From the classical ethers of Descartes and Newton to cosmons and sagions

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The present paper highlights the huge difference between the dynamic ethers proposed to explain the propagation and generation of gravity and the stationary, even solid, ethers proposed to support the transversal motion of electromagnetic waves. The vast majority of 20th century criticisms are addressed to the second class of ethers; besides, such critics completely disregard the dynamical Hertzian ether, which underlies his Galilean-invariant electromagnetic theory. The Michelson-Morley experiment (MMX) is usually cited as the crucial evidence to abandon cherished notions of classical mechanics and instead adopt Lorentz invariance. Contrariwise, it is argued here that whatever the outcome of the MMX there was no need to abandon the concept of ether, and even less to assume that the Newtonian notions of space and time were *démodé*. Instead, three alternative interpretations of the MMX are offered here, one of them is the comparison between two

models of propagation of light in the terrestrial laboratory: (a) relative to the boundary layer of earth and the fluid ether, or (b) relative to the bulk fluid ether. We end with three independent efforts by the end of the 20th century to explain all forces of nature with classical ether: (i) the cosmological gaseous ether proposed by Charles K. Thornhill, from which he derived an electromagnetic theory which is equivalent to Hertzian electromagnetism, (ii) the cosmonic gaseous ether proposed by Adolphe Martin to explain the existence of forces and particles, and (iii) our own fluid ether formed by discrete extended energy-like sagions which obey the laws of classical mechanics and the homogeneous wave equation. We briefly discuss the deeper meaning of our novel solutions for the classical wave equation, which lead to a unification of gravity, electromagnetism and quantum phenomena.

Physical knowledge has advanced very much since 1905, notably by the arrival of quantum mechanics, and the situation has again changed. If one re-examines the question in the light of present-day knowledge, one finds that the aether is no longer ruled out by relativity, and good reasons can now be advanced for postulating an aether.

P. A. M. Dirac, Nobel Laureate in Physics, 1933

Quite undeservedly, the ether has acquired a bad name. There is a myth, repeated in many popular presentations and textbooks, that Albert Einstein swept it into the dustbin of history. The real story is more complicated and interesting ... Einstein first purified, and then enthroned, the ether concept ... At present, renamed and thinly disguised, it dominates the accepted laws of physics.

Frank Wilczek, Nobel Laureate in Physics, 2004

I. Introduction

In the epigraph Dirac starts from his new theory of electrodynamics, and defines a velocity that appears in "*all points of space-time, playing a fundamental part in electrodynamics. It is natural to regard it as the velocity of some real physical thing. Thus with the new theory of electrodynamics we are rather forced to have an aether*" [60]. For his part, Wilczek starts from the contrived notion of spacetime, which has "*become a dynamical medium — an ether, if ever there was one*," and then describes various shortcomings of previous notions of ether [61]. In contrast, it is argued here that our atomistic three-dimensional extended sagions remedy the well known weaknesses of classical ethers.

Gravity is the most pervading and easiest to perceive force in Nature. Cavemen were surely aware that bodies tended towards earth, but the ancient Babylonian, Egyptian and Greek astronomers did not realize that the motion of planets and stars was related to the apparent attraction of matter by the earth. In contrast to our lowly terrestrial world, for Aristotle the heavens were perfect, immutable, and subject to divine laws. Until, at last, in the first half of the 14th century Jean Buridan at the

University of Paris dared to suggest that the heavens could be studied in the same way as the rest of nature [1, p. 53]; additionally, the immutability of the heavens suffered a lethal blow with the observation by Tycho Brahe of a new star —the 1572 nova. The time was ripe for a final assault, which lasted 150 years from 1543 when Copernicus published *De Revolutionibus Orbium Caelestium* until Newton's first edition of the *Principia* in 1687. In this long process contributions were also made by Kepler, Galilei, Descartes, Huygens, Hooke, and so on [2-6]; sadly, some of them have not received the credit they deserve.

Many have wondered why Newton did not publish his *Principia* around 1666. According to Reichenbach [2, p. 26]:

> Newton ... put his calculations away in a closet ... only twenty years later could the mistake be explained. The length of the earth's radius, taken by Newton as the basis of his calculations, had been inexact; new estimates on the astronomer's part gave a new measurement with which Newton's reflections about the moon proved to be in full accord.

Kuhn's account on this matter is much more detailed and does not put the blame on earth's radius [3, p. 257-258]:

> Newton ... was himself intensely aware of the metaphysical inadequacy of his working concept of gravity. That awareness probably accounts for at least part of his delay in announcing the results of his early work in celestial physics. In fact, the *Principia* did not appear until Newton, in 1685, succeeded in resolving one of the apparent conflicts between gravity and the corpuscular philosophy and until he had expended much fruitless effort in attempting to resolve the other.
>
> The first conflict between corpuscular premises and Newton's early theory of gravity appears in the calculation of 1666, which compared the earth's attraction for the distant moon and a nearby stone ... In 1685 he proved that, whatever the distance to the external corpuscle, all the earth corpuscles could be treated as though they were located at the earth's center. That surprising discovery, which at last rooted gravity in the individual corpuscles, was the prelude and perhaps the prerequisite to the publication of the *Principia*.

We have quoted this passage at length because the introduction of the center of mass in Newtonian mechanics allowed spatially extended

bodies to be treated *as if* they were mathematical points with mass. Unfortunately, when quantum physics was developed at the beginning of the 20th century, particles were defined as mathematical points with mass, the "as if" part having been forgotten. Let us continue with Kuhn's second reason for the delay in publication of the *Principia* [3, p. 258-259]:

> The great virtue of Descartes's system had been its complete elimination of all such "occult qualities." Descartes's corpuscles had been totally neutral; weight itself had been explained as the result of impact; the conception of a built-in attractive principle operating at a distance therefore seemed a regression to the mystic "sympathies" and "potencies" for which medieval science had been so ridiculed. Newton himself entirely agreed. He repeatedly attempted to discover a mechanical explanation of the attraction, and though forced at last to admit his failure, he continued to maintain that someone else would succeed, that the cause of gravity was not "uncapable of being discovered and made manifest" [8]. Again and again he insisted that gravity was not innate in matter.

In retrospect, the answer was at hand even at Newton's time: mechanics based on the Cartesian principle of conservation of linear momentum. To answer criticisms from the Cartesians, in the General Scholium written in 1713 for the second edition of the Principia, Newton explicitly recognized that: "*I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses*..." [7, p. 45]. For the general public of the 20th and 21st centuries the best known sentence of Newton is "I frame or feign no hypotheses"; for them, Westfall's comment may be illuminating [4, p. 158]:

> I feign no hypotheses —*hypotheses non fingo*. In one sense the words are obviously false; Newton did feign hypotheses, and rather grandiose ones at that. In the sense that he maintained a rigid distinction between demonstrated conclusions and hypotheses meant to explain them, and refused to dilute demonstrations with speculations, however, the statement can stand. Thus force was to Newton a concept necessary to the description of phenomena in mechanical terms. Its validity rested on its utility in demonstrations, not on hypotheses that might explain its origin.

The intention of the present paper is not to take sides on the bitter dispute that followed publication of the *Principia*, between the supporters of Newton (mainly) in Great Britain, and his opponents (mainly) in the European continent, or on a personal level where "*the case for Newton ... became steadily a case against Descartes*" [5, p. 312]. On the contrary, after the necessary *aggiornamento*, our purpose is to take the middle road, between a radical rationalism that forbids all unexplained assumptions, and a radical pragmatism where any brute-force assumption is acceptable provided that it leads to "correct" results.

Newton's pragmatic approach to science, epitomized by the *Principia*, was adopted by many scientists, and is the currently dominant paradigm for doing science in western countries. However, pragmatism has costs. For instance, over the years Newton's gravity became an innate property of matter and an action-at-a-distant force, both views strongly resisted by Newton himself [3, p. 259]; this in turn led to the necessity for a new gravitational theory taking into account a finite speed. During the 20th century the pragmatic approach eventually led to logical incoherence, such as a *vacuum* having "physical" properties, or a *vacuum* that instead of being empty by definition is filled with something, say dark matter. In our opinion, logical incoherencies unacceptable.

So, let us proceed from the cosmological origin of the Cartesian and Newtonian concepts of ether to some contemporary proposals.

II. Gravity and ether

A. Towards Newtonian gravity

As a context for his ether let us briefly recall the main steps leading to Newton's universal law of gravity. Kepler carefully analysed astronomical data collected since antiquity, plus more recent data gathered by Copernicus and Tycho Brahe; he identified some clear patterns and managed to express them as mathematical relations —

Kepler's laws. Newton *assumed* the existence of *pulling* forces between cosmic bodies, and by 1666 he found that, in particular, an inverse-square force could explain Kepler's laws. But Newton did not publish at that time. For completeness, two centuries later Bertrand demonstrated that only forces proportional to r and $1/r^2$ could lead to elliptical motion [9].

But why is 1666 important? In that year, at the end of a lecture at the Royal Society of London Robert Hooke showed the audience a conical pendulum as a model of the two dynamical elements present in circular (or in elliptical) planetary motion: inertial motion and a force towards the center [3, p. 249-256]. In Kuhn's words [3, p. 249]:

> Much influenced by Descartes, Hooke began with a complete conception of inertial motion and of the identity of terrestrial and celestial laws ... A moving planet ought ... to continue its motion uniformly in a straight line through space, because the senses reveal nothing to push or pull it. Since its motion is not straight ... the immediate evidence of the senses must be misleading. There must be an additional attractive principle or force operating between the sun and each planet.

The attractive force is represented by the tension in the cord of the conical pendulum (figure 50 in [3, p. 250]). Hooke put his ideas in writing in 1674, noting that gravity should depend on distance, but recognizing that he had not been able to find by experiment the functional dependency; in Hooke's words "*what these several degrees are I have not yet experimentally verified*" [10]. According to Kuhn [3, p. 256] "*if his own subsequent dating of the discovery is reliable, Newton had used the conceptions to determine Hooke's 'several degrees' of gravitational attraction eight years before the passage above was written*." Note the contrast between Hooke's experimental efforts and Newton's theoretical approach.

It is also remarkable that in 1666 Hooke already had a clear understanding of the implications of the principle of inertia, which leads to tangential escapes from circular motion, without any need for postulating centrifugal forces —which according to rigorous classical mechanics merely are *fictitious* forces that do not exist in inertial frames

[11]. Hooke's insight was a non-trivial achievement; just remember that as late as the mid-20th century some top-class physicists still believed in the existence of *real* centrifugal forces!

Regarding the origin of gravity, Newton often insisted that it was not an intrinsic property of bodies, as "*Not that I affirm gravity to be essential to bodies ... their gravity is diminished as they recede from earth*" [7, p. 5]. In his second letter to Bentley (17 January 1692/3) Newton noted that "*You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me, for the cause of gravity is what I do not pretend to know*" [7, p. 53] For Newton's concept of gravity see also [1, p. 133-142].

B. Cartesian physics

It is well known that from simple experiments with inclined planes Galileo clearly intuited the existence of the principle of inertia, but the role of Descartes is less known. According to Cohen [6, p. 153] "*the earliest known statement*" of the principle of inertia was in the book *Le Monde* (The World) that Descartes decided not to publish after learning of the condemnation of Galileo by the Roman Inquisition; the law of inertia appeared in *Principia Philosophiae* (The Principles of Philosophy) published in 1644, and afterwards in *Le Monde* posthumously published in 1650.

Cartesian physics was based on rules of impact that can be traced to the sixth century to John Philoponus in Byzantium, and even perhaps to Hipparchus in the second century before our era [1, p. 70; 3, p. 119]. Most impact rules formulated by Descartes were empirically incorrect, but the overall idea was right; the general and correct vector formulation was found by Huygens in the period between 1652 and 1656, and later on by Wallis and Wren around 1668 [12]. Those papers originated the modern principle of conservation of linear momentum (CLM). According to Davies [12, p. 9], Huygens fifth law is:

> *The quantity of motion of two bodies may be increased or decreased by their collision; but the same quantity always remains in any direction, after subtracting the quantity of contrary motion*.
>
> The first part may have been contrasting his law with the incorrect formulation of Descartes. In the second part the emphasis on directions and the need to subtract contrary motions was crucial; it was *copied very closely by Newton in Principia* (emphasis added by the present writer).

On the contrary, Cartesian cosmology has always been subject to strong criticism. The Cartesian model of the universe was a static three-dimensional (3-D) space completely filled by three different substances in permanent motion: ordinary matter, ether that fills the heavens, and light forming the sun and stars. Cartesian matter was infinitely divisible, and filled all space leaving no voids; the permanent collisions of moving matter led to the formation of vortices, and gravity was due to ether particles revolving faster than Earth, thus pushing down ordinary terrestrial matter. [5, p. 116-120]. Cartesian vortices have always been the main issue.

C. Newtonian ether

In the *Principia* ether receives only a passing mention in the last paragraph of the General Scholium of the second edition [7, p. 45]:

> And now we might add something concerning a certain most subtle spirit which pervades and lies hid in all gross bodies, by the force and action of which spirit the particles of bodies attract one another at near distances and cohere, if contiguous; and electric bodies operate to greater distances, as well repelling as attracting the neighboring corpuscles; and light is emitted, reflected, refracted, inflected, and heats bodies;...

In his *Optiks* and in private letters Newton was a strong advocate of ether as a medium required for the propagation of gravity. For instance, the third letter to Bentley (dated 25 February 1692/3) states that [7, p. 54]:

> It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate upon and affect other matter without mutual contact, as it must be if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one

> reason why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent, and essential to matter, so *that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity* that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent is material or immaterial I have left to the consideration of the readers (emphasis added).

In a letter to the chemist Robert Boyle on February 28, 1678/9, Newton described ether as a gas formed by discrete corpuscles [7, p.112-113]:

> I suppose, that there is diffused through all places an etherial substance, capable of contraction and dilatation, strongly elastic, and, in a word, much like air in all respects, but far more subtle. I suppose this ether pervades all gross bodies, but yet so as to stand rarer in their pores than in free spaces, and so much the rarer, as their pores are less.

D. Cartesian ether versus Newtonian ether

This may be the place to include some remarks contrasting Cartesian and Newtonian ideas. Firstly, both of them considered that material bodies were extended and impenetrable, in the sense of occupying a portion of 3-Dspace at some instant of time. In the rules for reasoning in philosophy (Book III of the *Principia*) Newton stated [7, p. 4]: "*Because we perceive extension in all that are sensible, therefore we ascribe universally to all others also... That all bodies are impenetrable, we gather not from reason, but from sensation ...thence conclude impenetrability to be a universal property ... hence we conclude the least particles of all bodies to be also extended, and hard, and impenetrable, and movable, and endowed with their proper inertia*."

Newton states here a difference with Descartes: his own beliefs had empirical origin, not pure reason. Our own opinion is that neither pure reason alone, nor empirical observation alone suffice. There was a sterile discussion for several centuries as to whether material bodies were hard or soft, or they were penetrable or not, see for instance [13, 14]. With the

advent of high speed photography in the mid-20th century it was easy to see that a ball hit by a tennis racquet or by a bat is heavily deformed, even billiard balls are deformed in head-on collisions.

A significant difference is that for Descartes matter was infinitely divisible, whereas Newton was a convinced atomist. Actually, Newton invoked the authority of ancient Greek atomists in query 28th of Optics [7, p. 155], and again in query 31st Newton mentions "*atoms*" several times as hard, solid and unbreakable particles of which "*all material things seem to have been composed*" [7, p. 175-177].

Perhaps the most important difference between Descartes and Newton is that Descartes had it very clear that his particles interacted by exchange of momentum, whereas Newton could never set his mind on what his ether was, and even less on how the ether corpuscles interacted. For instance, in Book I of the *Principia* (Scholium to Section XI) Newton said [7, p. 39]:

> I here use the word *attraction* in general for any endeavour whatever made by bodies to approach to each other, whether that endeavour arises from the action of the bodies themselves, as tending to each other or agitating each other by spirits emitted; or whether it arises from the action of the ether or of the air, or of any medium whatever, whether corporeal or incorporeal, in any manner impelling bodies placed therein toward each other (emphasis in the original).

Surprisingly, Newton says here that attraction could be some property arising "*from the action of the bodies themselves*." One senses some contradiction here, or at least ambiguity, in the face of Newton's protestations regarding non-innate gravity (quoted in sub-section II.A above).

Newton continued all his life searching for a mechanism to generate gravity. Newton's Optics was published for the first time in 1704, successive editions up to the fourth in 1730 differed mostly in the content of his conjectures: the queries. Query 31st, and last, stated that since "*the variety of motion which we find in the world is always decreasing, there is a*

necessity of conserving and recruiting it by active principles, such as are the cause of gravity, by which planets and comets keep their motions in their orbs and bodies acquire great motion in falling" [7, p. 175].

It is remarkable that Newton disqualified the principle of conservation of linear momentum as a viable candidate for the role of "active principle"; with which he was familiar (recall section II.B above). It may be conjectured that Newton did not fully grasp the far reaching implications of the *vectorial* conservation of linear momentum as opposed to the scalar variations of the magnitude of quantity of motion. In same Query 31st Newton explicitly said [7, p. 174]:

> The *vis inertiae* is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, and resist as much as they are resisted. By this principle alone there never could have been any motion in the world. Some other principle was necessary for putting bodies into motion; and now they are in motion, some other principle is necessary for conserving the motion. For from the various composition of two motions, *it is very certain that there is not always the same quantity of motion in the world* (emphasis added by us).

In support of his claim Newton offers the example of two globes joined by a slender rod, revolving about the common centre of mass (CM) at constant speed, while the CM moves at constant velocity. There is nothing paradoxical in this simple system where linear and angular momenta are both *separately* conserved. However, Newton intriguingly claimed that "*the sum of the motions of the two globes*" was different between two orientations of the rod relative to the linear motion of the CM. That is true, but the CLM refers to vectors, not to scalars. It is a pity that Newton's fixation on demonstrating that Descartes was wrong[1] did not allow him to see that the three Newtonian laws were closely related to the powerful Descartes-Huygens principle of CLM; this connection is common

1 This obsession was shared by Newton's closest associates: Roger Cotes, Richard Bentley and Samuel Clark. For instance, from their correspondence preceding the second edition of the *Principia* –in particular the writing of a General Scholium by Newton and a Preface by Cotes– it surfaces that a chief objective was to "*crush the Cartesians*." [7, p. 198-201]

knowledge today [15, p. 13-23]. All in all, Newton did not succeed in proposing a working microscopic mechanism for gravity, perhaps because his emphasis was on dynamics (*via* his second law) rather than on kinematics, *via* the CLM. Despite the great success of Newtonian gravity, the basic mechanism for its propagation has been a mystery for three centuries; as briefly described below, the present writer has recently proposed a Le Sage-type approach that works [16], thus solving the conundrum.

E. Fatio's ether

The Swiss Nicolas Fatio de Duiller was more successful than Newton in advancing a mechanism to explain gravity. Fatio was Newton's disciple and, for some time, his close friend; he suggested in 1685 that gravity might be due to a "*fierce current of exceptionally subtle matter that flows from all possible directions towards the centre of the earth, pushing all bodies downwards*" [17, p. 48]. Initially Newton supported Fatio's idea, but later on –apparently after their closeness ended– Newton changed his mind. Other contemporary scientists in London, like Huygens, Halley and Hooke, were not convinced.

By 1700 Fatio moved to the European Continent where he corresponded with Jacob Bernoulli, and later entered into some competitions in Paris to explain celestial gravitation. Eventually a copy of Fatio's work came into the hands of the Geneva mathematics professor Gabriel Cramer, who passed some of the ideas to his student Jalabert in 1731. For an entertaining account of Fatio's adventurous life see [17].

F. Le Sagian ether

Interest has recently revived in the work of another Swiss citizen, the Genevan George Louis Le Sage (1724-1803), who came on the scene 100 years after Newton [18, 19]. At age thirteen Le Sage became interested in gravity, and some years later he was acquainted with the corpuscular theory of gases developed by Daniel Bernoulli in his *Hydrodynamics*

published in 1738. After four years of pondering, Le Sage hit on his mechanism on 15 January 1747 at 11:30 in the evening: a continuous flow of tiny ultramundane corpuscles bombarding our world from all directions with extremely high-speed –much larger than the speed of light.

To honour Le Sage, his ultramundane corpuscles (with the few additional properties listed in section V below) are here called sagions; the name may be also interpreted as carriers of wisdom. If an isolated material body is hit by sagions from all directions the net effect on the body is null, but if two material bodies are close enough, they shadow one another from the flow of sagions, resulting in net attraction: gravity.

Le Sage was an honest investigator. In 1749 Cramer told Le Sage that his ideas –independently developed by him at the beginning of 1747– were similar to Fatio's ideas; thereafter, "*Le Sage scrupulously gave him credit in all his writings and often mentioned Cramer and Jalabert as well*" [20, p. 21]. This is a telling example for some well-known physicists, before and after Le Sage, who have difficulty acknowledging their intellectual debt to their predecessors. As is often the case, independently and about the same time as Le Sage, the Russian M. V. Lomonosov developed a very similar model for gravity [21].

G. Vortex atoms and the kinetic theory of gravity

Theoretical hydrodynamics initially addressed the simplest case of irrotational fluids, in particular those describable by velocity potentials; the Swiss Leonhard Euler and the French Joseph Louis Lagrange made significant contributions in the 18th and beginning of the 19th centuries. Then in 1858 Helmholtz published a paper in German dealing with vortex rings formed in a rotational fluid, that was published in English in 1867 [22], apparently translated by professor Peter Guthrie Tait —who shared with William Thomson the chair of mechanics at the University of Edinburgh, and was quite impressed with Helmholtz's findings. Tait

devised a method to produce vortex rings in the classroom using fumes from some chemical reactions; Thomson was greatly impressed by Tait's demonstration, in particular by the stability and the dynamical properties of the smoke rings. Within a month Thomson gave a talk on vortex atoms at the Royal Society in Edinburgh [23]. During the whole second half of the 19th century, Thomson (later Lord Kelvin) was a firm ether propounder, and published a significant number of papers on that subject [24]. At that time atoms were of interest both in chemistry and in the recently proposed kinetic theory of gases; in that context Taylor reviewed several kinetic theories of gravity [25].

Lord Kelvin was also sympathetic to Le Sage's gravity, and stressed its similarities with the kinetic theory of gases. In 1876, Picart in France proposed a gaseous ether formed by elastic atoms moving with high speed in every direction, whose collisions against a surface would generate pressure; he then described a shadowing mechanism to generate gravity which was the same as Le Sage's one-hundred year-old proposal [26]. Since Le Sage is not mentioned, it may be conjectured that Picart re-discovered the shadowing mechanism. Le Sagian ideas suffered a significant drawback due to Maxwell's criticism in 1878 that the absorption of sagions would heat matter [27]; several decades later Poincaré presented the same argument [28, p. 242-249]. Those criticisms almost killed Le Sage's theory.

Mainly in the context of electromagnetic theory, other well known British scientists also supported various versions of ether vortices, such as Leahy's oscillatory twists [29], Hill's spherical vortex [30], Pearson's vibrating spheres and ether squirts [31], and J. J. Thomson's ether filaments as late as 1931 [32] —after his own (J. J. Thomson's) discovery of the electron, the rise of Einstein's special theory of relativity, and the advent of quantum mechanics. In the USA, the inventor Charles Brush also propounded a kinetic theory of gravity [33].

As a close to this section it is stressed that the gravitational ether proposed by Fatio and Le Sage was endowed with motion in all directions of three-dimensional space, and that there was a clear distinction between the 3-Dspace and the ether that moved in that space.

III. Electromagnetism and ether

In the mid-19th century Maxwell developed his theory of electromagnetism by analogy with the transport of fluids [34, 35]. However, following the trend of his time, Maxwell's ether was stationary —as demonstrated by the partial derivatives appearing in his equations, rather than the total derivatives that necessarily contain the speed V of the terrestrial laboratory. For further comments see section III.C below on Hertzian dynamical ether and Galilean invariant electrodynamics. Let us turn now to various proposals for luminiferous ethers existing prior to Maxwell's theory —some of these ethers were not fluids, but elastic solids.

A. The luminiferous ether

In 1839 Samuel Earnshaw read a paper before the Cambridge Philosophical Society in which he criticized other authors for the "*symmetrical arrangements of the particles of the ethereal medium ... [that] it has never been shewn that such arrangements do exist in Nature, nor even that they can exist in Nature*" [36, p. 97]. So, he concentrated in arrangements which are not "*peculiar to the luminiferous ether*," and

> Assumed that the ether consists of detached particles; each of which is in a position of equilibrium, and when slightly disturbed is capable of *vibrating in any direction*. (Many solid as well as aerial bodies transmit sound, which is generally supposed to imply the existence of the same properties in them as are here assumed to be true of the ether) [36, p. 98] (emphasis in the original).

From the development in Earnshaw's paper it follows that his equilibrium is not dynamical (say, a planetary orbit) but simply means

ether particles at rest in the 3-Dphysical space; actually, his ether is closer to a liquid or solid at rest. Then, one may infer that the "*symmetrical arrangements*" that he criticized referred to crystals formed by ether particles.

For completeness it is mentioned that the paper just quoted is the implicit demonstration of Earnshaw's theorem used in contemporary electromagnetic theory: "*a charged particle in empty space cannot remain in stable equilibrium under electrostatic forces alone*" [37, p. 418]. This result may be inferred from the assumption made by Earnshaw in his paper that his ether "*particles exert attractive forces as well as repulsive forces*" [36, p. 109].

Then, the meaning of ether is not unique. As Max Jammer notes in the foreword to Kostro's book [38, p. iii]: "*in the middle of the nineteenth century fourteen disparate ether concepts had been in use at one and the same time*." Among the properties assigned to the luminiferous ether was elasticity, which at that time was deemed necessary to support propagation of the transversal electromagnetic waves. According to the Webster's dictionary, elastic means "*having the property of immediately returning to its original size, shape, or position after being stretched, squeezed, flexed, expanded, etc.*" Such properties describe solids rather than fluids — as the gravitational ethers were. Readers interested in details of electromagnetic ether may read Whittaker's history [39].

B. Ether and three-dimensional space confounded

In 1845 the French theorist Barré de Saint-Venant argued strenuously against the Newtonian concept of force, which, of course, is based on the faulty definition of mass in Newton's first paragraph of the *Principia*. Saint-Venant proposed instead a definition of mass based on the principle of conservation of linear momentum; twenty years later the Austrian Ernst Mach proposed a similar definition of mass [1, p. 215-217], and in the eighteen nineties Heinrich Rudolf Hertz made similar criticisms in Germany [40]. In the context of the positivistic attitude towards science

prevailing at that time, the Newtonian concepts of absolute space and absolute time were highly suspect as well.

Given the positivistic environment, it is not surprising that the physical three-dimensional space where the universe exists was identified with the solid elastic ether in which light and electromagnetic phenomena vibrate. For instance, in his model of ether the English professor Oliver Lodge assumed that "*the aether is the vehicle and medium of all stresses that exist. Stresses exist solely in the aether*" and that "*the aether as a whole is at rest, and velocities referred to it are absolute velocities*" [41, p. 422].

Einstein's father was the co-owner of a factory that built machines for electricity generation, so that it is no great surprise to learn that the young Einstein was interested in the ether, and that by about 1894 or 1895 he had written a note on ether and the magnetic field, which, of course, reflected the then current notion of an ether sustaining elastic strains and elastic deformations [38, p. 13-15].

According to Kostro, "*Einstein denied the existence of the ether for 11 years only, i.e. from 1905 to 1916*" [38, p. 27], and after the formulation of the general theory of relativity (GTR) Einstein reintroduced the concept again; in his monograph Kostro discusses at length the three different kinds of ether that are present in Einsteinian theories.

However, it seems that the 19th century identification of ether and space was still present in Einstein's mind when he delivered a lecture on May 5th, 1920 at the University of Leyden: "*Newton might no less well have called his absolute space 'Ether'; what is essential is merely that besides observable objects, another thing, which is not perceptible, must be looked upon as real, to enable acceleration or rotation to be looked upon as something real*" [42, p. 17].

C. Hertz's dynamical ether

Towards the end of the 19th century a separate development appeared in Germany: the *dynamical* ether proposed by Hertz in his posthumous book on classical mechanics [40; 43, p. 305-377]. This ether was intended

as a basis for Hertz's electromagnetic theory, which was automatically Galilean invariant. Unfortunately, neither the Hertzian ether, nor his electromagnetism received proper attention due to Hertz's premature death.

Currently, there is a revival of Hertzian ideas, which requires changing Maxwell's partial derivatives for the total derivatives that rule the general theory of fluids. For details see Phipps's book [44], where he notes that if the velocity V appearing in Hertz's equations is interpreted as the velocity of the detector relative to the inertial frame, then it follows that Maxwell's electromagnetic theory is the particular case of the Galilean invariant Hertzian theory for $V = 0$. Let us stress it again: Maxwell's theory merely is the particular case of a detector at rest in the inertial frame [44, p. 17-25]. Therefore, any theory that adopts Maxwell's equations as a starting point —as Einstein's special theory of relativity did — is intrinsically limited. For completeness, toward the end of past century Thornhill [45] rediscovered the superiority of the Hertzian approach, but he never realized that he had been anticipated by Hertz (see V.A below).

IV. Pre-relativistic interpretation of the MM experiment

A. The Michelson and Morley experiment

While Michelson was a graduate student of Helmholtz he carried out his first experiment to measure the relative motion of the earth and the luminiferous ether; the measurements started in Berlin, but, to avoid tram vibrations, the interferometer was moved to Potsdam [46]. The experiment was conceived within the then current model of an ether at rest in physical space, so that the motion of earth relative to physical space would be perceived in the terrestrial laboratory as an ether wind. To the

present day, the majority of discussions on the interpretation of the Michelson and Morley (MM) experiment [47] are cast in those terms.

The interferometer used by Michelson was not very rigid, and the empirical results were not of good quality. Michelson's initial paper published in 1881 [46] is almost unknown today, but it is important because this is where he reported the assumptions made in the design of the experiment; in particular, he explains why he expected to observe fringe-shifts smaller than one fringe-shift. Michelson assumed that our sun moves relative to physical space with a low speed of 30 km/s, a figure that was reasonable by the end of the 19th century, but it is 10 to 20 times smaller than current solar and local group speeds relative to CMB (369 and 627 km/s) [65].

After returning to Cleveland, Michelson joined efforts with Morley to repeat the experiment that failed in Germany. To avoid vibrations they placed the interferometer on top of a stone floating in mercury; after the stone was set in rotation (one turn in 6 minutes), readings were taken every 22.5°; this means that the experimenter had to run around the stone to chase the telescope on top of the stone to take a reading *every 22 seconds*, while the stone continued its motion. The observer looked at the position of the reference fringe, which *a priori* was interpreted as a fraction of one fringe. Actually, the observer did not have time to read anything else—even if he had the desire, or the means, to find out how many fringe shifts had rolled by in the interval between two consecutive readings. The Michelson-Morley (MM) experiment consisted of six sessions, three at noon, and three at six p.m., carried out on July 8, 9, and 11, 1887. There were six turns of the interferometer in each session, so that each point reported by MM was actually the average of six readings, whose standard error was not provided [47]. The six curves for the six sessions did not have the same general shape —some of them depicted harmonic variations compounded with an *increasing* overall trend, while others exhibited *decreasing* overall trends. Without apologies, MM simply

averaged the curves of the six sessions, thus smoothing out the variations. The resulting average amplitude of the sinusoidal oscillations was interpreted as an ether speed close to 8 km/s, *i.e*. about a quarter the expected orbital motion of the earth of 30 km/s.

Despite the (controversial) process of data reduction, *the measured value was non-zero*, although —not surprisingly—smaller than expected by MM. At the end of their paper MM simply jumped to the conclusion that the small speed that they calculated was consistent with no relative motion of earth and ether, but they never presented any statistical analysis to substantiate their claim. On the contrary, the paper claimed that the experimental error was quite small. *Given the difficult and hasty process of reading the telescope during running, the origin of that claim is a mystery*.

In Holland, Lorentz took the MM claims at face value and developed a theory for the electron that would account for these novel experimental findings (!!??); by the same token, in Ireland Fitzgerald proposed a length contraction as a possible explanation for the null-result of the MM experiment. Of course, Einstein's special theory of relativity (STR) predicts an *exactly* null result in the MM experiment, so that even the small speed (8 km/s) calculated by MM is inconsistent with STR predictions.

The conventional null-interpretation of the MM experiment was strongly disputed by Miller, who in 1902 worked together with Morley in several repetitions of the experiment, and continued alone for more than twenty years after Morley's death. In stark contrast to the scanty number of thirty-six turns in the MM experiment, Miller carried out observations involving one to two *hundred thousand turns* of his interferometers [48]. Miller consistently claimed that his results were *never* null.

B. Physical space interpretation of interferometer experiments

In the early nineteen nineties the present writer revisited the empirical basis of the STR [49], and found himself in agreement with Miller's claims [48]. The expected fringe shifts in Miller's interferometers were calculated using modern values of solar motion relative to physical space; a preferred inertial frame of coordinates, denoted by Σ, is anchored to a cosmic body (Aries), as in Newton's fixed stars. The speed of light is assumed to be constant along every direction in Σ; effective speeds of light along different directions in a terrestrial laboratory are calculated by Galilean vector addition [50]. In our calculations ether is never mentioned (let alone ether wind).

The speed of light in a terrestrial laboratory thus depends on direction, time of day, and epoch of the year. It follows that the shape of the fringe shift curves obtained with interferometers indeed depends on time of day, and epoch of the year, as also observed by Miller [48]. Of course, the calculated amplitude of the fringe shift depends on the solar motion relative to Σ —both speed and direction of motion. For the currently accepted values of solar speed it may be immediately concluded that the fringe shift amplitude in both MM and Miller's interferometers was always larger than one fringe shift. This is in contradiction with the experimental protocols of MM and Miller, thus casting serious doubts on their overall empirical validity. In the case of Miller's protocol, most contemporary commentators have missed the fact that when the reference fringe had drifted by more than one interference band, Miller hung a small weight at the end of one of the interferometer arms, thus changing its length [48]. From the foregoing, the present writer has concluded that there was no evidence for Lorentz contraction at the beginning of the 20th century [51]. Consequently, Einstein's STR had no empirical support at the outset.

Rather than entering sterile and never ending discussions regarding the experimental protocols of the MM and Miller experiments, and the details of the data reduction processes, and the details of how they interpreted the results of their data reduction process, the present author decided to repeat the experiment using laser light and an interferometer at rest in the laboratory, so that a 24-hour rotation was provided by the earth; readings were automatically collected every minute, rather than every 22.5°. It is stressed that the directional and temporal *resolution of our experiment was ninety (90) times better than in MM and Miller experiments*, the latter are equivalent to one interferometer reading every hour and a half (90 minutes) instead of every minute. In addition, our data reduction process included stochastic correction to subtract the contribution of the environmental variables (pressure, temperature and humidity), corrections absent in the MM and Miller experiments. Our experiment lasted more than two years, and the observations turned out to be consistent with our theoretical expectations [50]. Our empirical data was used to solve the inverse problem: calculation of the speed and direction of solar motion in the reference frame Σ; as reported at two international conferences [53, 54], our results are compatible with current values of solar velocity.

From the foregoing, the present writer feels entitled to entertain serious doubts regarding the empirical validity of STR. As a consequence, in the rest of the present paper the clock of history is wound back 120 years to the time of Hertz, Heaviside and Poincaré–but, of course, taking into account the new physical facts discovered in the 20th century, such as the existence of the photon, the annihilation of matter into photons, and the inverse phenomenon of matter creation from photons in electron-positron pair production, for example.

C. Distance and the Pythagoras theorem

The formulation of the special theory of relativity (STR) in 1905 opened the door to long standing controversies regarding whether length contraction, time dilation and mass increase were or were not physical phenomena, or mere artefacts of changing coordinates between systems in relative motion—some discussion is still ongoing. Two issues are the Lorentz transformation introduced to explain the *presumed null-result* of the MM experiment, and the new definition of simultaneity introduced by Einstein; Lorentz invariance [55], and Galilean invariance [56] are recurrent questions. The present writer will not enter into such discussions; instead, it is our contention that to bring common-sense into these abstruse subjects, the assumptions implicit in classical measurements should be made explicit; eventually one would obtain a formal theory similar to quantum and relativistic theories of measurement. To start the process, some extremely elementary comments are offered next.

Consider a non-rotating planet K at rest in the Euclidean physical space that contains our universe, and let O be the origin of a Cartesian system of coordinates. By rest, it is meant that the orientation of the laboratory relative to two very far cosmic objects (say, two fixed stars of Newtonian mechanics) does not change during the duration of the observation to be performed. Consider a point $P(x, y, z)$ described by the Cartesian coordinates (x, y, z). In cylindrical coordinates the same point is described as $P(\rho, \theta, z)$, and in spherical coordinates by $P(r, \theta, \phi)$, see left side of figure 1.

Further assume that the inhabitants of planet K have already developed units for length and time, similar to the standard meter and second of the 19th century. Let us evaluate the distance from O to P, say on top of a building. Using a rod calibrated against the standard of length, numerical values can be assigned to (x, y, z), and hence, r is evaluated using the Pythagorean theorem:

$$r^2 = \rho^2 + z^2 = x^2 + y^2 + z^2 \,. \qquad (1)$$

Now consider now a good quality gun that always fires small rubber bullets with the same muzzle speed *C*.

Observers at O and P are provided with previously calibrated clocks; the experimenter at O fires his gun towards P at time t_0, the observer at P registers t_1, the arrival time of the bullet; time of flight is $t = t_1 - t_0$, and to a first approximation $r = Ct$. If the clocks are very accurate they may register the difference between the idealized straight line path (only valid in the absence of gravity) and the real path, which is parabolic when gravity is present (see right side in figure 1). Then,

$$r^2 = C^2t^2 = x^2 + y^2 + z^2 \Rightarrow C^2t^2 - (x^2 + y^2 + z^2) = 0 \,. \qquad (2)$$

In the classical era of mechanics, up to the end of the 19th century, numerical differences between *r* and *Ct* in Eq. (2) were consistently attributed to experimental errors in the measurement of *t* and *C*, and to the presence of gravity, wind, air friction, and so on. Only after all those possibilities were exhausted, one could start considering deeper explanations, such as changes in the nature of space, time or velocity. Assume now that there are two different guns A and B, capable of shooting bullets with different muzzle speeds C_A and C_B. The same

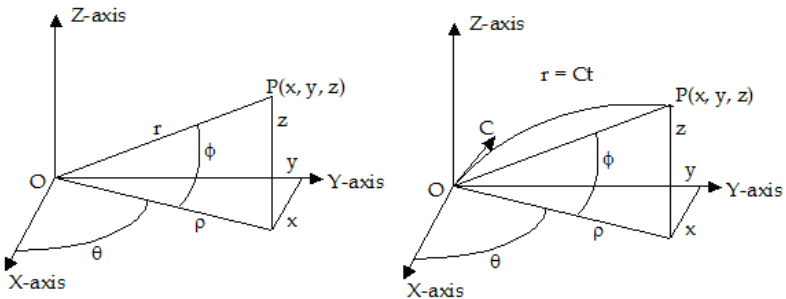

Figure 1. Left side: Point P in Cartesian, cylindrical and spherical coordinates. Right side: Measurement of distance *r* using a high speed bullet with muzzle speed *C*; the parabolic trajectory is exaggerated.

procedure leading to Eq. (2) is repeated firstly with gun A, and then with gun B, to get

$$r^2 = C_A^2 t_A^2 = C_B^2 t_B^2 \quad \Rightarrow C_A^2 t_A^2 - r^2 = C_B^2 t_B^2 - r^2 = 0\,, \tag{3a}$$

$$C_A^2 t_A^2 - (x^2 + y^2 + z^2) = C_B^2 t_B^2 - (x^2 + y^2 + z^2) = 0\ . \tag{3b}$$

Three further comments: (a) the time intervals t_A and t_B are obviously different, but the difference cannot be attributed to fundamental changes in the nature of time, or changes in the internal operation of the clocks. (b) The structure of Eq. (3b) is similar to Lorentz invariance. However, here Eq. (3b) only means that Pythagoras theorem is valid independently of the method used to measure r, without any need to contemplate a redefinition of time. And, (c) Jacques Trempe in the nineteen seventies [56] started from Eqs. (3) for his kinematic derivation of the Lorentz transformations in Galilean invariant space-time, with one of the two observers moving with speed V —*i.e.*, co-moving with the object being observed. Trempe's purely geometric approach is equivalent to Einstein's transformations, but without spacetime entanglement and deformation.

D. MM experiments with bullet guns

Consider now two macroscopic versions of the MM experiment in the inertial laboratory of previous section. In arrangement 1 there are four guns that are part of the interferometer and move with speed V along the X-axis; there are two guns at O, respectively pointing along the X- and Y-axes, and one gun at the end of each arm pointing back to the origin O. The guns at O are simultaneously fired at some arbitrary time t_0, bullets travel with speed C *relative to the apparatus*; when a bullet reaches the end of its arm at distance L, the gun at that end fires a bullet with speed C back towards the origin (see figure 2, left side). The travel time along the X- and Y-axes respectively are $t(X)$ and $t(Y)$ expressed as

$$t(X) = 2L/C, \quad t(Y) = 2L/C \quad \Rightarrow \Delta t = t(X) - t(Y) = 0\,. \tag{4}$$

It is evident that in arrangement 1 there is no time difference for signals travelling along the two perpendicular arms. Consider now arrangement 2 with the guns attached to the ceiling of the laboratory. There are two guns hanging from point O, one oriented parallel to the *X*-axis toward *X*1, the other gun along a line from O to *X*2. A third gun hangs over point *X*1 and points toward O, and a fourth gun hangs over *X*2 and points along the other side of the isosceles triangle, as shown in the right side of figure 2; all bullets travel with speed *C relative to the laboratory*. The apparatus moves with constant speed *V* parallel to the *X*-axis; when the vertex of the interferometer passes underneath point O the two guns fire simultaneously; the guns at *X*1 and *X*2 fire when they receive their respective bullet from O. In this case the travel times $t(X)$ and $t(Y)$ are given by

$$t(X) = L((C-V)^{-1} + (C+V)^{-1}),\ t(Y) = 2L(C^2 - V^2)^{-1/2}\ , \quad (5a)$$

$$\Delta t = t(X) - t(Y) \neq 0\ . \quad (5b)$$

Summarizing, in arrangement 1 no time difference is expected, whereas in arrangement 2 there is a nonzero time difference that would produce fringe shifts; actually, eq. (5) is the same given in the original MM paper [47].

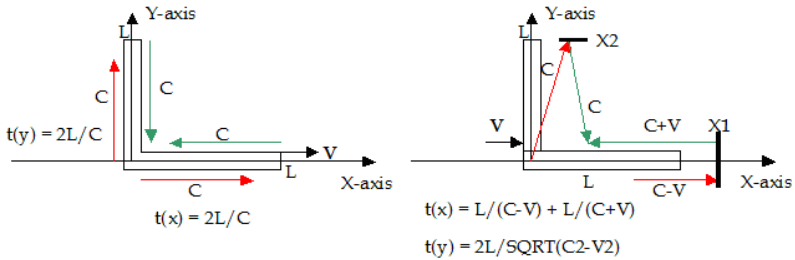

Figure 2.Two arrangements for a ballistic MM experiment. Arrangement 1 (left side): guns are at rest on the apparatus. Arrangement 2 (right side): guns are at rest in the inertial laboratory; the guns for the X-axis arm point along the X-axis, while the guns for the Y-axis arm point along the sides of an isosceles triangle.

The simple ballistic model just explained leads to a deep reformulation of the objectives of the MM experiment. Three (pre-relativistic) classical alternative interpretations of the MM experiment are offered next.

- **Alternative 1: comparison of light emission theories.** The experiment determines whether the light emitted by the source in the experiment moves with constant speed *C* relative to (1) a coordinate frame attached to the apparatus, or (2) relative to a coordinate frame attached to the inertial laboratory. If fringe shifts are observed the answer is (2), if no fringe shifts are observed the answer is (1).
- **Alternative 2**: **comparison of EM theories.** As shown in III.C above, Maxwell theory is the particular case of an electromagnetic detector at rest relative to the dynamical fluid of Hertzian theory. Then, the experiment determines whether arrangement1 or arrangement2 is a correct representation of nature. Explicitly, a null result in the MM experiment supports Maxwellian EM theory, while a non-null result supports Hertzian EM theory. The MM experiment, the thousands of turns in Miller experiments, and our empirical findings [53, 54] clearly support Hertz.
- **Alternative 3: thickness of the boundary layer.** In any classical macroscopic fluid, the material surface and the fluid are at relative rest at the boundary layer. However, the thickness of the boundary layer at the ether-earth interphase is unknown. If the boundary layer is a few meters thick, then the MM interferometer would be immersed in the boundary layer, and the MM experiment corresponds to arrangement 1. But if the thickness of the boundary layer is less than one meter (the laboratory table top), then the interferometer and the ether would not be at rest, as in arrangement 2. The fact that all the classical repetitions of the MM experiment gave a non-zero speed [49] constitutes a strong indication that there is motion between earth and the ether. The fact that the measured

speed was smaller than expected suggests a region of transition in the fluid, from complete rest at the boundary layer to maximum ether speed at the bulk of the fluid. The transition region may also *partially* explain the difference between the large fringe shifts observed with our *laser* light [53, 54], and the earlier MM and Miller experiments with *non-coherent* light [49].

V. Unified field and ether

Toward the end of the 20th century several individuals proposed various dynamical ether models [57, 58, 59], plus Dirac's ether [60], and the dark matter of the current majority view [61]. In the tradition of Le Sage, Tom van Flandern returned to inelastic absorption of corpuscles, and —to avoid criticisms similar to those of Maxwell [27] and Poincaré [28] — he assumed the existence of two separate ethers: a light carrying medium or Elysium, and a gravitational fluid [57]. In our view, such approach is unnecessarily complex.

The present writer finds interesting several traits of Wallace's fluid ether but does not assign inherent attraction to fundamental particles, as Wallace does [58]. Wallace's paper also denounces an almost unknown case of cover-up regarding a violation of the second postulate of Einstein's STR observed in the reflection on the surface of Venus of radar signals; indeed, the propagation of signals is consistent with Galilean vector addition, rather than the Einsteinian STR rule [58, p.385-386; 62].

Whealton [59] classically derived "*Schrödinger and Klein-Gordon equations for free, structureless particles ... from two different continuum approximations to a Boltzmann equation ... of a mixture*," thus bringing to the fore a deep connection between quantum and relativistic descriptions of nature. In our approach, both gravitational and quantum phenomena arise from our novel mathematical solutions for the classical wave equation, which represents the sagionic fluid [63, 64]. Let us briefly

describe three classical kinetic ethers independently proposed by Thornhill, Martin and Múnera to explain the structure and/or forces in nature.

A. Thornhill's rediscovery of Hertzian electrodynamics

In 1985 the English researcher Charles Kenneth Thornhill (1917-2007) proposed a kinetic theory of electromagnetic radiation, where he cogently argued that [45, p. 263]:

> Planck's energy distribution for a black-body radiation field can be simply derived for a gas-like ether with Maxwellian statistics. The gas consists of an infinite variety of particles, whose masses are integral multiples n of the mass of the unit particle.

Thornhill was inspired by the photoelectric effect which indicates "*that in interactions between matter and radiation energy exchanges occur, at any frequency* ν*, in integral multiples of some minimum quantity* $h_0\nu$," that he identified with the mass m of the unit ether-particle. Then, from the thermodynamic description for a gas at T = 2.7 K, Thornhill calculated that "*the mass of a unit ether-particle is* $m = 0.497 \times 10^{-39}$ kg" [45, eq. 4.7]. This result requires a reinterpretation of Planck's equation as:

$$E = nm = nh\nu = nhf. \tag{6}$$

If the electron is one of the particles of Thornhill's gas, then its mass $m_e = 9.109 \times 10^{-31}$ kg [65] contains 1.83×10^9 unit ether-particles.

In a second paper [66], Thornhill starts with Maxwell's equations and works backwards towards fluid theory. For that purpose Thornhill modifies the *partial* time-derivatives appearing in Maxwell's theory and changes them into *total* time-derivatives or convective derivatives. In that way, Thornhill unknowingly rediscovered Hertz electromagnetic theory. Thornhill argued that "*in a gas-like ether, the duality between the oscillating electric and magnetic fields, which are transverse to the direction of propagation of electromagnetic waves, becomes a triality with the longitudinal oscillations of motion of ether*," in that way electromagnetic waves become "*analogous to*

sound waves in a material gas" [66, p. 273]; Thornhill worked out the refraction of light in stationary and moving media [67].

In 1993 Thornhill generalized his ideal-gas-like ether to the case of "*unsteady flow of a general fluid ... at least, when the effects of viscosity and heat-conduction can be neglected*" [68, p. 495]. Since Thornhill accepted the null-outcome of the MM experiment, his theoretical development was strongly constrained; explicitly, he had to accept the validity of Maxwell's equations (see our comments in IV.D above), and assume that ether locally moves with constant velocity relative to the reference frame (Appendix 2 in the original manuscript [68]. Thornhill noted that the alternative interpretation "*that a null result from the Michelson-Morley experiment implies that the apparatus is moving with the local ether, has always been rejected, on the grounds that it is impossible for experimental apparati [sic], moving with different velocities, all to be moving with the uniform ether demanded by Maxwell's equations*."Hence, at that time, Thornhill was unaware of the properties of the boundary layer between the ether and the surface of earth (briefly mentioned above in IV.D above); however, in 2001 Thornhill incorporated the boundary layer in his theory (see below).

In his 1996 paper [69], Thornhill continued his search for an alternative interpretation for the *presumed or claimed* null-result of the MM experiment, and conjectured "*that the Michelson-Morley experiment demonstrates only that the ether has viscosity*." Obviously, Thornhill was aware that the Galilean invariance of Hertzian electromagnetism is far superior to Maxwell's equations, "*which led, by a mathematical freak, to the Lorentz transform*" [69, p. 209]. The null result of the MM experiment led Thornhill in 2004 to address the foundations of relativity; he stated once again that [70, p. 499] "*Maxwell's equations were, and still are, derived for a uniform stationary ether and are not, therefore, the general equations of electromagnetism. The true general equations, for an ether in general motion, have been derived and given in the literature for many years, but are continually ignored*." Thornhill was talking in that context about his own work; it

seems that he never realized that his Galilean invariant equations were anticipated by Hertz in the late 19th century, and that, indeed, they had been almost ignored!

In 2001 Thornhill formally developed his *non-singular ethereal cosmology* [71], work that this author read on May 28, 2015, in the final stage of writing the present paper; I found significant coincidences in our thinking, and sincerely I wish that I had read it earlier. In the abstract Thornhill noted that "*the universe may be finite and have a finite boundary with a true vacuum or void*," concept that closely resembles the physical space proposed by Francesco Patrizi in 1593 [72], space that the present writer denotes as Σ and adopted as one of the metaphysical principles for our theory of nature [73]. Thornhill's ether [71] and our sagionic ether [63, 73] both obey the same homogeneous classical wave equation; let us quote the beginning of Thornhill's paper [71]:

> **The ether concept**. It has been shown [66, 68] that the characteristic wave hypersurfaces and the wave hyperconoid for Maxwell's equations are exactly the same as those for the standard wave equation
>
> $$\nabla^2\phi = (1/C^2)\partial^2\phi/\partial t^2 \qquad (7)$$
>
> in which *C* is a constant wave speed. It is also well-known that Maxwell's equations reduce precisely to the single equation (7) when there is no current or charge distribution. The equation (7) is also found to be [68] the equation which governs the propagation of condensational oscillations or sound waves in any general fluid which is in a uniform state at rest. As such, equation (7), its characteristic wave hypersurfaces and its wave-hyperconoid are not invariant under transformation but unique to one reference frame. [Numbering of references and equation adapted to present paper].

We concur: in our approach, the same wave equation (7) is valid in the preferred frame Σ attached to Patrizi's physical space. It is also relevant to mention that Thornhill correctly noted in the abstract for his cosmological ether that [71]

> It is first necessary to clarify what is meant by 'seeing', 'distance' as distinct from radius of curvature of observed incoming light-waves,

curvilinear rays in an unsteady non-uniform flow, and red-shift as distinct from trivial case of Doppler's principle in a uniform medium at rest.

Thornhill elaborated his ideas in section 1.3 of the main text of [71], describing wavelength and frequency as two different measures of red-shift (see his equations 1.3.2 and 1.3.3), noting that "*in practice it is the frequency red-shift z_ν which is important, since it is the emission frequency which is recognised as the universal signature of a particular atom*."

Regarding the Michelson &Morley experiment, our boundary layer interpretation (IV.D above) agrees with Thornhill's new view of 2001 expressed in his ether paper [71, section 1.8]:

> The Michelson-Morley experiment is usually interpreted in terms of the non-ether concept and this leads to the Lorentz transform and relativity which, in the present context, are considered to be mathematically untenable. In terms of the ether concept and Newtonian mechanics the results of the Michelson-Morley experiment mean, quite simply, that the ether is moving locally with the apparatus and this implies no more than the ether like any other gas, has viscosity. When a body, like the Earth, moves relative to a surrounding fluid that has viscosity a viscous boundary layer is formed around its surface across which the relative velocity between the body surface and the fluid tends to zero as the surface is approached. Thus, experiments near the surface of the Earth will give null results or will, at best, over greater ranges which are still small compared with the boundary layer thickness, determine a relative velocity much less than the true velocity of the Earth relative to the mainstream flow outside its boundary layer.

Our conceptual models agree in many aspects, but we disagree on the physical content of the MM experiment: null in the case of Thornhill, positive in our opinion [49, 50, 51], and backed by our own observations [53, 54]. Thornhill and the present writer thoroughly agree on the Euclidean nature of our space, which leads to a Pythagorean definition of distance in section IV.C above; on his part Thornhill emphasizes the components of speed in 3-Dspace, and criticizes the Einsteinian approach thus [71,section 1.5]:

> The term 'space-time', in fact, is used indiscriminately both to refer to the real four-dimensional metric (x_i, Ct) in which the right spherical

> hypercone is located, and to the imaginary four-dimensional Riemannian metric (x_i, iCt) associated with the Lorentz transform and special relativity.

Finally, we also agree regarding the similar nature of sound and light waves, both of them propagating in a fluid. Regarding waves and the many classes of the ether, Thornhill wrote [71, section 1.2]:

> One of the last of these, prior to the advent of the non-ether concept, suggested that the ether must behave like an elastic solid, since Maxwell's equations show that the electromagnetic waves are transverse. Oscillations in the electromagnetic field-strengths, however, are not condensational oscillations of an ether, and so the suggestion could not be a valid one.

Our approach for demonstrating the sound and light equivalence was different: it has been shown that, contrary to conventional wisdom, Maxwell's equations also contain longitudinal components [74].

Thornhill and this writer disagree regarding the overall state of the ether and the mechanism for the generation of gravity. Reasoning by similitude with his experience at the British Ministry of Defence during the second world war, Thornhill considered that the universe, including the ether will go expanding forever, so that a frame of reference attached to the ether is accelerated, and according to Newtonian mechanics [71, section 1.9]:

> This force per unit mass towards the centre of the universe experienced by all masses (matter and ether) in the rest-frames of all material observers is seen to provide completely for the phenomenon of gravitation.

On the contrary, currently we do not have any opinion regarding whether the universe —including the ether— is expanding or not, but we both agree that the behaviour of ether in 3-D space is described by equation (7), whose solutions up to now are only harmonic. However, we consider more relevant our novel solutions, found in the mid-nineteen nineties, which contain longitudinal and nonperiodic components [75]. Regarding gravity, we have proposed a Le Sagian mechanism for the generation and propagation of gravitation [16]; our approach

incorporates scattering in addition to absorption, thus becoming immune to the destructive criticisms of Maxwell [27] and Poincaré [28, p. 242-249].

Towards the end of his long and productive life, in 2006 Thornhill wrote on stellar aberration [76], and his last unpublished short note on universal physics ends thus [77]:

> If Maxwell had been acquainted with Euler's general equations of fluid motion he would have derived the general electromagnetic equations for an ether in general motion rather than the particular equations for a uniform stationary ether. No one, then, would ever have heard of Relativity.

B. Trempe's Lorentz transformations à la Galileo Galilei

In the obituary that Adolphe Martin (1919-2008) wrote for his friend Jacques Trempe (1919-1990) he recalled that they met in 1948, and that shortly afterwards he (A. M.) started work on his gaseous ether; in early 1960 Martin and Trempe started regular meetings every Friday evening in downtown Montreal "*trying to interpret the Lorentz transformation in Galilean space-time*" [78]. Martin also recalls that in 1970 Trempe found that if the Lorentz equations are written in Costa de Beauregard hyperbolic form, then [78]:

> The Lorentz transformation is applicable to Galilean space-time, where the laws of classical mechanics are invariant ... [which] unites classical mechanics with electromagnetism.
>
> After 1971, we each investigated a different but complementary problem. Jacques was assigned to determine if the new transformations would be based upon different coordinates, but keep the same angles in both Einsteinian and Galilean space-time. I, meanwhile, looked into the possibility of retaining the Einsteinian coordinates in Galilean spacetime with different angle measurements.

The results of those three decades of work were published mostly in the early nineteen nineties; Trempe's findings as [56, 79, 80], and Martin's as [81, 82]. In Martin's words his achievement was [82, p. 47]:

> By interpreting Relativity in Galilean space and time, it was found that the time of light reception by an observer moving relative to a source is a

different event from the reception of the same light by an observer at rest. The Einstein viewpoint considers these two events to be the same, thus introducing the Special Relativity paradoxes.

Trempe summarized his findings thus [79, p. 121]:

> A new theory of light propagation is introduced by showing that the Lorentz transformation is applicable in Galilean-invariant space-time ... This form of the equation of an ellipse is then shown to be a Lorentz transformation, proving that the Lorentz transformation is a pure geometrical transformation of spatial coordinates, with no inherent relationship to space-time.

In short, Trempe considered two observers O and O′ at the origins of two systems of coordinates in relative motion with speed V along the X-axis. As shown in figure 3, the coordinates of point P on an ellipse measured by O and O′ respectively are $(x, w = Ct)$ and $(x', w' = C't')$. Trempe found that those coordinates are related by a Lorentz transformation. However, such geometrical relationship has nothing to do with the nature of space and time.

It is well-known that the process of measurement is at the heart of the foundations of both Einstein's STR and quantum mechanics, and as

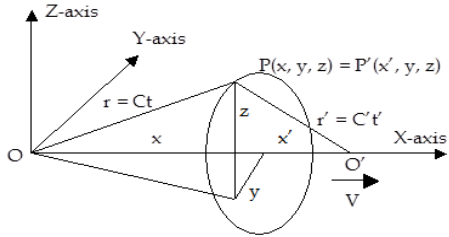

Figure 3. The foci of an ellipse on the X-Y plane are at O and O′; a point P on the ellipse is at distances r and r' from foci O and O′. Distance may be calculated with Pythagoras theorem, Eq. (1), using (x, y, z) measured with a calibrated rod; alternatively, distance r may be obtained from the time-of-flight t of a bullet travelling with speed C from O to P. A similar procedure is valid for observer O′. An ellipsoid is generated by rotating the ellipse around the X-axis, so that point P = P′ describes a circle.

such received significant attention during the whole 20th century. In contrast, in classical mechanics the meaning of measurement when observers (or, detectors) and emitters are in relative motion received little attention. It was not clear how to handle simple situations, as the motion of light along the transversal arm of the Michelson interferometer [46], leading to a mistake in Michelson's 1881 calculations; error that was noted by Lorentz, and corrected by Michelson & Morley in the 1887 paper [47]. Perhaps, some years before, immediately after the experiments of Fizeau involving relative motion of light and water, the need for a classical theory of measurement was already evident —but neither the discussion of Fizeau experiment, nor the M&M experiment was ever stated in terms of (a lack of a) theory of measurement.

So, when the procedure for data reduction used by Michelson & Morley led to a relative velocity between light and ether that was smaller than Michelson's expectations, they did not know what to do. Last paragraph in the main text of the1887 M&M paper is a naïve description of the bewilderment and hopeless confusion that M&M felt [47, p. 458-459]:

> It appears from all that precedes reasonably certain that if there be any relative motion between the earth and the luminiferous aether, it must be small; quite enough entirely to refute Fresnel's explanation of aberration. Stokes has given a theory of aberration which assumes the aether at the earth's surface to be at rest with regard to the latter, and only requires in addition that the relative velocity has a potential; Lorentz then proposes a modification that combines some ideas of Stokes and Fresnel, and assumes the existence of a potential, together with Fresnel's coefficient. If now it were legitimate to conclude from the present work that the aether is at rest with regard to the earth's surface, according to Lorentz there could not be a velocity potential, and his own theory also fails.

For the present writer it is unbelievable that those confused sentences mean that Michelson and Morley found a so called "null" result; further, I also find difficult to reconcile the sense of hesitation that transpires in the quoted conclusion of the M&M paper with Poincaré's

categorical view: "*les résultats indubitables des expériences de Michelson*" ("*the indubitable results of Michelson's experiments*") [83, p. 316; 84, p. 253]. Be it as it may, the historical fact is that to explain the presumed null-result of the M&M experiment, Lorentz and, independently, FitzGerald advanced hypotheses of length contraction in the direction of motion; then—to explain Lorentz hypothesis—Henri Poincaré proposed his principle of relativity [85, 86]. According to the translation of the Palermo Rendiconti [86] by Schwartz [87, p. 1288], Poincaré said:

> It seems that this impossibility to disclose experimentally the absolute motion of the earth is a general law of nature; we are led naturally to admit this law, which we call the *Postulate of Relativity*, and to admit it unrestrictedly. Although this postulate, which up till now agrees with experiment, must be confirmed or disproved by later more precise experiments, it is in any case of interest to see what consequences can flow from it.

It is evident that for Poincaré his principle of relativity did not have logical or metaphysical status, but only an empirical origin. The principle could be overthrown by further observations. According to Poincaré, the Lorentz transformations in modern notation were [86, p. 132; 87, p. 1289]:

$$x' = \gamma(x - \beta w),\ w' = \gamma(w - \beta x), \quad \gamma = (1 - \beta^2)^{-1/2}, \tag{8a}$$

$$y' = ly, \quad z' = lz, \quad l = l(\beta). \tag{8b}$$

Although it is not obvious that Poincaré actually read the original papers as hinted by the "*indubitable result*" quoted above, Poincaré was extremely impressed by the *claimed* null-result of the MM experiment, but it is not clear whether he meant the 1881 Michelson experiment [46], or the 1887 Michelson & Morley experiment [47]. Some examples of Poincaré's flattering words for Michelson are:

> One day Michelson thought out a much more delicate process [28, p. 219].
>
> Methods were diversified; finally Michelson carried precision to its utmost limits; nothing came of it [83, p. 311; 84, p. 248].
>
> Michelson has shown, as I have said, that the methods of physics are powerless to put absolute motion in evidence; I am convinced that in the case of *astronomical methods it will be the same*, no matter how far precision

> may be carried. However that may be, the data which astronomy will furnish in this direction will one day be valuable to the physicist. In the mean time I believe that the theorists, keeping in mind the experiments of Michelson, may count on a negative result, and ... (emphasis added) [83, p. 321; 84, p. 257].

It is worthwhile to stress that Poincaré only mentions Michelson as the creator of the famous ether experiment —he never mentioned Morley. The only occasion that Poincaré mentioned Michelson and Morley in the 1904 conference [84, p. 314; 85, p. 251] was for the repetition of Fizeau's experiment carried out around 1886 upon a recommendation of Lord Kelvin to Morley during the Baltimore Lectures. At any rate, that passing mention indicates that Poincaré was following in some detail the development of Michelson's work, so that it is rather strange that he disregarded strong criticisms addressed to the M&M experiment between 1898 and 1902 by Sutherland [88] and Hicks [89] in prestigious journals (such as *Nature* and *The Philosophical Magazine*) easily available to Poincaré. Also note that Poincaré was quite convinced that the relativity principle would be supported in the future by astronomical observations.

Against the previous backdrop, the works of Trempe [56, 78, 79] and Martin [80, 81] may be considered pioneering efforts towards a classical theory of measurement along the lines started by Poincaré. In his theory of the electron Poincaré considered "*a sphere carried along with the electron in its uniform translational motion*" and noted that the Lorentz "*transformation will change it into an ellipsoid whose equation is easily found*" [86, p. 133; 87, p. 1290]. The ellipsoids of Poincaré and Trempe might be related, but the present writer will not delve into that matter. Likewise, for the time being, I do not take sides in the controversy regarding Einstein's and Poincaré's principles of relativity [39, 90].

One may wonder what would be the position adopted by Poincaré if he were alive at the beginning of the 21st century. As quoted above, he clearly stated that his principle of relativity "*up till now agrees with*

experiment, must be confirmed or disproved by later more precise experiments" [87, p. 1288]. The following new information could be given to Poincaré:

- Almost all MM-type experiments have produced (large or small) positive results, thus casting doubts on the *interpretation* of the MM experiment. Examples are: the 1887 MM experiment itself [47], Miller's thousands of measurements [48], all other MM-type experiments up to 1930 [49], and my own work [53, 54].
- Even the outcome of a well-controlled experiment involving cavity-stabilized oscillators performed by a prestigious group at Stanford University shows diurnal harmonic oscillation: see fig. 2(a) in reference [91]. In 2002 the present writer predicted daily variations in a stationary MM-experiment [50], which are clearly supported by the observations of the Stanford group. However, they did not consider the possibility that the observed harmonic variation was related to the motion of earth, arguing instead that "*mechanical disturbances occasionally gave rise to a perceptible drift of the beat frequency amounting to a few MHz [millihertz] per day. We therefore fitted each record with*" a harmonic function defined by their eq. (4) [91]. In their Table 1, the Stanford group listed the parameters of their fitting function for *thirteen* instances (in days 1, 3, 18, 26, 59, 78, 80, 95, 98) of the so called "*occasional... perceptible drift*"; the fitted-curve —which represents the contribution of earth motion to the velocity of light— was *subtracted*, and the residual plotted as fig. 2(b) [91]. Of course, the residual does not contain any harmonic effect on the frequency of electromagnetic radiation —as the effect was eliminated by the subtraction. The residual was then interpreted as a more precise limit for Lorentz invariance! Obviously, the residual should be zero after the baby had been thrown out with the bathwater!

My personal guess is that Poincaré would recant, abandoning his principle of relativity. Then, there would be a place for a classical theory of measurement *without* the constraints of a null-result in the M&M

experiment. The present writer intends to tackle that problem in the near future along the line of thought in IV.D above.

Let us continue now with Martin's gaseous atomic ether, which he claimed was capable of explaining all known physical phenomena [92 - 95]. As a fitting environment for an atomistic theory, the first paper was delivered in Olympia, Greece; the introduction stated [92, p. 209]:

> Assuming the existence of a gas permeating all space and matter, we conclude that the mechanical properties of gases, known for over a century, are sufficient to explain the known physical phenomena such as electromagnetism, light propagation, gravitation, quantum mechanics and the structure of elementary particles, including the photon.

- Relative to the cosmic microwave background radiation (CMB), the local group of galaxies moves at speed of 627 km/s and our sun at 369 km/s in well defined directions [65]. This demonstrates that it is possible to detect motion relative to an energy-like substance (*i.e.*, the CMB) that fills the 3-Dspace, thus avoiding the need for *material* beacons, such as Newton's fixed stars! Moreover, the 2006 Nobel Prize in physics was awarded to John C. Mather and George F. Smoot for measuring the CMB anisotropy.

C. Adolphe Martin's cosmons

Martin's ether obeys the equations of the kinetic theory of gases, and is formed by discrete objects behaving as a "*gas ether*" [92, p. 212]:

> The ether particles are considered the smallest entities in the Universe, they are also the only substantial entities. These grains of cosmos will be referred to as "cosmons." Cosmons are individual spheres of a definite diameter and volume. Between cosmons we assume that there is an absolute void which cannot transmit any signal. Thus at the cosmon level there are no fields or forces. As the cosmons have no moving parts, they possess no internal energy and, according to Einstein, no rest mass (inertial or gravitational), no charge (electric or color) and no spin, since friction does not occur at this level. Hence, a cosmon is a boson.

Ten years later, Martin still held the same view [95(b), p.1]: "*cosmons are assumed the smallest units and only substance in the Universe*."It is not the

first time in the history of science that several people at well separated locations have reached the same idea about the same time. In this case Thornhill in England and Martin in Canada worked over the same time-span on a very similar kinetic gas model for the ether. My personal approach (see next section) focuses on the general fluid equations applied to a fundamental fluid formed by energy-like sagions (that may be identified with Martin's cosmons as described above). The only differences being that I explicitly identify "*substance*" as energy, and that I stress that ether behaves as a fluid, rather than the more limited notion of a gas. However, Martin acknowledges that "*cosmonic gas can behave as a liquid when concentration N nears N_{max} with mean free path approaching cosmon diameter... It can even take the form of a solid crystal at $N = N_{max}$ with no mean free path...*" [95(c), p. 4]. Regarding the speed of cosmons, Martin stated:

> Due to their agitation and lack of rest mass, cosmon velocities vary from zero to indefinitely high values. Interchange of velocity components when cosmons encounter other cosmons produces a velocity distribution similar to Maxwell's [92, p. 213].
>
> Cosmon speeds, due to mutual encounters, follow the Maxwell velocity distribution of gas kinetic theory. This gives cosmon speeds from zero to tremendously high speeds > 10^{10}c, but with number densities reducing asymptotically to zero toward the two extremes [95(c), p. 4].

In contrast, the present writer considers that speeds of sagions have a more complex probability distribution. Indeed, both sagion-sagion and cosmon-cosmon interactions conserve linear momentum and kinetic energy, but sagion-matter interactions may be inelastic in the sense that kinetic energy is not conserved. Rather, internal energy of matter may increase or decrease in a sagion-matter interaction —of course, always obeying conservation of total energy. The added complexity of sagion-matter interactions may lead to a non-Maxwellian probabilistic distribution of sagion speed.

I also have a further comment regarding the logical existence of cosmons with $V = 0$. By definition, a cosmon is immaterial, so that it does not have rest-mass, and if it is at rest in the absolute Galilean 3-Dspace, it carries no-energy. So, what kind of substance is the cosmon with $V = 0$, without mass and without energy? This implies that Martin should have defined that Probability $\{V = 0\} = 0$, rather than $\lim_{V \to 0} \Pr\{V\} = 0$, as implicitly done in the quotation above [95(c), p. 4].

Using the standard kinetic theory of gases Thornhill calculated that "*the mass of a unit ether-particle is* $m = 0.497 \times 10^{-39}$ kg" [45, eq. 4.7], and Martin [94, p. 157] estimated a similar "*cosmon mass-energy equivalent* $(=5kT/(2c^2), T = 2.736\ K)$" as 1.0506×10^{-39} kg [95(a), p. 45], thus agreeing in the order of magnitude —as expected since both of them invoked Maxwell's distribution for the particles of the gas.

For completeness it is mentioned in passing that in the context of non-zero photon rest-mass, in the nineteen nineties Vigier interpreted the claimed null-result of the MM experiment as a relativistic rest-mass of the photon of 10^{-68} kg [96]. The present writer carried out a similar calculation using Newtonian velocity addition obtaining a rest-mass of the photon between 10^{-38} and 10^{-37} kg depending on the value selected for the motion of earth (30 to 300 km/s) [97], values equivalent to around ten to a hundred cosmons. However, my present view is similar to Martin's in the sense that the photon is formed by energy-like sagions, and hence it does not have intrinsic rest-mass. Therefore, my previous calculations must be interpreted from this new viewpoint.

Continuing with the parallel between Martin and Thornhill, both of them emphasized the importance of polytropic gases, and the right-hand (three-finger) rule in hydrodynamics and electromagnetism —Martin in [94] and Thornhill in [66].

Martin and Thornhill differed on the description of the ether gas; as already mentioned in section V. A, Thornhill emphasized Euler's conservation equations, while Martin chose the thermodynamic

description of the gas, and focussed on the equations for the ideal and non-ideal gas. According to Martin, the ideal gas equation accounts for QED, while gravity is represented by the volumetric term appearing in the Clausius equation for a non-ideal gas [92]: the temperature-dependent volume *b* of the gas molecules is interpreted by Martin as proportional to the constant "*cosmon sphere of exclusion*"[94, p.156]. Martin's mechanism for gravity involves local cooling "*which transforms the internal energy of each element of volume into kinetic energy of free fall*" [94, p. 159].

In contrast to Thornhill, who merely scratched the surface of the subject [77], Martin obtained a model to represent all fundamental particles as circular and spherical (or spin) vortices [93, 95], thus reviving the 19th century smoke-ring models of Helmholtz and Kelvin [22, 23, 24]. Martin's work on this subject was simultaneous with other more detailed revivals of vortices, such as Ginzburg's spiral field theory [98].

D. Sagions

After discovering the new nonharmonic solutions for the classical wave equation in the mid-nineteen nineties [75], the present writer started a revision of some properties usually ascribed to Maxwell's equations, such as the conventional belief that the electromagnetic field *only* contains transversal components. I was also curious about Dirac's idea that a magnetic monopole should also exist from symmetry considerations; in this latter regard it was surprisingly found that simple vector algebra over the pair (**E**, **B**) leads to *symmetrised* Maxwell's equations *without* a magnetic monopole in terms of (**P**, **N**), where $\mathbf{P} = \mathbf{B}+\mathbf{E}$, $\mathbf{N} = \mathbf{B}-\mathbf{E}$ [99]. So, to my mind it was crystal clear that the magnetic monopole belongs in the realm of the unicorn; however, as of 2014 the search still goes on: "*isolated supermassive monopole candidate events have not been confirmed*" [65, p. 179]. Of course!

The symmetrised Maxwell's equations [99] also uncovered significant redundancies in the standard Maxwell equations:

(i) If the continuity equation is an independent condition, then only one source and one induction equation are independent; or, alternatively, the continuity equation is a useless condition, overdetermined by the redundancies.

(ii) To convert Maxwell's equations into wave equations, the Coulomb gauge is not necessary, which immediately implies that the standard Maxwell's equations over (**E**, **B**) are also compatible with longitudinal solutions, a prediction that was immediately confirmed [74]. The existence of a longitudinal component is also consistent with Dirac's formal theory; as a result, a longitudinal component was added to Majorana's photon [100, 101]. At a deeper level, longitudinal components in EM imply that (at least, some) electromagnetic waves are similar to sound waves, thus making both of them compatible with *fluid* ether, rather than solid ether.

(iii) The fact that the pair of vectors (**E**, **B**) may be expressed in terms of a single vector potential **A**, and a scalar potential ϕ, implies that the pair (**A**, ϕ) is both more economical and more fundamental than the triplet (**E**, **B**) and ρ (the electric source). Therefore, Maxwell's theory reduces to two classical wave equations for (**A**, ϕ) —one vector and one scalar wave equation. The only remaining challenge was to find the physical (as opposed to mathematical) meaning of the independent variables (**A**, ϕ).

A related question is the meaning of the EM field, in particular whether it is a mere mathematical construct or whether, on the contrary, it contains some elements of reality [102]. For instance, what happens to the EM fields associated with an electron and a positron when the particles suddenly disappear by mutual annihilation at time t_a. Explicitly, assume that at t_a the EM fields are acting upon a test particle; there are two possibilities: (a) the fields instantly disappear, which brings in the

thorny issue of instantaneous propagation of information; or (b) the fields continue acting during some time $t>t_a$ which means that they are somehow independent of the charges that caused them. A similar situation arises in the reverse process of production of a pair of charged particles from a photon interacting with a strong EM field [103]. For the present writer infinite speeds and action-at-a-distance both belong in the realm of magic, so that alternative (a) is rejected. Therefore, alternative (b) implies that the field is not a mere mathematical tool, but also has existence of its own, or, even better, that "field" is a short name for processes taking place in an objective substance, that we have identified with the ether. Assuming that ether behaves as a classical fluid, it then obeys the classical wave equations. This provides a clear physical meaning for the potentials ($\mathbf{A}$, ϕ).

In May 1999 while preparing a paper [100] to be presented at the CPT symposium in Zacatecas, I suddenly realized that Einstein's tensor equation of general relativity is simply the same as the scalar and the vector classical wave equations for a fluid. It was an instance of what Poincaré calls *mathematical discovery*, where "*one is at once struck by these appearances of sudden illumination, obvious indications of a long course of previous unconscious work*" [28, p. 55]. Later on I was advised that my "mathematical discovery" was a mere rediscovery of a fact well known to the specialists. Be it as it may, electromagnetism and gravity can be described by the same ether. The organizers of the CPT conference were kind enough to allow me to present an additional late paper containing some hasty ideas on a realistic four-dimensional hydrodynamic ether interpreted as a unified field equation [104]. For the particular case of non-viscous and uncompressible fluid ether, a straightforward calculation leads to an electromagnetic force containing a couple of additional terms [105].

In my1999 model the 3-DEuclidean space was a projection along the w-axis of a Riemannian four dimensional space ($w = Ct, x, y, z$). In that

early paper, ether was formed by *preons*, described as non-rotating discrete *material* particles in permanent motion, each one occupying a portion of 3-Dspace; two preons could not occupy the same portion of 3-D space over the same lapse of time. A flow of preons entering3-D space from the fourth dimension w constitutes the source of a repulsive force (say electric), while a flow of preons leaving 3-D space towards the fourth dimension w acts as the source of an attractive force (either gravitational or electric), thus solving the problem of infinities that still plagues physics. In that context the photon was modelled as composite particle [106, 107]. It was reassuring to find two years later, that Arthur Schuster had suggested the same far-fetched idea in 1898, *i.e.*, a hundred years before I did [108].

My 4-Dmodel had the advantage of directly unifying EM and gravity, without the Einsteinian assumption that space-time is a sort of deformable object; in our case, the "deformable object" is ether, which may adjust and change its shape in the same way as the macroscopic fluids around us (air, water, *etc*.).Furthermore, some of my novel solutions in spherical coordinates [75] have the nice property of being the same under Lorentz-invariant transformations and neo-Galilean invariant transformations (see next section), thus making equivalent the interpretation of the fundamental fluid as existing in a 3-D space which is a projection of 4-D space, and the interpretation that the said fluid exists in a 3-D Euclidean space plus a temporal dimension.

During the first eight years of the 21st century I taught Newtonian mechanics for physics majors at the department of physics of National University in Bogotá. As soon as I started teaching in 2000 when explaining Newton's concept of mass I felt the same uneasiness Hertz reported in the eighteen nineties [40]. Looking for a solution, in several courses I started from conservation of linear momentum, rather than from Newton's laws; this procedure is very economical in principle, and according to Ockham's rule is thus preferable [109]. It also means that

force is no longer a primitive notion; instead, it is just a name for the average exchange of momentum. So, there is no need to find a mechanism for the propagation of force (gravitational or otherwise). The gravitational problem thus reduces to finding a viable classical mechanism to explain the inverse-square law with collisions. One possible mechanism is the shadowing of ether proposed by Le Sage in the 18th century [18, 19]; to solve the heat problem addressed to Le Sagian ether by Maxwell [27] and Poincaré [28, p. 242-249], this writer analysed the preon-matter interaction in more detail, and introduced scattering in addition to absorption [16]. To honour Le Sage's pioneering work, our 1999 preons were renamed sagions in 2011.

After solving the heat problem in gravity [16], by the end of 2011 I could again continue extending my ether model to other forces. As is well known, the first unified force of nature is due to Boscovich [110], who placed his force at point centers; this force also had the property of acting before actual contact between particles. I immediately dismissed the Boscovich force for three reasons: it seemed to be *inherent* to mass, and emanated from a presumably *point* center, and when at short range, it *acted at a distance*. However, Boscovich was a good philosopher (while I am not a philosopher at all), so I checked for the reasons behind his choices, which appear in his *Theoria Philosophiae* [110], and also in Jammer [1, p. 170-178]. In short, Boscovich argues that all Cartesian exchanges of linear momentum violate the Leibnizian principle of continuity. Indeed, Boscovich's argument is correct if material bodies cannot deform, but it is incorrect when one allows for deformability of material bodies. Then, if one accepts *both* Leibnitz's principle of continuity and the principle of conservation of linear momentum in collisions between material particles (as I do), one is implicitly assuming that matter is soft and *deformable* at all scales. This has a deep implication: matter has internal structure and contains internal parts down to the smallest bit of matter. Thus, the smallest bit of matter can*not* possibly be a structureless sagion.

The logical Leibnizian principle and the physical principle of linear momentum conservation can be harmonized if the sagion is redefined as an *energy-like* object, rather than a material object; if it is an energy-like object, the rest-mass of the sagion strictly is zero, all other properties of the sagion remain the same [16]. My current theory of nature was presented at two conferences held in Baltimore in November 2014 —the Vigier IX [63] and the NPA [73] meetings; in short, the fundamental fluid is formed by energy-like sagions pervading a strictly 3-D Euclidean space, Newtonian time is a completely different dimension. Force is not a primitive notion, but merely describes the exchange of linear momentum in interactions between sagions and matter. Every sagion occupies a portion of 3-D space and is the smallest object in Nature. Photons are solitons in the sagionic fluid, formed by myriads of sagions. The smallest bit of matter is a bi-sagion, which is formed at rest in the 3-D Patrizi space as the outcome of the frontal collision of two sagions. Furthermore, matter and sagions are interconvertible in both directions, via the annihilation and materialization processes discovered in the 20th century [103].

E. Classical wave equation in spherical coordinates

Consider the spherical coordinates (r, θ, ϕ) shown in the left side of figure 1. Lorentz transformations are conventionally expressed in Cartesian coordinates, with an observer O′ in motion with speed V along the positive direction of the X-axis. One may arbitrarily choose the direction of a ray r in spherical coordinates so that it coincides with the direction of the X-axis; then, the Lorentz transformations defined by equations (8) become

$$r' = \gamma(r - \beta w),\ w' = \gamma(w - \beta r), \quad \gamma = (1 - \beta^2)^{-1/2}. \tag{9}$$

Given that the Euclidean 3-D space is isotropic, the Lorentz transformations are valid for any ray r, independently of the direction (θ, ϕ), thus making the conventional eq. (8b) unnecessary.

As argued in previous sections, our sagionic ether is described by the 3-D classical wave equation (7) for $\Phi(x, y, z, t) = \Phi(r, \theta, \phi, t)$ in spherical coordinates. The D'Alembertian $\Box$ is implicitly defined as:

$$\Box\,\Phi(r,\theta,\phi,t) \equiv (\nabla^2 - \partial^2/\partial w^2)\Phi = 0, \quad w \equiv Ct\,. \tag{10}$$

Our novel solution for eq. (10) is [75]:

$$\Phi(r,\theta,\phi,w) = Y(\theta,\phi)I(r) + Y(\theta,\phi)Q(q), \quad q \equiv w/r\,. \tag{11}$$

The novel solution is formed by two inherently quantized components:

A *time-independent* quantized background $\Phi_0(r, \theta, \phi) = Y(\theta, \phi)I(r)$, where $Y(\theta, \phi)$is the standard spherical harmonic function, and $I(r)$ is a polynomial dependent on the quantum number $\ell = 0, 1, 2, ...$[75]. The permanent existence of this term in the ether fluid accounts for many thus far unexplained phenomena in the conventional quantum theory based on the Schrödinger equation rather than in the non-linear equation (10).

A *time-dependent* Lorentz-invariant and Galilean-invariant quantized spherical flow $\Phi_1(r, \theta, \phi, w) = Y(\theta, \phi)Q(q)$. Instead of being harmonic, as in the conventional Fourier-type solution $\exp\{i(\omega t+\mathbf{k}\bullet\mathbf{r})\}$, our quantized solution is formed by three new nonperiodic functions of the first, second and third kinds $S_\ell(q)$, $T_\ell(q)$,$U_\ell(q)$, defined in [75]:

$$Q(q) = K_1 S_l(q) + K_2 T_l(q) + \eta U_l(q)\,. \tag{12}$$

As usual, the values of the arbitrary constants K_1 and K_2 are selected to comply with the boundary and initial conditions; the third constant $\eta$is another novel quantum number, which plays the role of the principal quantum number in the non-relativistic Schrödinger's quantum theory. Let us briefly stress two significant properties of our new solutions (a more detailed treatment appears in a forthcoming paper elsewhere):

1) **Quantum mechanics from the fluid equation.** It is well known that at the beginning of the 20th century Schrödinger's first choice for representing quantum phenomena was the classical wave equation (10), that he disregarded from considerations based on superposition.

Before Bohr and Schrödinger had proposed their theories of quantum mechanics, J. J. Thomson noted in 1907 [111] that the Boscovich force [110] could explain various recently discovered quantum phenomena, but at that time the Boscovich force was not attractive because it lacked mathematical support; for a recent list of phenomena that may be explained by the Boscovich force see [112]. What is the connection with our novel solutions for the wave equation? Simply, Boscovich force is one of the families of our functions $S_\ell(h)$ of the first kind.

2) **Function Q(q) is Lorentz-invariant and neo-Galilean-isomorphic.** The Lorentz invariance of the classical wave equation (10) has been well known since Poincaré [85, 86]. Our solutions have distance and time variables combined in the novel variable q. Substituting the Lorentz transformation eq. (9) one gets q' for an observer in motion:

$$q' = w'/r' = \{\gamma l(w - \beta r)\}/\{\gamma l(r - \beta w)\} = (w - \beta r)/(r - \beta w) \,. \quad (13)$$

It is noteworthy that the controversial parameter γ linked to length contraction and time dilation has simply disappeared from eq. (13). Also note that the right-hand side of equation (13) is the same (*i.e.*, *isomorphic*) for any arbitrary functional form of γ and l, which includes the case of a neo-Galilean transformation defined as

$$r' \equiv r - Vt, \quad t' \equiv t - \beta r/C \,. \quad (14)$$

For a neo-Galilean observer in motion, the value of q' is obtained from equations (14) as

$$q' = Ct'/r' = C(t - \beta r/C)/(r - Vt) = (w - \beta r)/(r - \beta w) \,. \quad (15)$$

The extreme right-hand side of equations (13) and (15) is the same, so that the function has the same value under a Lorentz-transformation or a neo-Galilean transformation. Therefore, the novel function $Q(q)$ has the extraordinary property of being the same for a large class of observers in motion, which includes Lorentz-invariant and neo-Galilean transformations. As such, it may

be part of a covering group for relativistic and classical theories —a conjecture that is left open for mathematicians to elucidate.

As stressed at a recent international conference [64], the new surprise is that the novel solutions of the classical wave equation immediately lead to quantized gravitational structures in the sagionic ether.

VI. Concluding remarks

The three ethers independently propounded by Thornhill, Martin and Múnera towards the end of the 20th century are all dynamic fluids, constituted by discrete objects called unit ether-particles by Thornhill, cosmons by Martin and sagions by Múnera. The three ethers share several properties: all of them are formed by discrete entities exhibiting 3-D extension and motion. Martin's cosmon is a boson, and Múnera's sagion is an energy-like object, both with strictly zero rest-mass; although the lines of reasoning leading to cosmons and sagions were different, the two objects are very similar. In all cases the speed V is variable, and the average speed is assimilated to the local speed of electromagnetic radiation. The three ether models are intended to be general theories of nature, including an explanation of all forces; however, we differ in our emphasis. Thornhill concentrated on Galilean invariant electrodynamics, Martin on modelling particles, and I myself on electrodynamics, in Le Sagian gravity, and in the microscopic interactions. But there are some differences in the descriptions of the fluid, in the external constraints imposed, and in the mechanisms to explain electromagnetic and gravitational forces.

For Thornhill and Martin ether is a gas, while Múnera describes it as a fluid, which in our local solar system may be treated as a gas, but it may behave as liquid at earlier times, or in other regions of the universe. However, Martin also acknowledges that his gas may behave as a liquid or a solid under some conditions [95(c), p. 4]. Martin distinguishes

between a contiguous medium (like water) and a discrete medium (like air) [95(c), p. 2], while we stress the fact that our fundamental fluid is formed by discrete objects (the sagions); the apparent continuity of water or any other liquid or solid is a mere artefact of the resolution of the instrument (say, the microscope) used to observe the liquid or solid. Then, a fluid is not continuous in a mathematical sense. To describe his ether Martin chose the ideal gas law, and the extension of Clausius to non-ideal gases. Thornhill's description of his ether in terms of Euler's equations allows a natural extension to regions where, or to epochs when, the ether did not behave as a gas. For both Thornhill and Múnera the ether obeys the homogeneous classical wave equation (10).

Thornhill and Martin both accepted the conventional interpretation of the Michelson & Morley experiment as null. Martin explains the null MM experiment *via* Trempe's geometrical Lorentz transformations in Galilean space and time; as discussed in V.B, Trempe's findings might be related to Poincaré's ellipsoids. To explain the MM experiment, Thornhill proposed a boundary layer between the ether fluid and the earth in relative motion, which is consistent with usual fluid theory, and also coincides with my own view stated in section IV.D. In the boundary layer interpretation, the M&M experiment is related to the thickness of the boundary layer, and has nothing to do with contrived contractions of length, or with far-fetched effects upon time and space. In the language of the 19th century ether, the discussion focussed on entrained versus non-entrained ether —qualitative notions that might be related to the boundary layer of fluid theory.

Thornhill and Martin are both Newtonians, thus facing the difficult task of explaining the origin or mechanism leading to the generation of Newtonian forces. It may be recalled that Newton himself insisted that gravity was *not* an inherent property of matter, but in the *Principia* he did not commit himself to any mechanism that might explain the origin of force. In Múnera's neo-Cartesian approach, force is a straightforward

result of sagion-matter collisions. On this regard, many authors have noted a deep connection between the Cartesian and Einsteinian approaches to gravity, for instance [1, p. 260]:

> Gravitation in general relativity has not the character of a force. It is a property of space-time. Mechanical events are thus accounted for by purely geometrico-kinematic conceptions. Descartes's program has finally been carried out by Einstein! It is only natural, therefore, that general relativity does not include —at least not as a rigorous law— the principle of action and reaction nor its most important dynamical consequence concerning the motion of the center of mass.

In some senses the sagionic ether described by the homogeneous classical wave equation goes farther than Einstein's general relativity. For instance, our neo-Cartesian approach strictly obeys conservation of linear momentum, and, as a consequence, Newton's action-reaction principle is strictly fulfilled. Furthermore, the novel solutions for the ether equation are consistent with both Lorentz-invariance and neo-Galilean invariance, and also lead to a non-linear quantum theory, thus unifying gravity, electromagnetism, and quantum phenomena. Consequently, the sagion ether would seem to be the answer to Einstein's dream for a unified force of nature. Einstein failed because he interpreted his general relativity equation as a representation of space-time, while we interpreted our similar fluid equation (10) as a straightforward 3-D fluid.

For completeness we mention another little known effort towards unification: as an extension of his kinetic theory of gravity [33], Brush carried out several experiments to find connections with electromagnetism, leading him to suggest in 1929 a unified spectrum for electromagnetic, gravitational and quantum phenomena [113]. In Brush's spirit, table 1 shows all scales of nature as a spectrum of sagionic ether waves; of particular interest is the identification in the nineteen nineties of ultra low frequency (ULF) electromagnetic waves associated with earthquakes [114-117]. The conventional view is to search for gravitational waves over "*a considerable frequency range from* 10^{-4} *Hz for*

large black hole interactions through 10^{-3} - 10^{-2} Hz for fast binary stars to 10^{3} Hz for stellar collapses" [118, p. 111]. The lower region of this frequency range coincides with ULF and with telluric and seismic waves. In our unified approach to nature ULF waves and gravity waves are manifestations of a common phenomenon: ether waves. The boundary between small and local scale phenomena (usually described as electromagnetism) and large scale phenomena, (conventionally described as gravity) is in the ULF region. In this regard, note that the conventional upper limit for the rest-mass of the photon [65] coincides with the 5 mHz frequency of the Spitak (Armenia) earthquake [117], which is the lowest ULF measured thus far; also it may not be a coincidence that the wavelength of such ULF is the same as the sun-earth distance, which in turn defines the gravitational dynamics of our earth. Likewise, the conventional upper limit for the graviton mass [65] coincides with the energy of an ether wave whose wavelength equals the observable universe.

Table 1.Spectrum of sagionic ether waves

f, Hz	λ, m 3 x	E, eV 4.14 x	Distances, sizes, frequencies & comments
10^{-18}	10^{+26}	10^{-33}	Observable universe: 1.3 x 10^{26} m. Graviton mass < 6 x 10^{-32} eV[65]
10^{-15}	10^{+23}	10^{-30}	Diameter of local galactic group: 3.1 Mpc = 9.6 x 10^{22} m
10^{-12}	10^{+20}	10^{-27}	Sun- Milky Way galaxy center: 2.6 x 10^{20} m
10^{-9}	10^{+17}	10^{-24}	Closest star: 4.1 x 10^{16} m. Oort cloud > 7.5 x 10^{15} m
10^{-6}	10^{+14}	10^{-21}	Eris aphelion: 1.5 x 10^{13}m. Photon mass < 1 x 10^{-18} eV [65]
10^{-3}	10^{+11}	10^{-18}	Sun-Earth: 1.5 x 10^{11}m.ULF: Spitak earthquake f = 5 mHz
10^{0}	10^{+8}	10^{-15}	Earth-Moon: 3.8 x 10^{8} m, ULF, Allais pendulum f=1Hz
10^{+3}	10^{+5}	10^{-12}	Surface earth to ionosphere: 1.5 x 10^{5} m
10^{+6}	10^{+2}	10^{-9}	Medium (long) radio waves: f = 1 MHz (f = 10 kHz)
10^{+9}	10^{-1}	10^{-6}	GPS, cell phones, radar and microwaves: f = 1 GHz
10^{+12}	10^{-4}	10^{-3}	At T = 2.73 K: λ = 5.6 mm, f = 54 GHz, E =2.2 x 10^{-4} eV
10^{+15}	10^{-7}	10^{0}	Blue light: λ = 3.8x 10^{-7} m, f = 7.9 x 10^{14} Hz
10^{+18}	10^{-10}	10^{+3}	X-rays
10^{+21}	10^{-13}	10^{+6}	Gamma-rays from electron-positron annihilation: 0.511 MeV
10^{+24}	10^{-16}	10^{+9}	Proton radii and mass ≈ 0.78-0.88 x 10^{-15} m and 0.94 GeV [65]
10^{+27}	10^{-19}	10^{+12}	Brush's "gravitation" and "quanta waves": f = 1.2 x 10^{27} Hz [113]
10^{+43}	10^{-35}	10^{+28}	Planck length and mass: 1.6x10^{-35} m and 1.2x 10^{28} eV [65]

According to Zwicky, there are no clusters of clusters of galaxies [119], but table 1 may provide a slightly different view, as follows. The energy of ether waves in the large-scale region (say 4.14×10^{-30}eV) suffices to hold together a cluster of galaxies such as our local group, and the energy of ether waves at the scale of the universe (4.14×10^{-33}eV), suffices to hold together the universe, which is then a cluster of clusters of galaxies.

Coming down to the terrestrial scale, for thirteen years in the nineteen forties and fifties Guido Buffo carried out observations with a Foucault pendulum in Argentina; he claimed that his pendulum exhibited erratic behaviour several days before an *earthquake* [120, p. 39-40]; the frequency of oscillation of a 25 meter long Foucault pendulum is around 0.1 Hz, similar to the frequency of ULF associated with large magnitude earthquakes (f < 0.1 Hz) [113-117]. Likewise, the frequency of the Allais pendulum is about 1 Hz, similar to the frequency of an ether wave whose wavelength equals the distance earth-moon. Then, the anomalous behaviour of Allais pendulum during solar eclipses might be related to resonance with stationary ether waves between earth and moon. The possible connection between pendulums and resonant ether waves opens a new avenue for interpretation of gravity anomalies during solar eclipses.

For completeness, table 2 shows the scale that the late Adolphe Martin had for the microworld seeming "*to have a quantum step of* 10^{-5}" [95(c), p. 5].

Table 2.Scales of the microworld according to Adolphe Martin

Scales	In meters	Comments
Human	1	
Molecules MFP	10^{-5}	MFP: mean free path
Molecules, atoms	10^{-10}	Orbits of electrons
Electrons, nucleons	10^{-15}	Orbits of quarks
Quarks	10^{-20}	
Cosmons	10^{-25}	
Planck length	10^{-35}	

The present author will not enter into sterile controversies with those claiming that "*modern ether theory is relativistic*" [121, p.25], further stating that [121, p. 16-17]:

> It will require *hundreds* of undisputed detections of ether drift, carried out by impartial investigators in first class laboratories, all over the world, with impartial witnesses, and publication of meticulous records, before the normative status of Einstein's relativity is called into question [emphasis added].

It is simply stated that modern day zealots do not understand Popper's principle of falsification, which requires only one experiment to falsify a theory. Einstein accepted the principle. Regarding Dayton C. Miller's work, Einstein clearly accepted that[122, p. 2283]

> The existence of a not trivial positive effect would affect very deeply the fundaments of theoretical physics as it is presently accepted.

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