silberstein's proposal.

The omission of the MGP experiment is all the more glaring as it was supposed to provide a test for Einstein's "principle of equivalence", the actual basis for GR, which posits the equality of inertial mass and gravitational mass. And this is precisely the excuse that textbooks on the matter utilize to ignore the MGP experiment: that it falls outside the scope of Special Relativity and can only be addressed by GR. In this vein, A. P. French's MIT course and textbook on SR did not even mention the MGP or the Sagnac experiments once.

This argument can certainly be seen as specious if we consider that, strictly speaking, the MGP experiment has never been cited as an experimental confirmation of GR - not even by Einstein when he enumerated, towards the end of his life, the three major tests of GR as being: the oval orbit of Mercury, the bending of light rays in a gravitational field (which he considered confirmed by the English Solar Eclipse Expedition) and the spectral redshift. However, around the GR theory, Einstein elaborated a series of considerations on gravity waves (1916) and the gravitational aether, which were not really part of GR but in fact straddled his attempts to develop a unified field theory. Be that as it may, the question that awakens one's attention is - why should Relativity (GR), when predicting the outcome of the MGP experiment, expect a positive fringe shift with regard to the rotation of the earth, whereas beforehand, as a Special Theory (SR), it had based its axiomatic assumptions upon the null result of the MM experiment with regard to translation of the earth?

Back in 1924, the relativistic expectation, as proposed by Silberstein and sanctioned by Einstein, was indeed that the MGP experiment should detect a full fringe shift if it were to confirm Relativity, whereas a null result would have been compatible with the notion of a partial aether drag. The expectations regarding the null result had been inverted with respect to the MM experiment, because the MGP experiment tested for rotation and not translation of the earth - so argued Relativity. The major difference between the MGP experiment and

the MM experiment is that the MGP experiment *utilized a fixed interferometer rather than a rotating one*, measuring a four-way propagation of light around a very long rectangular pathway (the East-West legs were 612m long, and the North-South legs were 339m long). Since there was no rotation of the observer, the latter remained fixed to the revolving frame of the earth.

The outcome of the MGP experiment was ambiguous, though maybe no more ambiguous than the small persistent positive shift observed in MM experiments. Composed of 269 separate tests with readings that varied from -0.04 to +0.55 of a fringe, and a mean at +0.26 fringes, the MGP experiment could be interpreted to yield a positive result of ≈ 0.3 km/s - therefore near the speed of the earth's rotation, but the result was of borderline significance. It could be said that the experiment was inconclusive because it adduced neither proof that there was a shift in the phase of the light beams, nor that there wasn't one. With his typical inclination towards ambiguity, Michelson concluded that "the result may be explained on the hypothesis of an ether fixed in space, but may also be interpreted as one more confirmation of Einstein's theory of relativity" (1). This was a major ambivalence on Michelson's part, and one which might appear to justify Einstein's reservations about Michelson's *own* understanding of the problems at stake, were it not for the fact that Einstein himself was subject to a comparable *ambivalent oscillation*. Indeed, why should GR predict that rotation was optically measurable but not translation?

This question is all the more poignant as Ernst Mach, whose work was considered by Einstein himself to be the forerunner of Relativity, had suggested precisely this postulate on the basis of what he saw to be the impossibility of distinguishing whether the earth rotated or was immobile and the stars alone circled the earth. This *indiscernability and equivalence* was the basis for postulating the relativity of all motion with respect to the motion of other *material* bodies, and was the cardinal assumption which Einstein elaborated into the first guiding principle of SR. When Mach had enunciated this principle with respect to rotation, it did not yet constitute a complete break with classical thought, exactly because rotation was considered to form a "bad and forbidden system of coordinates" (to employ Einstein's and Infeld's expression in their criticism of classical kinematics), an anomalous non-inertial frame. Einstein, however, applied Mach's principle to translation, where the frame is directly considered to be inertial. Why then, when Einstein returned to the problematics of gravitation and rotation, should he choose to invert Mach's original proposition by suggesting that, whereas with SR the absence of fringe shift in the MM experiment was explained by Mach's principle, GR should predict the presence of fringe shifts for the MGP experiment, in apparent contradiction with Mach's principle?

To many authors, herein lies a clear indication of the *fundamental ambivalence* of Relativity regarding the physics of a 'non-inertial' rotating frame. After all, to be consistent with itself, as Aspden correctly pointed out in his "Physics Unified", Relativity should have followed Mach's lead and concluded that there should be no way to measure - optically or electromagnetically - the speed of rotation, or even detect the rotation of a body with respect to space. If, with General Relativity, Einstein had attempted to demonstrate that the fundamental laws of Physics ought to be the same in inertial and non-inertial, or revolving, frames of reference, why should inertial frames be unable to optically measure their translation, but non-inertial frames be able to measure their rotation? The question is all the more poignant as Newton's Law of Gravitation was easily deduced from Kepler's Laws of Planetarian Translation, but remained disconnected from planetarian rotation. Yet, the circular-Galilean or elliptico-Keplerian motion of the planets must be considered to be just as much a form of angular motion as planetary rotation is.

The only possible way for Einstein to explain this seeming contradiction between the presuppositions of SR and those of GR, would have been to assume that c is referred to the inertial axis of the earth for purposes of translation and thus permits detection of rotation with respect to the same non-revolving axis. But, as we shall shortly see, that is not the route he took. In fact, the route Einstein embarked upon was a tortuous one, utilizing elements that, strictly speaking, were outside of GR, to define Space as the domain of a 'gravitational aether'; only to end up in a geometric formalism of a Spacetime that serves as an empty container defined by an elastic tensegrity of intervals. But because Relativity, in its restricted form, had largely discarded the problem of rotation from consideration of the null effect of the MM-type experiments, it could appear to be consistent with both electromagnetic detectability of rotation and undetectability of translation, and thus appear to withstand not only this contradiction but also its ambivalence with regard to the detectability or undetectability of rotation!

The ensuing confusion amongst physicists was so deep, that the results of the MGP experiment could advantageously be seen to confirm Einstein's Relativity with respect to rotational motion, irrespective of the outcome of the experiment (!) - and just as well appeared to confirm the adequacy of Michelson's method to detect the rotary deflection predicted by aether theory. While Relativity was satisfied with the negative result with respect to translation, it was *nearly* indifferent to the results obtained with respect to rotation.

This ambiguous situation was reflected in the ranks of relativists. Those who believed that the positive result from the MGP experiment was significant, like Silberstein, would argue that all it proved was that "the earth rotates in its axis", precisely what Foucault's pendulum had demonstrated. Those who believed that the result was non-

significant, like A. Compton, would conclude that the earth's rotation had no effect on the speed of light and that the MGP experiment had definitely disproved the aether-drag hypothesis and confirmed Relativity. The latter view has today become the accepted one, and most discussions of the speed of light tests ignore the MGP experiment and feel justified in doing so. Jaffe, in his book, "Michelson and the speed of light", gives the matter one paragraph in which he does not even report the findings.

However, at the time, in 1925, the lines were not yet drawn in the sand, and the perplexed and ambivalent state of physicists and relativists alike was translated by the famous New York Times headline of January 9, 1925 - "Michelson Proves Einstein Theory - Ether-Drift is Confirmed - Rays found to travel at different speeds when sent in opposite directions"!!

The paradox could not have been greater.

For the problem is that, if GR is to uphold optical detectability of rotation, even arguing that the inertial frame of reference of rotary motion is the non-revolving axis of the earth which therefore precludes optical detectability of translation, it must accept the notion of an aether, albeit a non-stationary one. We have seen that Einstein was so inclined, and this likely explains what appears to be a contradiction between the predictions of SR and GR, as his own attempt at relativizing (Special) Relativity itself. Indeed, one could read into this aspect of GR the requirement that an aether must exist; an aether which is in a state of rotation around the planet and is nearly synchronous with the rotation of the latter, a concept akin to that of Stokes' aetherosphere but involving not a drag caused by translation, but an actual rotating aether envelope propelling the earth forward. Yet, for reasons altogether obscure, Einstein's thought after 1926 made a complete U-turn with respect to this problem, and he ended up by embracing the phenomenological postulates underlying the Special Theory (an effectively empty space occupied by a gravitational field that only in principle is independent from matter) as being the very foundations for a field unification which was, even in his own estimation, unsuccessful.

It is in this sense that A. Compton was ultimately correct - if the results of the MGP experiment are, or were, to be considered significant, they could never be seen as proving Einstein's theory. What was consistent with Mach's principle was the complete inability of an observer to detect either his rotation or his translation by optical reference to a fixed aether. Hence, for A. Compton, the MGP experiment presented a non-significant phase difference and therefore confirmed Relativity because there was no aether-drag that could or should be invoked. With the triumph of this view, a new set of rules had insidiously crept into the game. Relativity now required a null result in both the MM and the MGP experiments, and the door was closed on the matter of the aether.

> "The ratio of the masses of two bodies is defined in mechanics in two ways which differ from each other fundamentally; in the first place, as the reciprocal ratio of the accelerations which the same motive force imparts to them (inert mass), and in the second place, as the ratio of the forces which act upon them in the same gravitational field (gravitational mass). (...) It is only when there is numerical equality between the inert and gravitational mass that the acceleration is independent of the nature of the body."
>
> Einstein, A, "The meaning of relativity", 1955, p. 56

2. The Old and New theories of gravitation

In Newtonian physics we learned that all bodies, independently from their mass density or weight, fall towards the earth with the same acceleration. That is, if air were absent so that the Archimedes law of buoyancy could not apply, a feather and a ton of lead would fall with the same acceleration, free fall being proportional to the mass of each body. Newton's Second Law postulates that, if force is constant, acceleration decreases as the mass of a body increases; but, with respect to terrestrial gravity, a body twice the weight of another will have twice the force of gravity pulling it down. As weight and mass effects will cancel each other, gravitational acceleration will be the same or constant in all cases. Released from the same height, and in the absence of air, the feather and the ton of lead *should* reach the ground at the same time.

Newton formalized this relation in the law of gravitational attraction between the masses of two bodies:

$$F_g = G\,(M\,m_g)/d^2$$

where F_g = the gravitational force, G = a constant, M = mass of the earth, m_g = *gravitic* mass of the object in free fall towards the earth, d = distance from the center of the earth to the center of the object in free fall. As the force exerted on an object with *inertial* mass m_i is:

$$F = m_i\,a$$

or the product of *inertial* mass times acceleration, we obtain, *on the condition that gravitational and inertial masses be the same*, the following equation:

$$G\,(M^*m_g)/d^2 = m_i\,a$$

which resolves to-

$$G\,(M)/d^2 = a$$

In other words, the acceleration of an object under the action of a gravitational field is *independent of the mass* of the object. Having arrived at this conclusion, Newtonian mechanics does not explore it further. But Relativity holds that a gravitational force of attraction expressed by *downward* motion (free fall) is equivalent, for all bodies regardless of mass, to a comparable *upward* linear acceleration of any inertial frame (the elevator analogy) in a gravitational field. Both approaches - gravitational and inertial - to the phenomenon of the free fall of mass are equivalent.

This thought-experiment or, effectively, *this axiomatization, equates therefore gravitational motion with acceleration of inertial frames of reference*. The bottom line of GR's principle of equivalence is that an accelerating reference frame is equivalent to an inertial frame upon which a gravitational field has been imposed. Phenomenologically, GR proposes that there is no way to distinguish between the weight m that 'wants to remain behind' - due to inertia, when its frame of reference moves upward- and the weight m being pulled down because of its heaviness (gravitational mass). If the weight of a body is distinct from its mass, that is, if weight is but the effect of attraction of this mass by the earth (far from the earth, the body would still have mass but its weight would be negligible), then it is the mass that determines the weight of the body once a gravitational field is given. Since this defines gravitational or heavy mass, inert mass simply becomes the property of resistance to changes in motion. Heavier or volumetrically denser mass may have a stronger downward pull than lighter mass, yet at the same time the pull has to carry or displace a greater inert mass - hence the fall is not any faster. Because inert and heavy mass are the same, no distinction between accelerated motion and gravitation can be made in General Relativity.

The problematics raised by the Michelson-Morley experiment affects not only the restricted theory of Relativity, but also General Relativity, as it raises the whole question of the equivalence between revolving and inertial or translating frames. Moreover, if the MM experiment cannot be truly considered as a test of SR, the MGP experiment was intended specifically as a test of General Relativity.

The peculiarity of the inverse positions of Relativity vis-a-vis translation and rotation finds its roots in the fact that for restricted Relativity a negative result of the MM experiment was consistent with the notion that the earth's translatory motion through Space could not be detected; but it was inconsistent with Newtonian mechanics, specifically with Newton's Second Law and his Law of Gravitation. If objects attracted each other with a force that depended on the distance between them, and action-at-a-distance were true *nonlocality* of action, then the gravitational force could not be subject to the limitation imposed by the

speed of light, as enunciated by Special Relativity but now generalized to gravitational fields by GR. This of course raises the problem of the propagation of the gravitic interaction and its relationship with the propagation of electromagnetic disturbances. In this respect, GR also makes a set of assumptions, which can be dissected as follows:

1) The local equivalence of Gravity with acceleration of inertial coordinate systems is considered in the context of a curved extension of flat 4D pseudo-Euclidean Minkowski Spacetime to obtain a pseudo-Riemannian manifold described by a set of tensors that preserve the interval metric and the spatialization of Time.

2) Accordingly, just as the invariant c applies to the propagation of electromagnetic field disturbances for all inertial frames in uniform translation, so does it apply to the propagation of gravitational field disturbances. Hence GR predicts the existence of gravitational waves or field radiation propagating at speed c.

3) Point masses under no other influence but that of gravitation, follow 'time-like' geodesics, whereas light rays under the same conditions form 'null-geodesics' of Spacetime.

4) It is the deviation of particles from their 'time-like' geodesics which gives rise to inertial effects (a rehabilitation of the Newtonian notion that it is the deviation from straight line motion by an acceleration which produces inertial forces).

To this set of evident assumptions, GR couples a set of hidden or intrinsic assumptions, which bear closer scrutiny. The most important of these are -

1) The *axiomatic assumption that gravitational field energy can be treated*, not only as being ruled by the limit c as an invariant absolute velocity of propagation, but, far more fundamentally, *as reducible to the interval metric structure of Spacetime itself*. From an energeticist perspective, this is an essential metaphysical lapse - emptying gravitation of its energetic content and replacing it with the structure of a manifold which is susceptible to the criticism that it essentially confuses Time with Space. The whole theory also forsakes the Machian designs of 'true relationism', by becoming susceptible to the criticism that it confuses energy and its effects with an axiomatic Form of the continuum.

2) This betrayal of Machian hopes is made final by the fact that in GR the structure of the manifold is not determined exclusively by mass-energy distribution. The distribution of mass-energy in the universe contributes to the determination of the Spacetime metric structure, but the metric itself has axiomatic constraints of its own.

This relativistic somersault, still more fundamentally, raises the question of why classical Physics should have considered rotation as forming a 'forbidden' system of coordinates devoid of equivalence with inertial systems. SR established that the laws and concepts of physics are the same for all inertial frames, each inertial frame of reference describing any event with its own set of numbers (x, y, z, t). As there is no extra-special

frame, no absolute point of reference, all inertial frames in relative uniform motion must yield the same physical laws. So why should the laws of physics not apply to 'non-inertial' frames of reference, such as revolving frames or frames subject to acceleration and deceleration?

This question has a direct bearing upon the MGP experiment. For, an observer on a merry-go-round will not be allowed to deduce the equivalent laws of physics, since its frame of reference is 'non-inertial' and allows one to argue that Newton's first law does not apply, as in rotating bodies the direction of velocity is constantly changing. Yet, so argues GR, it is possible to describe the same laws of physics from the rotating observer's viewpoint, if one postulates that what is revolving is not the observer, but the rest of the world around him. This is what Mach was getting at with his principle of the relativity of motion.

Now, this was precisely the ostensive point of Einstein's assault on the matter with his proposal of a generalized Relativity - yet, paradoxically, what the theory ended up doing was to axiomatically establish the absolute character of rotation. With the stated objective that GR should demonstrate how the fundamental laws of physics ought to be the same in inertial and non-inertial frames of reference, whether the latter were revolving or under acceleration, Einstein, between 1908 and 1914, unsuccessfully attempted a treatment of gravitation that was compatible with the special theory. When the final of two such treatments emerged, in 1915, Einstein claimed that it had been achieved at the cost of positing a *new concept of the aether* - as he put it five years later in "Ether and Relativity" (2) - by retaining the speed of light as a cosmic invariant that also applied to gravitational fields. Hence, we find Einstein attacking the hollow and static aether concepts of physicists like Lenard, while invoking Mach to do so but, and at the same time, we find him going beyond or astray of Mach's positions as well: "the idea of the relativity of force if stated in the form given by Mach, can be used only in connection with rotary motion. Einstein had to extend the idea in such a manner as to make it applicable to *every* motion. He achieved his aim through the principle of equivalence" (3), at the cost of turning Mach on his head, and admitting to an absolute rotation of Spacetime.

As Einstein adapted it, Mach's principle became expressed in the fundamental GR notion of a curvature of Spacetime determined mechanically by the distribution of matter in the universe (one can no longer speak of distribution in Space proper either) and the kinetic energy of motion of the bodies populating that universe, and determined axiomatically by consideration of the intrinsic properties of the metric tensor. Einstein's concept of a curvature of Spacetime has been linked to FitzGerald's imprecise notion of gravity which postulated that gravity resulted from a change in the structure of the aether caused by the presence of matter (4). Yet, As Whittaker has indicated, FitzGerald was 'actually thinking' of

alterations in the dielectric constant and the magnetic permeability of the space surrounding the mass of a body, "by analogy with the fact that in a liquid whose dielectric constant varies from point to point, an electrified body moves from places of lower to places of higher dielectric constant" (5).

But Einstein's new theory of gravity in GR, as elaborated in 1913-1914 in two papers with the Swiss geometer M. Grossmann, replaces the Newtonian notion that gravity is a force operating on masses across empty and absolute Space, with the notion that gravity is a modification of the geometry of Spacetime. Einstein and Grossmann suggest that the translatory motion of a particle 'in the free aether' but 'in the absence of any field', would be described by

$$(ds)^2 = c^2(dt)^2-(dx)^2-(dy)^2-(dz)^2$$

thus proposing that the path of a body in free fall in a gravitational 'field' is a geodesic in 4D Spacetime, with a metric defined by the quadratic differential equation-

$$(ds)^2 = \sum_{p,q=0}^{3} g_{pq}\, dx^p\, dx^q$$

Here, the gravitational 'field' ceases to be the attribute of a single scalar potential-function to become specified instead, in tensor calculus, by the ten coefficients of g_{pq} (the 'gravitational potentials') which determine both the scale of length in every direction and the length-equivalent rate of clocks. *Einstein was in fact operating a reduction of gravitational theory to geometry, and precluding therefore any recourse to the notion of gravitational energy*.

It is indeed curious how the attempt at a General Theory by Einstein in 1915, which aimed at defining a *new concept of the aether*, ended up by treating the gravitational field as a mere question of geometry. Force, in the Newtonian sense, is no longer involved nor propagated; the body that falls or moves from one place to another only does so by the shortest route, the geodesic. The reduction of gravity to a metric of Spacetime effectively empties Space of energy and permits *exclusive identification of physical energy with the electromagnetic field*. In defining the "new physical characteristics" of the continuum, instead of realizing that Space devoid of electromagnetic energy is not Space devoid of energy, Einstein defined formally the force of gravity as a mere geometric property of the fabric of four-dimensional Spacetime, ignoring thereby any possible functional treatment of gravitational energy as such.

From our perspective, this was in all likelihood an inevitable and necessary mistake of GR. Despite Einstein's claim that "We therefore arrive at the result: the gravitational field influences and even determines the metrical laws of the space-time continuum." (6), the field remains conceptualizable only by the pseudo-Riemannian manifold, which, on its own, fails to analytically treat the difference in dimensionality between Space and Time, fails to differentiate between them as distinct manifolds, and fails to account for them as the intrinsic properties of energy in flux. To hold the field as determinant of the metric, when the metric is intervalar and the field a mere geometric extrapolation, effectively constitutes a method to empty both the field and the metric of energetic considerations. The problem harks back to the topological concept of a continuum as it was first enunciated by SR - it does not even satisfy full consideration of matter as electromagnetic energy in the 'energy tensor of matter', 'even if matter is to be regarded as the principal part of the electromagnetic field', because it limits itself to the principle of addition of flattened dimensions. And although one might still hold, as does GR, that the gravitational field transfers energy to that matter or, to paraphrase Einstein, gives it energy, nonetheless, this gravitational field, too, becomes defined by the same principles of Gaussian geometry. The problem, we think, lies right at the heart of the relativistic concept of the continuum. Einstein's impetus to develop GR, his proposal of a ZPE continuum, his drawing attention to de Broglie's wave-mechanics and his several attempts at a unified field theory (UFT) all betray his relentless search for continuous structures that would link the quantum discontinuities. In 1954, a year before his death, Einstein wrote to Besso -

"I consider it quite possible that physics cannot be based on the field concept, ie on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included and the rest of modern physics."

And in his last writing, the second Appendix to "The Meaning of Relativity", Einstein distanced himself from attempts at 'quantization' that reduce to a statistical theory of field probabilities, treating essentially non-linear phenomena by linear methods, even though he also acknowledged the possibility that quantization itself might yet disengage an algebraic theory which could preclude his complex tensor theory of a continuous field. Most institutional physicists today see this as a recognition, by Einstein, of the mere epiphenomenological reality of a continuum. Yet Einstein's admission of failure related quite specifically to a *field* theory of the continuum, not necessarily to any theory of the continuum.

It is not our objective in the present communication to provide alternative views to those of relativity. While we have misgivings concerning SR's approach to the problem of the manifold(s), specifically regarding the spatialization of Time as condition for its

geometric treatment, the proposed 'geometrism' also suffers from intrinsic or immanent difficulties. By the time that the problem is formulated as a mere matter of flat topology, and that alone, energy dynamics has been expurgated. The very demonstration of the equivalence of inertial and gravitational mass (what Einstein once called 'an astonishing fact') falls short of its objective, and manages to address what is solely a formal distinction, since it is the same mass that freely falls in a gravitational field and that resists changes in motion. Indeed, no real understanding of force, whether inertial or weighty, can be forthcoming unless one succeeds in treating the gravitational field as a continual exchange of graviton particles (be they quantic or subquantic). One could then grasp a physical sense to the dual reality of inert mass, seat of inertia and mass-energy, and gravitational mass, seat of the graviton energy as a necessary double of inertial mass. And one may then, at last, come to where W. Reich stood, when he enunciated the dimensional equivalence between mass and length, which the gravitational pendulum has long demonstrated but our understanding has failed to grasp. Indeed, an atom of mass-energy by gaining a graviton does not thereby gain twice its mass, but only affects to its mass a wavelength that defines the characteristic graviton unit associated with it in every gravitational field, and independently from local values of g. Alas, no topological treatment of an equivalence (m_i a = m_g g) that remains obscure, could replace an energetic approach that construed graviton energies from first principles and bench experiments. But this is a matter that we leave for another occasion.

"(...) The null geodesics are the tracks of rays of light. When Einstein created his new general theory of relativity, in which gravitation was taken into account, he carried over this principle by analogy, and asserted its truth for gravitational fields. (...) Strictly speaking there are no 'rays' of light - that is to say, electromagnetic disturbances which are filiform, or drawn out like a thread - except in the limit when the frequency of the light is infinitely great: in all other cases diffraction causes the 'ray' to spread out."

E. Whittaker, "A History of the theories of aether & electricity", Vol. II, p. 165

3. Generalized Relativity and the problem of rotation: the dragging of Spacetime

Why then should GR predict a positive result for the MGP experiment and not a null result, as for an MM-type experiment, when Mach's principle - which it *pretended to generalize* - was first enunciated for rotation rather than translation? Shouldn't GR reject the idea of measurability of absolute rotation or nonrotation, just as SR rejected the idea of measurability of absolute translation?

This problematics has direct bearing upon the conceptual and practical distinctions between the Michelson-Morley type experiments (including the later Miller experiments) and the Michelson-Gale-Pearson experiment. The MM result is negative, but precisely with respect to the problem of translation of the earth. Yet, *when the rotating reference frame ceases to be the frame of the apparatus itself*, as it is in the MM experiment and the Miller experiments, *and instead becomes the earth*, as in the MGP experiment, then it becomes possible to optically measure varying speeds for the propagation of light. Why?

The answer is tied in to some very obscure elements of Einstein's theory which deal with the precessionary behaviour of gyroscopes as a function of the curvature of Spacetime (the gravitational 'field') predicated upon the presence of mass. Two effects were proposed by Relativity to explain gyroscopic precession:

(1) the de Sitter geodetic effect involving deformation of parallel axes caused by the curvature of Spacetime, and

(2) the so-called 'relativistic dragging of inertial frames' which proposes that, in the neighborhood of a rotating body, Spacetime itself becomes 'dragged' along with the rotation.

H. Thirring in 1918 and 1922 suggested that Einstein's theory of gravitation or GR should be taken to indicate that the spontaneous orientation of gyroscopes and the phenomenon of atmospheric wind could be treated as if the earth were stationary (not rotating) and 'the distant stars' were moving around it at a speed high enough (>>c) to generate strong gravitational effects (fictional centrifugal and Coriolis forces). Clearly, this was thought of as an embodiment of Mach's principle, and it was applied even to systems of

moving coils in order to establish the principle of equivalence of magnetic and electric charges, ie moving and static charges. Yet, GR betrays this Machian principle of equivalence when it assumes that spinning the observer's laboratory or spinning the total mass of the universe around it are not exact physical equivalents because rotation of the laboratory frame is, strictly speaking, 'at the limit', non-inertial, and only the rotation of the Spacetime shell, the dragging of Spacetime caused by the rotation of the total smoothed out mass of the universe, is absolute.

According to the Newtonian theory of gravitation, the interior of a rotating shell of gravitational mass is free from gravitational forces, with the result that if a gyroscope could be placed within it, with its axis perpendicular to the axis of rotation of the shell, it would not precess as it would be free from the effect of gravitational forces. Now, with GR, we obtain the same result, unless, and only unless, the notion of a dragging of the inertial frame is introduced. This now permits the prediction that a gyroscope enclosed within that rotating shell of mass will, in fact, precess in the same direction as the rotation of the shell. If we exclude the 'relativistic dragging of inertial frames', the generalization of Relativity would have demanded precisely that no fringe shift should be observed due to the rotation of the earth, because any and every motion has no preferred frame of reference located in space. Furthermore, GR holds that the gravitational field, being directed toward the outside of the shell, only affects rigid rods and clocks external to it, in its surrounding Spacetime. If we abstract from the dragging of inertial frames, then it would be correct to argue, as has many a 'true' Machian disciple of Relativity, that it should not matter whether we hold that the universe (the distant stars) is nonrotating and the earth is rotating, or that the earth is nonrotating and the universe is rotating.

Assuming that the earth's inertial frame coincides with its axis of rotation, Thirring predicted that an inertial frame at the earth's north pole would appear to be rotating with respect to the distant stars because rotation of these stars induced a dragging effect by deformation of Spacetime vicinal to the earth. In sum, GR should propose that a body, such as the earth, actually 'rotates' (though only in a relative sense) because the Space-Time around it is dragged along by a small degree that relates to the mass-density of the body but is induced by the rotation of the shell of the universe (the absolute rotation of the smoothed out total mass of the universe). This implies that the axis of rotation of the earth is 'dragged along' by the rotation of the planet and therefore itself rotates (even if very slowly) with respect to the distant stars. Relativistic dragging of Space-Time, now known as the Lense-Thirring effect, was next highlighted in 1923 by Eddington, who suggested that it formed a verifiable prediction that proved the relativity of rotation, and this in turn inspired Silberstein's proposal with regard to Relativity's requirement of a positive fringe shift in the

MGP experiment. This was a curious situation indeed, for classical aether theory had never once bothered to address the problem of rotation and its effect upon optical propagation, leaving behind an unoccupied problem that GR now made its own. This classical omission had even been the basis of Joos' attack (7) on the believers of aether drag theory, to the effect that they had overlooked rotation in their argument for a 'partial aether drag', which they saw as caused exclusively by translation with respect to absolute Space.

Since this relativistic dragging of inertial frames, which is deemed to be an effect even smaller (!) than the geodetic effect, was not taken seriously by institutional physicists until Dicke's theory in the mid-1960s reformulated it, the MGP experiment and its results effectively lost all interest, even for GR. It was as if, once the relativistic orthodoxy was formed, relativists had become embarrassed to admit that Einstein was now calling for a 'gravitational aether' in the form of a drag effect (!) clearly borrowed from aether-drag theory but this time applied in a relativistic fashion to 'the Spacetime' of rotation. Unproven until this day, the relativistic notion of the dragging of revolving frames as an explanation for gyroscopic precession appears to stretch the Machian logic of Relativity beyond believability.

If the postulate of the 'dragging of inertial frames' alone "guarantees that rotation must be defined relative to distant matter, not relative to some absolute space" (8), then, despite all the noise to the contrary, what GR, or more properly, its extension, is proposing is simply tantamount to the assertion that there is absolute rotation. Clearly, Mach's principle is denied, once we claim that we can actually detect rotation because the axis of the inertial frame is rotating relative to the distant stars. Moreover, if the dragging is invoked with respect to the motion of the revolving frames - and one can see little reason why it should not be equally applied to inertial frames in translation, given that the planetarian ellipses of translation around the sun are equally "explained" by the distortion of the geodesics caused by the mass of the sun - then Relativity should be predicting a phenomenologically stationary and deformable aether, not precluding it. The same criticism that Joos addressed to the partisans of aether drag theory, could be addressed to the partisans of Relativity - though in reverse: why should *rotation be measurable* because of a Spacetime drag of inertial frames (eg the gyroscope's axis) in rotation, and *translation remain unmeasurable* and unable to elicit the dragging of its own inertial frame, when translation is also a gravitational motion and there must be equivalence 'in principle' between inertial and non-inertial frames?

This positioning of GR with regard to the problems of gravitation and rotation strike at the heart of an old conflict in astrophysics and cosmology. The Ptolemaic conception of the world placed the earth at its center and the sun, planets and other stars in orbits around the resting earth. But Copernicus with his circles and Kepler with his ellipses showed that the earth revolved around the sun, which now appeared stationary. With respect to the

question of rotation, Whittaker has sternly indicated that it is a mistake to regard the Einsteinian GR theory as indicating that the 'Ptolemaic' conception, which says that the stellar universe performs one revolution around the earth in the period of a day, is any more valid or invalid than the 'Copernican-Keplerian conception', which says that the earth rotates on its axis orthogonal to the equatorial plane, because GR would hold that only the Copernican-Keplerian axes of the planets are inertial, while the Ptolemaic axes are not. It is only with respect to inertial axes that GR permits the description of the earth as rotating, with the result that c is only invariant with reference to inertial frames. Hence, "there is no difficulty in the fact that the fixed stars have velocities *greater* than c with respect to axes fixed in the rotating earth, for such axes are not inertial" (9). They are not considered to be inertial by GR, and c is not to be measured with respect to them...

When we read the words the apologists of GR write today on this matter we may well get so helplessly confused as to conclude that if we do not understand Relativity, then it must be a very profound theory. For it claims subreptitiously that there are relative and absolute rotations, absolute rotations (of the ensemble of distant stars and the Spacetime envelope) which are relative to the inertial effects of frames in translation - and, at the same time, appears to claim that all motion is relative, and none is absolute, including rotation or non-rotation! Witness Clifford Will, great panegyrist of GR-

"If you ask yourself, "Am I rotating?", and you wish an answer with more accuracy than you can get simply by seeing if you are getting dizzy, you usually turn to a gyroscope, for the axis of a gyroscope is assumed to be non-rotating relative to inertial space. (...) If your laboratory happened to be situated outside a rotating body, the gyroscopes would rotate relative to the distant stars because of the dragging effect (...). Therefore, your laboratory can be non-rotating relative to gyroscopes, yet rotate relative to the stars. In this way, general relativity rejects the idea of absolute rotation or absolute non-rotation, just as special relativity rejected the idea of an absolute state of rest. (...) The existence of the dragging of inertial frames then guarantees that rotation must be defined relative to distant matter, not relative to some absolute space. This is what makes the detection of this effect so vital [for Relativity]." (10)

Relativist loops are a conundrum. First you are told that SR rejects the idea of an absolute state of rest, yet, by the same token, there is an inertial frame for every body in motion (relative to other bodies...) with respect to which that body is always and *absolutely* at rest!! But then, when relativists apply this principle to a terrestrial laboratory, they act as if they forgot that any and every terrestrial laboratory is not at rest with respect to the earth's inertial axis, nor, therefore, with respect to the inertial frame of translation, but revolving around it, in a frame of rotation superimposed over the translatory motion.

How then can one pretend that a gyroscope axis is non-rotating relative to inertial Space? And what is the rotation of distant matter, but a euphemism for the rotation of an absolute Spacetime, the stand-in for Spacetime? To begin with, a qualifier is required to define which inertial Space, such as *the earth's* 'inertial Space', otherwise our relativist soon sounds like a XIXth century defender of the most static of aethers. Moreover, only if the gyroscope were rotating in 'free Space' (away from any revolving body), could one pretend that its axis was non-revolving with respect to its own inertial Space, for there would be no other nearby inertial Space to refer it to. But next comes the obvious problem: a gyroscope, on or near the earth, whose axis is parallel to the earth's axis of rotation, *is still rotating with respect to that axis* and rotating, just as well, with respect to the earth's inertial axis of translation, which axis in fact does not coincide with the earth's equatorial axis of rotation.

The relativist appears to be all balled up, only to conclude that the same laboratory can be non-rotating relative to the gyroscopes, yet rotate relative to the stars! Yet if the gyroscope rotates and preserves its attitude, it obviously does so relative to the local revolving frame of the laboratory, which evidently, and despite all attempts of GR to confuse the issue, is not revolving around the rotating gyroscope, but revolving around the earth's axis, and so is the gyroscope whose axis is 'at rest in' the laboratory revolving frame!

Relativistic metaphysics was born this way - in the Hegelian fashion of rehabilitating the old under new clothes. Little wonder that in his 1920 criticism of GR, Whitehead claimed that it had made *rotation*, and specifically, the earth's rotation, *into a mystery* by introducing the notion of a curvature of Space-Time [(11)]. (We wonder however whether the paradoxes of rotation have not legitimately arisen well before Relativity.) If we should assume that a gyroscope within a gravitational mass shell would still precess in the direction of the earth's rotation, surely the gyroscope would rotate around the earth's equatorial axis, remaining therefore well within the gravitational field of the rotating shell.

This is the physical hiatus regarding rotation. For it implies that inertial motion may or may not be equivalent to the motion caused by the gravitational 'force' or the 'field'. In other words, not every translation, said to be an inertial displacement, is equivalent to every other translation. When SR departs from the assumption of the equivalence of all inertial frames of translation, it jumps from (1) the situation between a stationary observer on the revolving frame of the earth and a passing train which moves relative to that revolving frame *and* to the observer; to (2) the situation of the translation of the planets around the sun. But right here there is a vitiation of the first postulate, a vitiation which is further occluded by GR, for the motion of the train is inertial but subject to the gravitational field of the revolving frame (ie subject to the gravitational 'field' of the earth), whereas the motion of the earth 'around the sun' is not simply inertial, but above all a gravitational motion whereby the

earth deploys its own gravitational 'field' in the context of that deployed by the sun and the other planets, in the form of a superimposition of 'field' energies. Furthermore, the translatory frame, though appearing to have uniform speed, is in fact undergoing periodic accelerations and decelerations. The problem at hand is of the same order that led us to state that no aether drift is 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 move.* Einstein might say what he says, but if the train accelerates and decelerates, it is only the coffee in the cups aboard it that will spill over and splash, not the coffee in the cups held by the onlookers. Surely, it is the inertial motion of the train that gives rise to those effects, when superimposed over the gravitational field of the earth. It therefore cannot be accurate to regard a description of the way in which the train moves on earth as if it was equivalent to a description of the earth moving inertially under the train. The train (or the moving elevator, for that matter) does not deploy its own gravitational field, only inertial mass *within* the gravitational 'field' of the earth. The train alone moves inertially with respect to the earth, not the earth with respect to the train. Hence, the train remains subject to the law of free fall when it must exert energy both to climb uphill and to brake going down. And if a bridge fails, the train will crash onto the earth. Not so with the earth, which is not subject to free fall into the sun, or into the train, for that matter, and whose 'inertial motion' is not supported by bridges or rails. The translation of the train on the earth does not involve rotation of the train on any of its axes; that of the earth around the sun does, and its axis of rotation is not the same as its axis of inertia or, for that matter, as the axis of its translatory motion. In other words, the equivalence of inertial frames sought by SR already abstracts from the fact that the inertial frames it considers are all subject to the same gravitational frame, and are therefore not equivalent to inertial frames that define their own gravitational frame by virtue, precisely, of their rotation, or something powering their rotation. It fails therefore to grasp the physical process that generates gravitational fields associated with the motion of inertial frames.

To deny the reality of the aether would be, to use Einstein's own words as they appeared in his analysis of General Relativity, to assume that Space empty of matter has no physical qualities. According to GR, Space always has physical characteristics, therefore an aether must exist, though this aether is no longer stationary, as it was for the luminiferous theory, for the corpuscular theory or for Maxwell and Lorentz: "this conception of the ether to which we are led by Mach's way of thinking differs essentially from the ether as conceived by Newton, by Fresnel, and by Lorentz. Mach's ether not only *conditions* the behaviour of inert masses, but it is *also conditioned* in its state by them" (12). With GR, "the conception

of the ether has again acquired an intelligible content, although this content differs widely from that of the ether of the mechanical undulatory theory of light" (13).

So wrote Einstein, yet Mach never once, for a moment, entertained the notion that there was an aether, or some other form of aether! Nor, for that matter, did General Relativity *per se* entertain such a notion. Einstein had in fact reserved this problem for his Hermitian theory of the unified field. Hence the speculations entitled "Sidelights on Relativity".

What Einstein did not make clear in those sidelights was that he was naming as physical, properties which were strictly determined as geometrico-mathematical axioms simply assumed for the sake of logico-mathematical consistency, but which resulted in undecidability on the part of the theory towards its physical objects of study. In Einstein's understanding at the time, the aether of GR, unlike Lorentz's aether, was only partially determined by its connections with matter and the state of the aether in neighbouring places. This permitted him to argue that the nature of the aether of GR is neither electromagnetic nor mechanical: "the aether of the general theory of relativity is a medium which is itself devoid of *all* mechanical and kinematical qualities, but helps to determine mechanical (and electromagnetic) events" (14). As we can easily conceive of Space devoid of an electromagnetic field but not one devoid of a gravitational field, the former has a secondary connection to the aether (15), whereas the relation of the gravitational field to the aether is a foundational one. However, this relation is far from being conceived as a physical foundation per se, an energetic function; it is in fact taken as an axiomatic relation, a logico-mathematical foundation that poses a geometric constraint. Hence, one cannot be deluded by Einstein's suggestion that, as matter is but varied condensations of the electromagnetic field, the relations between the "gravitational aether" (the expression is Einstein's) and the electromagnetic field are the very relations between *Space and matter*.

It is here, at last, that we can see the basis of the confusion which condemns Einstein's "gravitational aether", it too, to abominable failure. Einstein is keenly aware that Maxwell's notion of a non-mechanical *electromagnetic* field pervading Space empty of matter is not tenable, precisely to the extent that this field is *secondary* to a 'primary field', the gravitational 'field'. If matter is but condensation of the electromagnetic field, it also becomes obvious that matter cannot explain the gravitational 'field', as the latter is supposed to exist already in the absence of the electromagnetic field. Something other than matter must define the gravitational field in a universe empty of mass, but this something - in Einstein's eyes - will turn out to be not energy, but the metric of a pure, but fuzzy, form, a topological continuum.

Having arrived at that conjuncture, Einstein would either have to predict that there was another form of energy, *gravitational energy*, whose detection should be made possible by kinetic and (primary) electric effects in Space *empty of matter*, or he would have to retrench by reducing this 'gravitational aether' to a mere geometric form of Spacetime partially determined by the distribution of matter. This is what led to the notion that there must be, in space, *gravitational waves* moving at speed c, as these waves must ostensibly arise from local readjustments of the Space-Time curvature when the motion of massive bodies warps the undisturbed continuum.

Why it was not similarly assumed that the continuum itself is in motion, becoming distorted when meeting stationary objects, remains undisclosed to this day... For the fact of the matter is that it is equally limited to hold that the stars rotate but not the earth, or vice versa, that the earth rotates but not the stars, or even that both are true propositions because their mathematical descriptions are equivalent and the physical effects either gives rise to are interchangeable. For the simple reason that it is invalid to suppose that, at any time, the earth or the stars are fixed or non-rotating. Special Relativity introduced this artificial suspension of thought by restricting itself to the problems of inertia and translation and ignoring gravity and rotation; but why should we generalize a physical relationship when this demands that we assume an obvious error - that either the earth is non-revolving or the stars are fixed - in order to arrive at an equivalence between two equally erroneous points of view? The correct premise should have been to assume the obvious: that both have peculiar rotary and translatory motional components.

This is the story of how the 4-D topological model of a supposed gravitational aether, devoid of physical properties and divorced from any energetic conception, came to be accepted and identified with pure empty Space, the Void, defined exclusively by the negative, by the absence of matter. What then are the physical properties of this 'empty Space aether'? That it has curvature, even in its small t time or lack thereof?

These are the facts and considerations that will lead any mind which is still open to examine the problem of the aether and Relativity, to become suspicious of Einstein's utterances about *an aether compatible with* Relativity. The problem is that the 'aether' that Einstein increasingly appeared to have in mind, rather than becoming, as promised, a 'non-material, non-mechanical and gravitational aether', became instead a pure *metaphysical fiction*; a disembodied physical reality endowed solely with a mathematical existence. Instead of discovering a dynamic aether comprised of non-mechanical and electrogravitic properties, Relativity ended up with a pure geometric form set in an imaginary four-dimensional Spacetime. And this fiction succeeded in the minds of physicists because it became metaphysically endowed with *mechanical* properties, courtesy of the dictatorship of the

absolute speed of light. Hence, the curvature of space remains a function of matter, and when the matter required to explain this curvature is found to be 'missing', recourse is taken to the expedient explanation that it is missing no longer but has miraculously been 'born-again' as black or invisible (ie undetectable) mass... It is here that Relativity ceased being a scientific theory, to become an academic doctrine bandied about with the same arbitrariness as any other religious vision of the world. A platonic metaphysics of the form.

It is physical nonsense to speak of a pure Space devoid of matter *and* energy. Such a pure Space is not an aether, but a meta-aether, a metaphysical aether, like the Ur-Aether of Lenard. And whether we call it the void of Spacetime and write it in four dimensions, or call it meta-aether and retain Euclidean Space as pure container, it remains a metaphysical abstraction. From a strict physical viewpoint, only an energeticist position can make sense. While Space and Time may be considered to exist outside the function of matter, independently from it, *they cannot be conceived outside the function of energy*. To suppose otherwise implies *tout court* that Space and Time cannot be physical concepts, nor actual functions, and are *ipso facto* condemned to become mere apparitions of physical reality, mere mathematical and geometric fantasies with no practical value other than the political importance that social formations arbitrarily decide to lend them. Obviously this means that the current *imperium* of relativistic truth has been selected by social and political criteria that are entirely foreign to science itself, as *sciens*, as knowledge that is factual cognition.

"The great attraction of the theory is its logical consistency. If any deduction from it should prove untenable, it must be given up. A modification of it seems impossible without destruction of the whole."

Einstein, "Out of my later years", p. 58.

4. The 1913 Sagnac attack on Relativity

4.1. A perspective on the Sagnac experiment

The notion of a stationary aether, in all of its variations, ruled over XIXth century Physics. This was not simply and merely due to the domination of the undulatory wave theory of light. In one fundamental respect, adherents of both the corpuscular theory and the undulatory theory agreed - that motion had an absolute frame of reference in the stationary structure of space. The question of whether this absolute space was empty but populated by corpuscles, or whether it was gel-like and crisscrossed with undulations, was the core of ongoing dispute.

Few realize today that what began undermining this dispute and its very foundation was not really Relativity, or the MM experiment, but Faraday's research and Maxwell's electromagnetic field theory. These influences could actually be considered to have provided the first openings in classical physics for an energetic perspective - keeping in mind that in Newton's time the very concept of energy was not known. With the work of Maxwell, we have for the first time a comprehensive answer to the connection between electric, magnetic and optical phenomena, where the speed of light already plays the role of an invariant for the propagation of the field pattern; hence, the notion of radiative flux as electromagnetic field energy. But this first unification of Physics, which one can denote as the classical electromagnetic theory, also contributed another element, far more corrosive of the classical luminiferous aether theory - the notion that the energy filling up space was distributed in the *non-mechanical* form of a continuous and non-material field. The filiform wave definition of the propagation of electromagnetic disturbances involved only continuous radiation fields and required the symmetric orthogonal disposition of magnetic and electric fields, both perpendicular to the direction of propagation. The very notion of high-frequency displacement currents responsible for electromagnetic induction, in Maxwell's theory, required the concept of a medium for their field propagation.

Maxwell however had failed to foresee the fundamental developments that would decode classical Physics at the beginning of the XXth century: specifically, the introduction of discontinuity into the theory of electromagnetic radiation, and the rise of Special Relativity, predicated on the null result of the MM experiment - now taken to indicate that

there was no stationary medium filling up Space, nor any reference to absolutely inertial Space. However, if the former development was largely an experimental one which threatened the entirety of the classical edifice, the latter development was essentially a theoretical one which suffered from tremendous limitations. Two of these limitations have been highlighted in the accompanying paper: the artificial delimitation of SR to the problem of the electromagnetic detectability of translation, and its corollary of a complete inability to address the question of rotation; and the negation of a mechanical, stationary substance of Space with its corollary of the invariance of c for all inertial or Copernican frames. In other words, SR had left open the questions of rotation, gravitation and the possible existence of a dynamic aether. But it had also precluded the notion of this dynamic aether being equivalent to Maxwell's non-material electromagnetic field.

To deal with the limitations of SR, Einstein enunciated the framework of GR - in an attempt to provide a relativistic treatment of gravitational 'forces' as equivalent to the centrifugal forces developed by stable rotation. The linked problems of a 'gravitational aether', gravitational waves and the dragging of inertial frames by the curvature of Spacetime, were only addressed later - by Einstein and others - mainly in the wake of the end of WWI, and it led directly to Silberstein's proposal to test SR by Miller's repetition of the MM experiment at altitude to detect the earth's translation, and test GR with the MGP experiment to detect the earth's rotation. At that time, Relativity appeared to have successfully occupied the domain of rotation apparently abandoned by the defenders of the old aether theory. Subsequently however, as we have also examined, the ambiguity of the MGP results led to an effective abandonment of interest, both theoretical and applied, in the subject of rotation and the adequacy of GR to explain it. This situation has prolonged itself to this day, assuming very curious forms of scientific repression. When difficult questions, such as those posed by the MGP or the Sagnac experiments arise, they are simply swept under the rug with *the ready-made excuse that the topic falls outside of SR and is not, therefore, within the MM rubric*. This is indeed the reason resorted to by all those who fail to mention the Sagnac experiment in the context of a discussion of the MM experiment.

These omissive procedures of institutional science are an integral feature of the constitution of modern Physics, as it operates veritable molar lines of thought and financing in its investigations, leaving its own operational paradigms riddled with holes that have a long term impact. A case in point is the Sagnac effect, which was first reported by Sagnac in 1913 and was utterly discarded, ignored and ridiculed until 1932, when it came to be utilized, under the impetus of WW II, in military navigational systems. To this day, the Sagnac effect has remained largely unknown to most physicists, and is almost completely absent from the discussion of the problematics of the aether and Relativity. Yet, a few hard-

core defenders of the theory of the stationary aether, some because of religious motives, others for good experimental or theoretical reasons, have taken shelter in the Sagnac effect and have launched, from there, their own missiles against official Relativity. Why? Because the Sagnac experiment was and is one of those gaping holes in the paradigms of SR - and, by extension, of GR. The actual experiment was described in two consecutive papers published on the eve of WW I, two years before Einstein would address the question of rotation in GR, and it directly faulted SR for having been unable to address rotation. Specifically, Sagnac's discussion focused on how the rotary motion of a body may be optically detected, and how the experimental values appear to confirm the Newtonian addition of speeds and not the relativistic addition.

4.2 The 1913 Sagnac experiment

The omission of Sagnac's experiment in the context of GR is all the more glaring as Sagnac was the first self-styled 'luminiferous aether' theorist to have occupied the terrain of rotation, effectively voiding Silberstein's notion that, on the matter of rotation, the stationary aether theory had nothing to offer and thus should not expect rotation to be detected. In fact, Sagnac addressed the question of rotation before Einstein did. Keeping this in mind, let us examine briefly the Sagnac experiment [(16)]. The apparatus employed by Sagnac is, like the interferometer of the MM experiment, a rotating one. However, Sagnac's device has a number of critical differences, beginning with the fact that it is the entire self-contained apparatus which rotates with angular velocity ω. Light source, collimator, beam-splitter, light pencils and mirrors, were all mounted on a spinning disc with a 1m radius and rotating about once per second. Essentially, a monochromatic light beam is split, with the transmitted beam propagating in an anticlockwise direction around the polygonal mirror course, and the reflected beam propagating clockwise through the same circuit. The two beams are then recombined and focused on a photographic plate, permitting measurement of fringe shifts with little possibility of error.

Sagnac obtained his control interference fringes with the apparatus stationary and observed that, once the apparatus was set in motion, the fringes shifted, thus indicating that the speed of the two light signals through the circuit was not the same. When the turntable was rotated in one direction or its opposite, the fringe shift moved to opposite sides of the stationary fringe. Sagnac gave the difference in the number of wavelengths of the two paths as-

$$\delta = 4A\,\omega\upsilon/c^2 = (L/\lambda_1) + (L/\lambda_2)$$

where $A=\pi r^2$ is the circular area of the path traveled by the light, ω is angular velocity of the turntable, υ the electromagnetic frequency (c/λ), and $L = 2\pi r$, the circular path traveled by light for a single rotation of the disc. This is known as the closed-loop Sagnac effect. A full fringe shift required a rotational speed of 13 m/sec; and Sagnac reported a shift of 0.07, corresponding to 0.91 m/sec. Relative to the rotating interferometer, the propagation of light was observed to vary by an amount which depended upon whether the beam was traveling in the same direction as that of rotation, resulting in retardation, or counter to it, resulting in an advancement. Here was positive evidence that "the observed interference effect is certainly due to the rotational optical effect of the movement of the system with respect to the aether" (16). If the speed of light propagation for each arm of the circuit were the same and no fringe shift had resulted, one would have had to reach the same conclusion that SR came to regarding the MM experiment. But the observed shift indicated that the speed was c+v on one arm and c-v on the other, where $v= \omega r$ is the tangential speed of the rotating interferometer relative to the laboratory frame. It follows therefore that-

$$\delta = 4A\, \omega\upsilon/c^2 = (2L/\lambda)\ (v/c)$$

and

$$\lambda_1 = \lambda/(1-v/c)$$

$$\lambda_2 = \lambda/(1+v/c)$$

Two months after publication of the first paper, Sagnac would conclude his second and final paper on the matter with these words-

"The result of this methodology demonstrates that, in the surrounding space [of the apparatus], light is propagated with a velocity V_o which is independent of the movement of the parts of the system, light source (...) and the optical circuit" (17). This is the central theme of Sagnac: that the propagation of light appears to be independent of the state of rotation of his self-contained apparatus, exactly because one can differentially measure its advance or retardation as a function of the speed of rotation of the apparatus.

What is the consequence of the Sagnac experiment for the MGP experiment? To begin with, Sagnac's apparatus was rotating (with the control fringe pattern being obtained first with the apparatus 'at rest'), whereas the MGP setup was a stationary one. This fact is intimately linked to the nature of the measurements in question: the Sagnac experiment detects the rotation of the revolving interferometer (relative to the 'rest state'), whereas the

MGP experiment, with its interferometer fixed to the local revolving frame, detected the rotation of the earth. Because of the resolution limits, the Sagnac experiment could never have hoped to detect the rotation of the earth, anymore than the MM experiment could have detected the rotation of its own apparatus [(18)]. What the Sagnac experiment did, however, unequivocally demonstrate was that there was a precedent for the optical detection of rotary motion. But relativists, including Einstein, largely discarded this fact for nearly three decades. An open-loop Sagnac effect ($\delta t = 2A\,\omega/c^2$) is today well established for the paths of electromagnetic signals around the planet: employing the GPS satellite relay system, delays have been measured by clocks on the order of fractions of microseconds in the W-E transmission with respect to the E-W transmission[(19)].

4.3 The Sagnac legacy: dispute with General Relativity

Up until 1932, when Joos finally enunciated the Relativistic postulates regarding rotation and translation, the Sagnac experiment was deliberately ignored by physicists, save for a few adherents of the stationary aether theory. All the relativists who pondered over it dismissed the experiment by invoking the possibilities of systematic errors. Joos, who pointed out the error of these relativists, suggested that the Sagnac effect belonged to the same order of experiments as the MGP, to be treated by the complex solutions of GR. Whittaker, in his "History of the theories of aether and electricity", only mentions Sagnac once in a footnote. In fact, Sagnac's work is a conspicuous absence within physical theory. But maybe this is not so astonishing, as the experiment affords a measure of altered speeds of propagation which take no recourse to relativistic formulas.

No relativist today would dream of disputing the findings of the Sagnac experiment. Most transoceanic planes, nuclear submarines and communications satellites navigate today with laser ring gyroscopes that utilize the Sagnac effect for position location. The accuracy of the original Sagnac experiment has been estimated at 1:100, but a repetition of the Sagnac experiment with lasers, in 1963, by Macek and Davis, confirmed the result to $1{:}10^{12}$ [(20)].

Curiously, many relativists and experimentalists get caught in their ignorance of the Sagnac effect. In 1979, Brillet and Hall [(21)] reported a null result (absence of frequency shift) with frequency-locked laser beams, one set in a rotating interferometer, and the other kept stationary, and thus concluded in favour of the isotropy of space. However, not only did they observe a 50 Hz signal at precisely the rotation rate of the turntable employed, but also another more troublesome signal, at 17Hz. Aspden, who has suggested that the null result may well be the inevitable consequence of such frequency-locked laser tests because "the frequency of the lasers will adjust to the reorientation of the apparatus exactly to cancel any effect due to motion through the light-reference frame" [(22)], commented on the 17Hz

frequency shift findings of Brillet and Hall, which had been ignored by them as a "persistent spurious signal":

"Interpreting the 17 Hz signal as the second harmonic of table rotation found by Brillet and Hall in relation to the laser frequency $8.85*10^{13}$ Hz, we find the ratio $1.92*10^{-13}$ and, as this is 0.131 $(\upsilon/c)^2$, we find that υ/c is $1.21*10^{-6}$, giving v as 363 m/sec. If our theory is correct then, within the errors of measurement, this should be the west-east speed of earth rotation at Boulder, Colorado. Being at 40°N, Boulder has, in fact, an earth rotation speed of 355 m/sec." [(23)] Apparently, Brillet and Hall were conducting a control on the MGP experiment using the Sagnac effect to detect the earth's speed of rotation and with the required resolution, without knowing it!

More recently still, there have been confirmations of the Sagnac effect for electrons and neutrons. In 1993, Hasselbach and Nicklaus [(24)] reported a shift of 0.06 fringes using rotating electron beams. The result clearly indicates that atmospheric charges flow faster westward than in the opposite direction. Werner et al [(25)] confirmed the Sagnac effect with neutron interferometry. With a swiveling apparatus, they showed that if the interferometer rotated in a N-S plane the effect was extinguished, whereas in a W-E plane it was at a maximum. Hence, the propagation of neutrons, apparently unaffected by magnetic and electric fields, is, like the propagation of light, affected by the west to east rotation of the earth. Propagation of electromagnetic signals and neutrons is only invariant with respect to the inertial frame of the earth's translation, not with respect to the earth's revolving frame. Rauch [(26)] confirmed the neutron results and suggested a dual explanation for his experiments with a revolving interferometer rotating about an horizontal axis. He invoked both GR's model of differential gravitational potentials arising for the two beams, and the Sagnac effect for the "phase shift between two paths oriented in opposite directions about the earth's axis of rotation", giving time-dilation a wide berth.

A confirmation of the MGP experiment has been recently carried out by Bilger et al employing a ring He-Ne laser apparatus fixed to the surface of the earth [(27)]. They demonstrated that the measurements obtained by the MGP experiment are due to the West-to-East direction of the rotary motion of the earth. The tests were conducted at 43°29' S latitude, in New Zealand, and the observed fringe shift was opposite in direction to that of tests carried out in the Northern hemisphere (in the Southern Hemisphere, clockwise rotation causes retardation when viewed from the South Pole, just as counterclockwise rotation causes retardation when viewed from the North Pole). With a resolution of $1:10^{20}$, the Bilger et al result confirmed that electromagnetic signals propagate slower eastward than westward.

Many anti-relativists claim that neither SR nor GR can explain the Sagnac effect. But more to the point is the fact that the effect, concerning the motion of a non-inertial frame, does fall within the scope of GR, but that GR cannot adequately account for it. In fact, the results predicted from GR only account for an infinitesimal portion of the experimental results. Two relativistic effects are invoked by GR to explain the detectability of rotation of photons, electrons and neutrons, from a de Broglie/Bohm perspective. They are: 1) the variation in the gravitational potential of the beams subject to rotation, due to the West-to-East rotation of the earth, and 2) the Sagnac effect, which is interpreted as a function of time dilation, and is assumed to be greater for a particle traveling against the rotation of the disc than for one traveling in the same direction; the result being that the particle in question will have traveled a greater distance in the same time interval (the direction of the observed shift being opposite to the direction of rotation of the platform).

Aspden once addressed the problem inherent to SR's first postulate as being due to a fundamental ambiguity in the determination of inertial frames:

"The problem is that our measurements require this inertial reference frame to be, in some cases, a frame located by the centre of the earth and, in other cases in which the test apparatus is rotating, a frame referenced by the structure of the apparatus itself. The consequences of this are very perplexing and the Theory of Relativity does not provide an adequate answer because it gives no basis for distinguishing the inertial frame to be used when applying the Principle of Relativity. (...) It is one thing to look to distant stars as mediating between matter on earth to help account for inertial properties in a way linked with gravitation. It is quite another matter to expect distant stars to affect the speed of propagation of light between two points on the earth's surface, especially if this speed changes with latitude." (28)

Relativists would certainly object that the invariance of c only applies to relative speed measured with respect to frames in uniform translation and hence, that it can vary with respect to revolving frames, as permitted by GR. But the problem is further highlighted by the Sagnac effect which demonstrates that the propagation of two countermoving light disturbances can be retarded or advanced *by the direction of rotation of an apparatus, as seen from the apparatus' viewpoint*, as well as from the viewpoint of the observer who is stationary in the laboratory; or, for a fixed interferometer, *by the direction of rotation of the earth*. The question therefore is really no longer whether the interferometer is fixed or rotating - given that, as Aspden argues, even a rotating interferometer can measure electromagnetically *not only its own rotation but also that of the revolving frame with respect to which its rotation axis is at rest*, and he has effectively confirmed this contention with his interpretation of the Brillet

and Hall results by demonstrating that they did detect the rotational motion of the local earth surface revolving frame, even if unbeknownst to them.

Recently, A. G. Kelly has claimed novelty for a "new theory of light", as he titled his proposal, succinctly described in these terms -

"Light generated upon the earth, travels with the earth on its orbit around the sun, but does not adapt to the spin of the earth upon its axis. Light is in a frame of reference with its origin at the centre of the Earth. That centre travels on its orbit around the sun, but does not spin with the earth." (18) This is an obvious proposal which, for the sake of preserving the irrational mystique of higher relativistic mathematics, has long been ignored. However, it is not new. It essentially follows Sagnac's model, and other similar proposals have been suggested - most notably, by Aspden. What needs to be unequivocally explained is that Relativity (as SR) treated the observer, stationary in the laboratory frame, as being at rest in a non-revolving or inertial frame whose origin was located by the center of the earth. It then proceeded to describe a plurality of such observers in identical inertial frames and asserted that, relative to any observer, the speed of light is constant. But in the process of generalizing the relative invariance of light to any and every observer, it now had to include an observer in a revolving frame; and here, Relativity (as GR) found itself having to admit that *the speed of light is no longer constant for any and every observer*. The rationale for this 'adjustment' of the theory was ascribed to such factors as gravitational potentials, time dilation and the dragging of inertial frames in rotation. In other words, when experimentally confronted with the electromagnetic detectability of rotation, be it the rotation of the earth (the MGP experiment) or the interferometer (the Sagnac experiment), Relativity found it had to perform a theoretical volte-face, and to deny the very principle it claimed to have generalized! Yet, Relativity can neither account for the magnitude of the Sagnac effect, nor for the time delays in signal propagation around the globe.

The results of the Sagnac experiment, the MGP experiment and the Brillet and Hall experiment, all indicate that one can effectively measure rotation by optical means, whether the interferometer is rotating or not. Given the required resolution, a rotating interferometer will always be capable of optically measuring its own rate of rotation, as well as that of the revolving frame on which its axis of rotation is inertially at rest. A stationary interferometer can only electromagnetically measure the rate of rotation of the revolving frame on which it is inertially at rest.

"There turned out to be a constant unexplained signal - a hiss, a hum - coming out of the receiver no matter how the antenna was positioned, even if it was pointed at empty space, no matter when the experiments were done."

D. Overbye, "Lonely hearts of the cosmos", 1991, p.133

5. The new Aether drift

5.1. The return of the repressed: the cosmic microwave background radiation as a space frame of electromagnetic reference.

If the negative results of the Michelson-Morley experiments ushered in the relativist age by failing to demonstrate any contribution on the part of the linear motion of the earth to the local velocity of light, the discovery in 1965 by A. Penzias and R. Wilson, at Bell Telephone Laboratories, of the 2.73 Kelvin cosmic background radiation (CBR), in the form of a bothersome hiss that would not go away, marks the rebirth of the notions of absolute motion and the "new aether drift" (Peebles' expression in (29)).

The Penzias and Wilson discovery presented an isomorphic (to 1 part in 1,000) microwave radiation field, detected at wavelengths of mm to cm. This discovery was immediately hailed by R. Dicke as proof of G. Gamow's 1949 prediction of an isotropic electromagnetic radiation indicative of the Big-Bang event. From then on, the CBR was consistently interpreted as the fossil remains of a very hot phase of the universe. The isotropic distribution of the flux was assumed to be due to the cooling, through expansion, of the 4,000K fossil radiation emitted when primordial hydrogen ceased being ionized.

What was essential for the 'Princeton gnostics' was the presence of microwave radiation at a wavelength of 7.35 cm (at 4GHz), because this was seen by them as the physical marker for the beginning of the universe, the primordial explosion (theory of sudden creation), and provided the necessary evidence to discredit the competing astrophysical theory of a continuous creation of matter required to 'fill' the increasing space between atoms in an expanding universe. In accordance with the relativistic Big-Bang hypothesis, space is uniformly occupied, as the originary explosion is not an explosion of matter in space, but an explosion of space itself (30). Hence the importance of the observed isotropy indicating absence of structure at various angular scales, and suggesting that the CBR has the spectral characteristics of a black body.

The scientific mania of finding an origin to time and space, here, reached its pinnacle of devotion with what is tantamount to an article of faith: the CBR is taken as 'proof' of the smooth evolution of the present expansion-phase of the universe, another credo fused to relativity theory following Hubble's 'discovery' that 'all' galaxies 'are' moving away from our

own. So, even if strictly speaking the notion that the CBR is a fossil of time does not require Relativity, it soon became a cornerstone of relativistic astrophysics.

Subsequent experimentation by independent groups has extended the range of measurements up to 400 GHz and, within that range, the relative intensity of the radiation increases proportional to frequency. Extrapolations for a decrease in relative intensity with frequencies above 400 GHz, are solely the result of relativistic computations.

5.2. The anisotropy of the cosmic blackbody radiation

This perfect picture of cosmic isotropy was disrupted, soon enough, by the demonstration that the temperature of the cosmic microwave radiation is not, in fact, precisely the same in all directions [(31)]. Two Dicke radiometers, working at a frequency of 33 GHz (λ = 0.9 cm, a wavelength at which the galactic background microwave radiation is low), carried aboard the NASA-Ames Earth Survey U-2 aircraft, detected a cosine anisotropy (a cosine dependence on the angle between the direction of the peak and the direction of the observation) on the order of <1 part in 3,000. In the context of General Relativity, this anisotropy was readily interpreted as due to the motion of the earth (more precisely, the motion of the solar system) relative to the rest frame of the cosmic background radiation, in the direction where radiation is the most intense. Assuming this peculiar motion of the earth, the CBR is slightly 'bluer' (hotter) in the direction of the motion, and slightly 'redder' (cooler) in the opposite direction. So, the findings were seen as confirmation that GR is correct about the expansion of the universe. This, in turn, led to the conclusion that the CBR constitutes the cosmic background of energy in a frame of reference that is moving at 99.9% the speed of light with respect to the matter of the Big Bang.

This discovery of the 'new electromagnetic aether drift' effectively resurrected the notion of an electromagnetic frame of reference fixed in space, even if it be defined as the expanding coordinate system in which the galaxies are nearly at rest. The peculiar velocities of galaxies and other astrophysical bodies are determined with respect to this CBR frame. Using T_0 = 2.7° K as the average temperature of the cosmic blackbody radiation, and the maximum temperature difference of T_1= 0.0035 K, Smoot et al calculated that, taking into account the Doppler shift, the earth is moving at a velocity of -

$$v_{SSpec} = (T_1/T_0)\, c = 388.6 \pm 60 \text{ km/s}$$

in the direction of galactic co-ordinates 54°±10° lat. N, 245°±15 long., towards Regulus, the brightest star of the Leo constellation [(32)]. A previous, lower-resolution determination by Corey and Wilkinson had given 270±70 km/sec [(31)].

The reader should note that this is not the velocity expected to arise from the solar system's translation around the galactic center, but the integral value of the translational velocity of the solar system in space, just as if we were measuring the absolute speed of motion of the earth in space! If we knew exactly the velocity of the solar system due to rotation of the galaxy, we could in principle determine the peculiar velocity of the galaxy with respect to the CBR. Assuming the 1977 result of Visvathan and Sandage for a galactic translational speed of the solar system on the order of 300±50 km/sec, in the direction of galactic co-ordinates 0° lat., 90° long., the peculiar velocity of the Milky Way was approximated by Smoot et al as 603 km/sec (10.4 R.A., -18° dec, or 261° gal. long., 33° gal. lat.) "with respect to the cosmic background radiation" [(32)].

As Rowan-Robinson sagaciously commented, this finding presents all sorts of problems:

"What are we to make of this? The authors note that the velocity they have found conflicts with various attempts to measure our velocity with respect to nearby galaxies but offer no explanation of this. With respect to the Local Group [the group of galaxies to which the Milky Way belongs], the motion of the solar system hardly differs from that expected due to our circular motion around the galaxy. This suggests that the whole Local Group has to be moving along together at this velocity of 600 km/sec with respect to the microwave background. And this velocity is more than ten times the residual random motion of galaxies within 20 Mpc [$6.17*10^{23}$ m or 65.2 Mly] about the Hubble flow, so that most nearby galaxies, including the Virgo cluster of galaxies, would have to move along together at this velocity. The universe may be much more inhomogeneous than we realized till now, and we may have to be careful about interpreting the expansion time-scale we measure locally as the age of the universe."[(33)]

These wise words put in perspective all the interpretative steps involved in current cosmology. Smoot et al's results conflict with the magnitude of the measurements of the peculiar velocity of the earth or solar system with respect to nearby galaxies, as well as with the celestial or galactic co-ordinates of the motion [(34-35)]. The direction of the net galactic motion of the earth and sun obtained by Smoot et al [(32)] is almost at right angles to the results of Rubin et al [(35)]. Moreover, the velocity of the Local Group with respect to nearby galaxies suggests that there is considerable turbulence in the universe, a result which is difficult to reconcile with the isotropic character of the CBR, and which led to Hawking's proposal that the universe itself (the structure of Space-Time) may be spinning.

Whether the CBR is an expanding or a fixed system of coordinates, ie whether or not it is the residue of the Big Bang, it now figures within GR as a preferred frame of reference for electromagnetic radiation and motion! It would seem therefore that absolute motion in

space can be measured after all with respect to the cosmic microwave background radiation, as a function of measured anisotropy. With respect to the CBR frame the propagation of light remains essentially isotropic and invariant. A universal frame of reference had been found, yet Relativity postulates that all co-ordinate systems are interchangeable (the universality of Relativity). This is another clear testimony to the saying that nothing dies of contradiction.

5.3. On the eve of an epistemological upset

The worst enemy of any advancement in our comprehension of nature is not the magnitude of the unknown, but the prevalent belief that there is very little remaining to be known. Not only because this fosters a complacent attitude, foreign to the true scientific spirit, but above all because, instead of supporting *basic* investigation of that unknown, it increasingly denies such support by invoking *a priori* limitations derived from inadequate mathematical theories. The stationary aether fixed to absolute space was one such limiting notion, and yet it was overcome by another notion (Relativity) which was no less limiting. Even if Relativity could account for the MGP experiment, it was never able to deal adequately with the Sagnac effect, limiting itself to adding a superfluous time dilation that has the sole effect of needlessly complexifying the relations at stake. If it were not for the security afforded by accepted paradigms, and if scientists were to apply Ockam's razor rather than merely providing it lip service, Relativity would not have much to stand upon when confronted with the Sagnac effect, which should have made Mach swallow his words with respect to the relativism of rotary motion. With the Sagnac effect, not only the rotation of the interferometer but also that of the earth could be determined by optical and electromagnetic means. This should have more than sufficed to put Relativity on the spot. But official science, having incorporated Relativity, was able to gloss over this challenge. Over a century after Mach's words, we can state firmly that rotation is an absolute state of motion, and not even the most rabid relativist can avoid this realization. To put it bluntly, Mach was wrong.

It was Michelson's 1881 mistake which appeared to reduce the question of the existence of the aether to whether the orbital motion of the earth could be detected by electromagnetic means. Equated in these terms, which no longer obeyed Fresnel's law, the null result was taken to be the death of the concept of the aether. Yet, even Einstein would argue that the only aether which had died was the stationary one. But his gravitational aether fared no better than the stationary aether, when he and other mechanistic-minded physicists sought instead to establish the geometric primacy of a Space-Time devoid of

energetic considerations, a pure mathematical abstraction without actual physical qualities, and employing imaginary time.

For adherents of both the stationary aether and Relativity, the MM experiment has been taken to mean that light adapts to the translatory frame of the earth's motion around the sun. Relativists express this relation by saying that light is referenced to the inertial frame of the earth in a substantial condition of translation. By the same token, the proposal has been made that the Sagnac experiment demonstrates that light does not adapt to revolving frames, such as the earth's revolving frame; a proposal which relativists express as non-adaptation to non-inertial frames. In fact, all one was entitled to conclude at the time, at this conjuncture, was that the MM experiment showed that none of the translatory components of the inertial motion of the earth were detected optically - something which was later confirmed by frequency-locked laser experiments: neither the orbital translation of the earth around the sun, nor the galactic translation of the earth and the solar system around the galactic center, nor any absolute or peculiar velocity of the earth or solar system were in fact detectable.

Still, all this would be fine and dandy if Relativity did not insist on its pretentious claim of being able to measure the 'peculiar' velocities of astrophysical bodies by interpreting any displacement of electromagnetic radiation with reference to a general body of galaxies and, more recently, with reference to a cosmic microwave background radiation that appears to be slightly anisotropic because of our peculiar motion. By resurrecting the question of absolute motion as the measurement of peculiar velocity with respect to the CBR, the entire aethereal can of worms has been reopened.

Here is reason to examine exactly *what* it is that produces the invariant effect of propagation of c, the phenomenon discovered accidentally by the MM experiment. In other words, there is very good reason to question - in just which frame of reference is the light speed constant? Is it in the translational frame of the earth's solar orbital? In the translational frame of the galactic orbital? In Aspden's words-

"Of crucial importance is whether this background space lattice is locked to and referenced on mother earth for some distance above the earth's surface, or whether it has some connection with the sun, or whether it is set in some absolute or cosmic frame of reference." (36)

From the tortuous course of null and positive results, we can at present conclude:

- Space no longer appears to be empty, as it once did for Special and even General Relativity. An absolute vacuum of matter and energy is unattainable and not a real physical possibility that should or need be considered. The "vacuum state" is a misnomer, for the "vacuum" is filled with energy. The concept of empty space, a tributary to Democritus' idea

of a void between the atoms, is no more pertinent and apt a description of physical reality than was the static aether image of the XIXth century, when the Michelson-Morley experiments dethroned it.

- The perfect symmetry of Space-Time does not describe physical reality, only an ideal reality that is imaginarily perfect. There is no intrinsic or heuristic requirement on the part of the Sagnac effect or the Silvertooth experiment for any time-dilation transformations. The very notion of spatialized Time is most doubtful, if not a prejudice that prevents enunciation of a Physics of Simultaneity.

- With respect to the CBR frame, the propagation of light remains essentially isotropic and invariant. A cosmic universal frame of reference for the propagation of electromagnetic energy has been found - in direct contravention of Special Relativity - but this discovery has been co-opted by the Big-Bang ideologists.

- States of rotation of material bodies can be determined optically and electromagnetically. Mach was wrong.

Einstein once hoped that Relativity would become the strict relationist theory Mach had called for. Einstein's response to Mach's difficulties was to treat inertial effects not as a function of some absolute acceleration, but rather as the result of the gravitational interaction of the test system with the rest of the mass of the universe, as expressed by a synthesis of mechanical and geometric factors. Einstein could not hope to satisfy Mach's postulate of an *absolute identity* of the Spacetime continuum with the set of spatiotemporal relations between material bodies. We know today that reference to the detectable mass of the universe does not serve to explain the electromagnetically measured peculiar velocity of galaxies, stars and their systems. To a certain extent, GR guarded itself against this shortcoming of Mach's theory by adding geometric constraints to the inertia of systems in motion - and later, to patch the hole, the notion of dark matter was added. Einstein was in fact obliged to treat the continuum as a pseudo-Riemannian manifold that had a *separate physical reality distinct* from the spatiotemporal relations between material objects. The manifold is presented as being affected by the distribution of mass within it, and as affecting the motion of this mass. This clearly introduces substantivalist considerations into what was originally deemed to be a relationist project. These substantivalist considerations are essentially embodied by -

1) The adoption of both mechanical and merely axiomatic constraints in the definition of the metric structure of Spacetime.

2) The persistence in treating Time as equivalent to a timeline (first reduction) that can be reduced to an extension length (second reduction), in turn treated as a relative interval (third reduction) of a pseudo-Riemannian manifold.

3) The arbitrary imposition of an electromagnetic invariant absolute speed on the radiative description of gravitational fields.

4) Most importantly, the reduction of gravitational energy to the metric structure of Spacetime.

The Spacetime of SR was a flat Minkowski manifold. In GR, the manifold becomes instead curved, or a Gaussian spheroid surface, precisely to indicate the manifestation of gravitational fields in the form of a deviation of the geodesic lines from the coordinate axes of any chosen inertial frame of reference. But thereby, for as long as the Weyl tensor (or conformal curvature tensor) is held to remain unchanged - as a minimum curvature of the Spacetime continuum - a claim can be made that the theory holds Spacetime to be independent from the energy-stress tensor, and thus independent from both energy and mass. Spacetime does not exist simply as a set of relations between material bodies. It is 'affected' by the distribution of both matter and electromagnetic fields, and in turn it 'affects' the combinations of mass (or energy, in relativistic language) and linear momentum. Moreover, it also has some degree of existence as a set of relations that is independent of the terms, independent from the actual distribution of matter in the universe, and serves as milieu for those relations. A return to the philosophy of empiricism may seem inevitable, but it occurs in the strange form of a geometrical 'supersubstantivalist program': if relations exist outside of the terms, one may hold that the continuum of Spacetime exists as a structure of the overall set of relations that not only has a being of its own, but also underlies the being and the structure of matter and its relations, 'thus identifying all material objects with Spacetime itself', to paraphrase Sklar. Since the curvature of the continuum is the very condition of its volumetric existence (thus 'there are true gravitational fields even in empty space'), and since curved Spacetime is identical with the physical notion of a 'true gravitational field', such an approach is tantamount to making the existence of Space everywhere dependent upon gravitational fields. This alone precludes the existence anywhere in the cosmos of a true inertial frame, even of one that could be asymptotically construed in regions very distant from any gravitating masses. One might suggest, as others have for three decades, that it is the Spacetime envelope which is engaged in absolute rotation, and that this justifies both the notion that the Weyl tensor remains unchanged and that Space itself should depend upon 'true gravitational fields'. One wonders why GR never deployed the notion that the Spacetime continuum itself develops a minimum gravitational field embodied by the Weyl tensor, when the Ricci-Einstein (or energy-stress) tensor vanishes. Maybe it was feared that any move in this direction might, after all, lead the theory back to the notion of a single Time; or maybe it was sensed that it would lead to a still more embarrassing difficulty - having to explain how the volume of Space would have had to arise

from geometric considerations that depended upon a gravitational field being deployed in the absence of mass.

Curiously enough, the notion that the Space and Time continuum exists independently from material bodies and even from their relations, and that it at once encompasses the entire set of these relations plus the intrinsic energy structure of all material bodies, is not necessarily a geometric or a metaphysical proposition. However, in order to avoid the traps of either position, one must understand the continuum not as a set of points, not as a topological abstraction, but as energy in flux, as a continuum of superimposed lines or wavefunctions, which are not to be defined by any succession of points, no matter how close one places them. Waves do not undulate in flat or curved Spacetimes. And they do not exist independently from energy, either. If there is any deep meaning to the first law of conservation of energy, it is that Space and Time are conserved and thus infinite as such, and this is not to the detriment of Space being finite at any instant of Time. In order to assemble the functions of an energy continuum productive of Space and of Time, one requires entirely different concepts than those of GR. A fundamental contamination has taken place. What are in fact two distinct manifolds were abusively fused into one, instead of being recognized for what they are, property sets of both number and *qualia* that belong to a single continuum. And the volumetric existence of Spacetime was made to depend upon a gravitational field devoid of matter and also of energy...Herein lies the rub: if Spacetime depends upon gravitational fields, patchy or not, these fields are conceptualized as void of energy because they are void of mass (on the very abusive basis that all energy has mass). Yet, there is no reason to be lost in this way. Energy may, can and does exist in massless forms devoid of inertial effects. Moreover, if one succeeds in tying together the structure of the continuum (the properties of Space and Time) with the properties of an energy flux, then what is pertinent to ask is instead: how do gravitational fields arise - together with the matter that they assign - from precisely the massless flux of the continuum? Then, a single and universal Time may yet turn out to be but the property of the rotation of the entire continuum of Space and Time.

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