THE AETHER

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Abstract

The existence of the electromagnetic aether is argued from two standpoints. Conceptual, based on the nature of physical waves. And practical: the various experimental measurements that demonstrate it. Possible reasons for the strange nullification of the positive 1887 Michelson-Morley aether-wind result are discussed.

CONTENTS

Preamble

To leave the main body of the text as uncluttered as possible, cross-references and 'asides' are placed in footnotes. The end-notes contain source references only. In the Internet case they comprise the main site name, with year and month of access in brackets.

Contrary to custom, quotations in general are not *de rigeur* with all the (...)s and [...]s in the right places. They may be abridged, or combined with others from the same source. But their meaning is never consciously distorted. Whenever possible, the original source reference is given. Italics in general are "ours".

Since the English language in its wisdom does not provide non-gender-specific pronouns, for "he", etc. in general read "he/she" etc.

Due to the common ground between this and the companion 'Einstein' article[1], there is some repetition.

Thanks are due principally to Barry Cavell and Stan Heshka, who read the original text and made many useful comments, most of which got incorporated. Also to Nick Landell-Mills and Arthur Mather who likewise gave valuable feedback.

INTRODUCTION

'**Aether**'

The "aether" today is a scientific verbal obscenity, the "unspeakable ae-word" that no professional physicist shall ever be heard to utter on pain of being branded a deranged crackpot and saying goodbye to his hopes of a successful career:

> "The concept of an aether was long ago discarded as a relic of 19th century voodoo science."[a][2]

Robert Laughlin[b]:

> "The word 'aether' has extremely negative connotations in theoretical physics, due to its opposition to Relativity. This is ironic, because it nicely captures the way most physicists think about a vacuum[3]."[4]

The aether nevertheless has a long distinguished pedigree. The word derives from the Sanskrit *akasha*, which can also simply mean 'space'. References to it are common in Greek, Egyptian and Indian philosophy from the 5th century b.c. onwards, where it was conceived as the material filling the 'aethereal' region above the terrestrial sphere, being described as:

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[a] This would include the likes of James Clerk Maxwell.

[b] Robert Laughlin (1950-) of Stanford University, physics Nobel Laureate.

> "The most subtle substance in creation, the mother of all other phenomena."[5]

Homer[6] uses it in the sense of "fresh air" or "clear sky", the pure essence breathed by the gods[7]. Anaxagoras[a] speculated that atoms[b] are vortexes in the aether; an idea that was taken up in modern times by Lord Kelvin[c][8].

In the medieval cosmos, the innermost terrestrial sphere was made[d] of the four classical elements: fire, earth, air and water. The outer celestial sphere containing the heavenly bodies was "quintessence" (the '5th essence'), effectively the aether.

Light

In the early scientific era of the 17th century there were two conflicting theories of light. Based on its properties of reflection and travelling in straight lines, Isaac Newton[e] held it to be a *stream of particles*. But this did not explain *optical dispersion*, where a beam of white light is split up by a glass prism into a rainbow of colours. Neither did it account for *diffraction*, where light passing a small hole or narrow slit causes fringes on a screen.

Both of these phenomena are consistent with the *wave model* proposed Christian Huygens[f]. That light has a *characteristic speed c* and a *frequency f* are also wave properties. Since physical waves require a *medium*, Huygens propounded a l*uminif-erous aether*, conceived at the time as essentially homogenous and stationary in space.

Mainly due to his greater prestige, Newton's corpuscular theory held sway for more than 100 years. Max Planck[g] spoke of Huygens as "having dared to contest the mighty emission theory of Sir Isaac Newton"[9]. Although in fact the corpuscular theory wasn't even "Sir Isaac's". It was first formulated in the 10th century by the Arab polymath Ibn al-Haytham[h], who wrote in his "*Book of Optics*":

> "Light rays are streams of minute particles, lacking all sensible qualities except energy."[10]

This is essentially the modern concept of a photon.

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[a] Anaxagoras (~500-428 b.c), pre-Socratic Greek philosopher.

[b] For the likewise pre-Socratic Greek philosopher Democritus (460-370 b.c.), atoms were the hypothetical invisible smallest components of all matter.

[c] Lord Kelvin (William Thompson) (1824-1907), Irish mathematician and physicist.

[d] Conceived as made.

[e] Isaac Newton (1642-1727), English physicist.

[f] Christian Huygens (1629-1695), Dutch physicist.

[g] Max Planck (1858–1947), German physicist.

[h] Ibn al-Haytham (965–1040), Arab mathematician and astronomer. .

But then in 1803 the English physician Thomas Young[a] performed his famous *double-slit experiment* that demonstrated the *interference property* of light. This being explicable in wave, but not in particle terms, after this the corpuscular theory started to go out of fashion, and by the mid 1800's had been generally abandoned in favour of a wave model.

And when in 1865 James Maxwell[b] calculated from the electric and magnetic properties of a vacuum (the aether[c]) that electromagnetic waves should travel through it at the known speed of light of 300k km/s, the ondulatory nature of light was generally accepted. As was likewise the existence of its medium the luminiferous aether.

It is interesting that at one point Newton also cogitated an aether, writing in his 1704 *Opticks*:

> "Is not the heat of a warm room convey'd through a vacuum by the vibrations of a much subtiler medium than air, which remained after the air was drawn out? And is not this medium the same as that by which light is refracted and reflected?"[11]

But he then apparently had second thoughts, arguing that:

> "Such a medium would have to extend everywhere in space, and would disturb and retard the motions of the planets and comets. So there is no evidence for its existence, and it ought to be rejected."[12]

Newton seems to have conceived the aether in *mechanical* terms. In fact it appears to be *purely electromagnetic*, with electric and magnetic but no mechanical properties[d].

That light travels at a *finite speed* was first proposed by the Greek philosopher Empedocles[e], who held that the Sun's rays take time to reach the Earth. The earliest quantitative measurement was made in 1676 by the Danish astronomer Ole Römer[f], based on the eclipses of Jupiter's moons. His value of 200k[g] km/s was however too low, due his taking the time light takes to cross the Earth's orbit as 22 min rather than the true 16 min. Correcting for this gives 275k km/s, close to the actual 300k km/s.

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[a] Thomas Young (1773–1829), English physician and polymath.

[b] James Maxwell (1831–1879), Scottish physicist.

[c] p.2, note.

[d] Density, etc. Below.

[e] Empedocles (490-430 b.c.), pre-Socratic Greek philosopher.

[f] Ole Römer (1644–1710), Danish astronomer.

[g] 'k' = thousand.

Einstein

Contrary to what is often believed, Einstein[a] was a strong supporter of the aether. He somewhat half-heartedly rejected it in his 1905 Special Relativity paper, writing:

> "The introduction of a 'luminiferous aether' will prove to be superfluous."[13]

But in 1919 he apparently had second thoughts, since he wrote in a letter to Lorentz[b]:

> "It would have been more correct if I had limited myself to emphasizing only the nonexistence of an *aether velocity*, instead of arguing its total nonexistence."[14]

And in his 1920 Leiden address he finally resoundingly brought it back again:

> "Recapitulating, we may say that according to the General Theory of Relativity space is endowed with physical qualities. In this sense there exists an aether. Space without an aether is unthinkable. Not only would there be no propagation of light, but also no standards of space and time."[15]

This evidently directly contradicted his original 1905 statement. But then, Albert was no stranger to contradiction[c16]

CONCEPTUAL

Waves

Experimentally light behaves both as waves and as particles – the so-called *wave-particle duality*. For present purposes its wave behaviour is of most interest.

A wave[d] is not itself a material object. It is an *event*, a time-dependent *disturbance* propagating through a *physical medium* at a *characteristic speed c* determined by the properties of that medium:

wave = disturbance propagating through a medium

When one throws a pebble into a pond, the disturbance spreads out as ripples propagating over its surface at a characteristic speed determined by the properties of the water medium. The same holds for *sea waves*, Fig. 1a[e], the disturbance here being caused by the wind.

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[a] Albert Einstein (1879–1955), German theoretical physicist.

[b] Hendrik Lorentz (1853-1928), Dutch physicist.

[c] Relativity article.

[d] Here always a *physical* wave, as opposed to the mathematical variety.

[e] 'Absolute' = with respect to the Earth's surface.

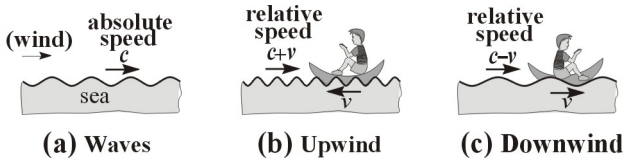

Fig. 1. Sea waves.

For a boat sailing upwind at speed *v* though the water, Fig. 1b, the velocity of the waves relative to it is then the sum of the two velocities *c*+*v*. When the boat sails downwind, Fig. 1c, the waves overtake it at the difference of the two speeds *c*–*v*.

The same applies to *sound waves*, pressure disturbances propagating through the air medium at a characteristic speed *c*=1240 km/h determined by its properties[a], Fig. 2a.

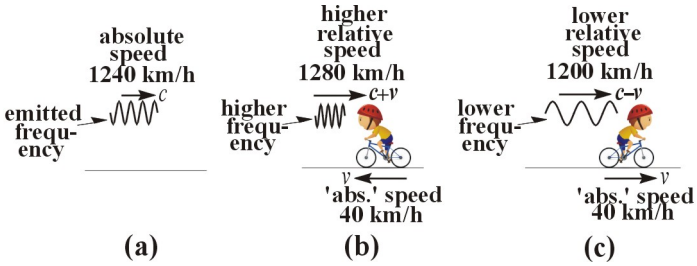

Fig. 2. Sound waves.

When a cyclist pedals at speed v=40 km/h in the opposite direction to the sound waves, Fig. 2b[b], their speed relative to him is the sum of the two speeds *c*+*v*=1280 km/h. And he experiences them as 'bunched up', with a higher frequency than if he were at rest[c] – the so-called *Doppler effect*[d].

Conversely, when pedalling in the same direction as the sound waves, Fig. 2c, they overtake him at the difference of the two speeds *c*–*v*=1200 km/h. He here experiences them as 'spread out', with a lower frequency than if he was at rest[e].

If one takes a length of rope and shakes one end up and down, Fig. 3, *rope waves* travel down it at a speed determined by the mechanical properties of the rope medium; and so on.

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[a] Its density and compressibility (below).

[b] Assuming no wind.

[c] Fig. 1b.

[d] Named after the Austrian mathematician and physicist Christian Doppler (1803-1853). When standing beside a motorway, the sound frequency of approaching cars is higher than that of receding ones, and falls abruptly as they pass.

[e] Fig. 1c.

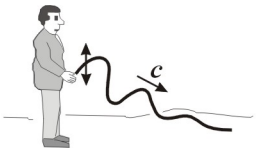

Fig. 3. Rope waves.

The idea of waves without a medium – pond or sea waves without water, sound waves without air, rope waves without a rope, light waves without a corresponding luminiferous aether[a] – is nonsensical[b]. A wave is a *disturbance*. And for there to be a disturbance, *something* (some physical thing) has to be disturbed. One can't have a disturbance of nothing. In the humdrum everyday world we live in there can be no smile on the face of a Cheshire cat without a Cheshire cat.

Maxwell:

> "Whenever energy is transmitted from one body to another, there must be a medium, or substance, in which the energy exists after it leaves one body and before it reaches the other".[17]

Albert Michelson[c]:

> "The undulatory theory of light assumes the existence of a medium, the aether, whose vibrations produce heat and light, and which is supposed to fill all space."[18]

Acccording to Thomas See[d], Michelson openly rejected Einsteinian Relativity on the grounds that:

> "It does not account for the transmission of light, but holds that the aether should be thrown overboard"[19]

See himself later said[e]:

> "A strange tendency has arisen in recent years for abandoning the aether as an unecessary hypothesis."[20]

Henri Poincaré[a]:

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[a] Defined for present purposes as "that which light is conceived as a disturbance propagating through".

[b] 'Non-' + 'sensical' = doesn't make sense.

[c] Albert Michelson (1852-1931), American physicist of 'Michelson-Morley experiment' (below) fame.

[d] Thomas See (1866-1962), American astronomer.

[e] In 1920.

> "We know whence comes our belief in the aether. If light takes several years to arrive to us from a removed star, it must be sustained somewhere and supported, so to speak, by some material."[21]

Hendrik Lorentz[b]:

> "I cannot but regard the aether as endowed with a certain degree of substantiality, however different it may be from ordinary matter."[22]

Stephan Gift:

> "It is important to note that Lorentz defended the concept of the aether right up to his death in 1928."[23]

Paul Dirac[c]:

> "It is natural to regard light as the velocity of some real physical thing[d]. So we are forced to have an aether".[24]

John Bell[e]:

> "The aether was wrongly rejected on the purely philosophical grounds that what is unobservable does not exist"[f25].

Characteristic speeds

The characteristic speed c_s of sound waves through the air is given by:

$$c_s = \sqrt{\frac{1}{\rho\varepsilon}} = 1240 \text{ km/h} \qquad \text{(eq.1)}$$

where ρ, ε are the density and elasticity[g] respectively of the air medium.

Similarly, the characteristic speed c of light through a vacuum is:

$$c = \sqrt{\frac{1}{\mu\varepsilon}} = 300\text{k km/s} \qquad \text{(eq.2)}$$

where μ, ε are its magnetic permeability and electrical permittivity.

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[a] In 1900.

[b] In 1906, a year *after* Einstein's Special Relativity paper.

[c] Paul Dirac (1902-1984), English theoretical physicist.

[d] Cf p.2, note.

[e] John Bell (1928–1990), Irish quantum physicist, in a 1951 interview.

[f] QM article.

[g] Or 'compressibility', the inverse of its bulk modulus K_s.

Magnetic permeability μ being associated with electrical inductance, it is effectively 'electric inertia'[a]. Electrical permittivity ε being associated with electrical capacitance, it is effectively 'electric elasticity'[b].

The mathematical expressions for the characteristic speeds of light and sound[c] are thus *exactly analogous*. Again strongly suggesting that both refer to essentially the same phenomenon, namely the propagation of a physical disturbance through a physical medium.

And if – as mainstream Relativity maintains – light is a "mediumless wonder", a disturbance of nothing propagating through nothing, the questions it has to answer are:

– 1) in this case, *what determines* light's characteristic speed *c*=300k km/s?
– 2) is it *a mere coincidence* that this is exactly the speed one would predict for an electromagnetic disturbance propagating though a medium with the electric and magnetic properties of a vacuum[d][26]

These are both excellent questions, to which Relativity to date has provided no coherent answers.

EXPERIMENTAL (1)

Michelson

A good starting point for the experimental evidence for the aether is the famous (some might say "infamous") 1887 *aether-wind measurement* carried out by Albert Michelson and Edward Morley[e] at the Case School of Physics in Cleveland, USA.

Albert Michelson was born in Strelno, Prussia. When he was two his family emigrated to the USA, where he grew up firstly in small mining towns where his father was a merchant. And then for his high school years in San Francisco, where he lived with an aunt.

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[a] Applying a force to a mass, the motion takes time to build up. Applying a voltage (electrical force) to an inductor, the current (electrical motion) takes time to build up.

[b] Applying a force to a spring, it at first cedes, but then builds up an opposing force. Applying a voltage (electrical force) to a capacitor, it at first cedes, but then builds up an opposing voltage.

[c] Eqs.1,2.

[d] Aether (p.2, note).

[e] Edward Morley (1838–1923), American physicist.

Fig. 4. Albert Michelson.

As an academically outstanding, but financially impoverished student, in 1869 Michelson was awarded a special appointment to the U.S. Naval Academy by the US president Ulysses Grant. There he excelled excelled in optics, heat, climatology and drawing. After graduation, and a further two years at sea, in 1875 he returned to the Naval Academy to become an instructor in physics and chemistry.

Having decided to pursue a career in physics, in 1880 he obtained leave of absence from the Navy to study in Europe, spending time at universities in Berlin, Heidelberg and Paris. In 1881 he resigned from the Navy. And in the following year returned to the USA to take up an appointment as Professor of Physics at the Case Western Reserve University in Cleveland[27].

Michelson 1881

That light is electromagnetic waves had been confirmed by Maxwell in 1864. Their existence was first demonstrated experimentally by Heinrich Hertz in 1887. Since waves imply a medium, in this case the hypothetical luminiferous aether, experiments to determine its properties had high priority in 19th century physics.

Measurements of stellar aberration had led to two main theories. The first, formulated in 1818 by Augustin-Jean Fresnel[a], held that the aether is essentially *stationary in space*[b] – for practical purposes within the solar system. In which case there should be a measurable aether wind of some 30 km/s at the Earth's surface, its orbital speed around the Sun, Fig. 0-5.

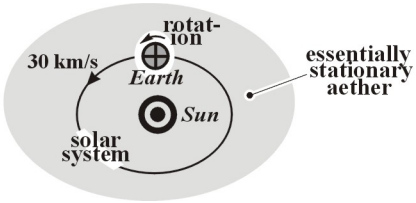

Fig. 0-5. Earth's orbit.

[a] Augustin-Jean Fresnel (1788-1827), French civil engineer and physicist.

[b] Or at the most, only partially dragged along by the Earth.

In 1844, however, George Stokes[a] put foreward an alternative *aether entrainment* theory: that the aether is "dragged along" by Earth[28]. In this case there should be little or no detectable aether wind on Earth.

Michelson's experiments were designed to test for these two hypotheses. And not for the existence of the aether itself, which was virtually universally accepted by the physicists of his time. He wrote in the introduction to his 1887 report:

> "The experimental trial of the first [Fresnel] hypothesis forms the subject of the present paper".

The interferometer he used is shown schematically in Fig. 6a. A beam of light is split into 'main' and 'perpendicular paths. These are then recombined to form an *interference pattern* on a screen.

An aether headwind on the main axis would make the average speed of light along it *slower* than on the perpendicular axis, resulting in a 'fringe shift', a displacement of the interference pattern. From this the aether speed can be calculated.

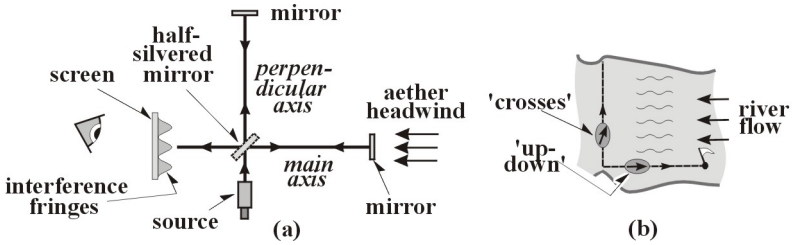

Fig. 6. Michelson-Morley (1).

An analogy is two twins swimming in a river, Fig. 6b. One, the "crosses" twin, swims across the river and back again. Due to the river's flow, he has to head upstream somewhat and takes longer to cross than if the river were stationary.

His "up-down" brother swims the same distance, but first upstream and then back again. Because the time he loses on his upstream leg is not compensated by his gain on his downstream leg, he ends up taking longer than his 'crosses' brother.

In interferometer terms, a slower light travel time on the main axis would imply the existence of an aether wind.

Michelson's first interferometer was designed and built in 1881 during his time in Hermann von Helmholtz's[b] laboratory in Berlin. It is shown in Fig. 7.

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[a] George Stokes (1819-1903), Irish mathematician and physicist.

[b] Hermann von Helmholtz (1821–1894), German physician and physicist.

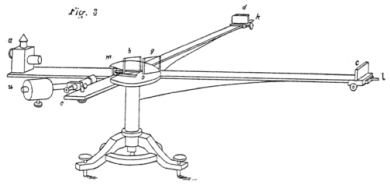

Fig. 7. Michelson's 1881 interferometer[29].

In spite of its being mounted on a solid stone pier, however, due to the instrument's extreme sensitivity to vibrations it soon became apparent that it couldn't be used in a city like Berlin. It was accordingly moved to the quieter grounds of the *Astrophysicalisches Observatorium* in Potsdam. But even there, although under ordinary circumstances the fringe shifts were measurable, Michelson noted that:

> "Stamping on the pavement 100 meters from the observatory could make the fringes disappear entirely!"[30]

Apart from this, there were a number other practical problems due to temperature variations, mechanical distortion of the arms during rotation, etc.

The aether speeds obtained with this instrument were considerably less than the 30 km/s Michelson expected on the Fresnel hypothesis. In view of this, and the further experimental uncertainties, he concluded that Fresnel's stationary-aether theory could not be substantiated, reporting that :

> "The interpretation of the results is that there is no displacement of the interference bands. The hypothesis of a stationary[a] aether is thus shown to be incorrect."[31]

Stokes' theory of complete aether dragging was thereby implicitly confirmed.

Michelson-Morley 1887

In 1885 Lord Rayleigh[b] wrote to Michelson urging him to repeat his 1881 experiment with greater accuracy[32]. Michelson by now being Professor of Physics at the Case School, he accordingly began a collaboration with Edward Morley, Professor of Chemistry at the Western Reserve University situated on the same campus.

The improved interferometer they created together is shown in Fig. 8. To minimize the thermal and vibrational effects that had dogged Michelson's previous experiment, it was assembled in the closed heavy stone basement of a Case school dormitory. Vibration was further reduced by mounting it on a large sandstone block floating in a circular trough containing 275 kg of mercury. The sensitivity was improved by increasing the light paths to ten times their previous value by repeated reflection.

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[a] Within the solar system.

[b] Lord Rayleigh (John William Strutt) (1842-1919), English scientist.

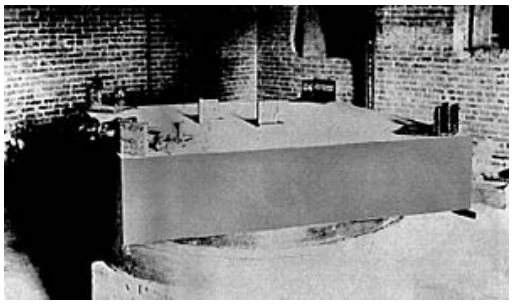

Fig. 8. Michelson's 1887 interferometer[33].

The mercury trough allowed the instrument to turn with close to zero friction. Given an initial push, it would rotate slowly for many minutes while the fringes were observed through a telescope. But even so they could at times disappear completely due to distant thunderstorms, passing horse traffic, etc. And the observer could easily "get lost" when they returned[34].

A total of 36 sets observations were made over four days in July 1887, during an hour at noon and an hour at six o'clock in the evening[35]. In 1998 Héctor Múnera reanalyzed the results using modern statistical methods. He found that they gave at a 95% confidence level aether speeds of:

– midday readings: $v_{e\in}$ [a] = 6.22+/-1.86 km/s
– evening readings: $v_{e\in}$ = 6.8+/-4.98 km/s[36]

They are plotted in Fig. 0-9. The somewhat higher value and the greater spread of the evening readings are explicable[b].

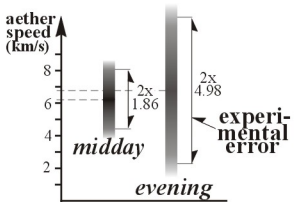

Fig. 0-9. Michelson-Morley results.

Compared to the 1881 experiment the results were this time *definitely positive*. But since they were still well below the 30 km/s expected on the Fresnel stationary aether hypothesis, Michelson reported that:

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[a] Using the subscripts 'e' for 'Earth' and '∈' for 'aether'.

[b] Below.

> "The relative velocity of the Earth and the luminiferous aether was certainly not one fourth, and probably not one sixth, of the Earth's orbital velocity [of 30 km/s]."[37]

In August 1887 he wrote to Lord Rayleigh saying:

> "The result is decidedly negative [for the Fresnel theory]. The deviation of the interference fringes from zero was not the expected. It follows that if the aether does slip past, the relative velocity is less than one sixth of the Earth's[a]."[38]

Michelson himself never questioned the aether's *existence*. But only the extent to which it is entrained by the Earth's motion. This is evident from the title of his two papers: "*The Relative Motion of the Earth and the Luminiferous Aether*". In spite of being a religious agnostic, Michelson firmly believed in the aether to his dying day[39]. Obviously, since his own experiment had confirmed it.

Nullification (1)

In spite of Michelson-Morley's clearly positive aether-wind result[b], well outside his experimental error, it later:

> "Came to be said to be within the range of an experimental error that would allow it to be actually zero."[40]

This is the famous "null" result quoted in most physics textbooks. It made Michelson's "the most famous failed experiment in history"[41], and gained for him a physics Nobel prize[c], the first American ever to receive one[42]. After this the aether went out of fashion.

As just seen, however, the M&M result was *very definitely not zero*. And they themselves did not report it as such. So how could it have "come to be said" to be null within experimental error? Dayton Miller[d] commented in 1933:

> "The indicated effect was *not* zero. The conclusions published in 1887 stated that the observed relative motion of the Earth and aether did not exceed one fourth of the earth's orbital velocity. This is quite different from the null effect now so frequently imputed to this experiment."[43]

Anyway, then because something is less than expected doesn't make it "null". And since when have "experimenters' expectations" been a valid criterion for judging a scientific experiment? To the contrary, Science purports to be open-minded and

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[a] Ditto.

[b] Averaging the noon and evening readings: ~6.5 km/s (Fig. 0-9), .

[c] In 1907. "For his optical precision instruments".

[d] Dayton Miller (1866–1941), American physicist and astronomer.

objective, and to proceed from experimental results to explanatory theories and not vice-versa. And since when has "coming to be said" been accepted scientific methodology?

In their final report M &M made the further important qualification that:

> "In what precedes the motion of the solar system is not considered[a]. The experiment will therefore be repeated at intervals of three months, and all uncertainty will be avoided. "[44]

This they unfortunately never did. Had they done so, the course of modern physics could well have been very different.

And even if M&M *had* obtained a null result, as they themselves recognized, that wouldn't have established the aether's non-existence. But simply that its speed is zero *at that particular point* in the Earth's orbit.

Sagnac

In 1913 Georges Sagnac[b] mounted an interferometer on a circular platform rotating uniformly around a vertical axis. The interference fringes were recorded on a photographic plate. They were found to change position both with the sense of the platform's rotation[c], and also with its angular velocity.

Sagnac considered his experiment to be conceptually similar Michelson-Morley's. He reported his results in two papers bearing the titles[d]:

> "The *existence of the luminiferous aether* demonstrated by means of the effect of a relative aether wind in a uniformly rotating interferometer" (italics ours)

and:

> "On the proof of the *reality of the luminiferous aether* with the experiment of the rotating interferometer."

In 1925 Michelson and Gale repeated the experiment with a very large fixed interferometer ~650m x 360m in size, using the Earth itself as the disc and its angular velocity as the rotation.

In spite of their results being consistent with Sagnac's, however, physicists of the time showed little interest in them, as if they posed no challenge to Relativity. Einstein never mentioned them in his publications[e45].

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[a] Above.

[b] Georges Sagnac (1869–1928), French physicist.

[c] Clockwise or counterclockwise.

[d] In French.

[e] He wouldn't, would he!

μ_0, $\mathcal{E}_0$

Physical objects have physical properties. If something had no physical properties, we wouldn't discriminate or recognize it, and it wouldn't be anything (any physical thing) for us.

A 'vacuum' is defined in a dictionary[46] as "a space entirely devoid of matter". And so cannot have *material* ('matter-ial', effectively 'mechanical') properties – density, elasticity, viscosity, etc. But that doesn't exclude *non-material*[a] attributes. Because a vacuum has a measurable magnetic permeability μ_0 and electrical permittivity $\mathcal{E}_0$, given by[b]:

$$\mu_0 = 4\pi \times 10^{-7};\ \ \mathcal{E}_0 = 8.85 \times 10^{-12} \qquad \text{(eq.3)}$$

it by definition 'is something physical' and exists[c].

Synonyms for a 'vacuum'[d] are "void, nothingness, vacuity". Making it an unsuitable term for something that exists physically. We prefer the traditional "aether".

Dayton Miller

In 1900 Morley was joined at the Case School by Dayton Miller. Together they increased the interferometer's sensitivity by extending the lengths of its arms[e] to three times the original values, and made various other improvements.

Fig. 10. Dayton Miller in 1921[47].

Measurements in 1905-6 in Cleveland gave a still positive, but nevertheless lower value of ~3.5 km/s[f48]. Remembering however that since very small '2nd order' differ-

---

[a] Not-mechanical.

[b] The determinants of the speed of light *c* (eq.2, p.8).

[c] Strictly: will be said to exist.

[d] In the same dictionary.

[e] The parallel and perpendicular paths, Fig. 6a

[f] Although still definitely positive in terms of the experimental error.

ences[a49] of around one part in a million[b] were being measured, some variation was to be expected.

From 1906 onwards Miller continued experimenting alone. His most important work was done during 1925-6 on top of Mt Wilson in California at 1750 m above sea level. The idea was again to reduce the effect of any possible aether entrainment[c], the aether being dragged along by the Earth .

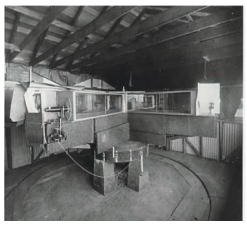

Fig. 0-11. Miller's Mt Wilson interferometer[50].

Miller made ~12'000 sets of observations[d], as opposed to Michelson-Morley's 36. And since he made them over the course of a year[e], he was able to eliminate the effects of the Earth's orbit and calculate the velocity[f] of the *solar system* through the aether. He obtained an aether velocity of[g]:

$$v_{s\in}{}^{h} = 8.22 \pm 1.39 \text{ km/s @ } (5.2\text{h}, -67^{o})^{i}$$

in the direction of the *Dorad*o (Swordfish) constellation in the Great Magellanic Cloud[51].

Whereas Michelson-Morley, who could only measure the *projection* of the aether wind onto their interferometer plane at one point in the Earth's orbit[j], obtained a correspondingly lower aether speed.

Fig. 12a shows specimen Miller readings[a], and Fig. 12b,c his averaged overall results[52].

---

[a] Due to the $(v/c)^2$ term in the Lorentz factor (eq.4, p.20). The Earth's true aether speed is around 0.1% of that of light (below).

[b] A difference of 10 cm in a journey of 100 km.

[c] p.11.

[d] Rotations of the interferometer.

[e] What M&M recognized needed doing, but never did.

[f] Magnitude and direction.

[g] At a 95% confidence level.

[h] Solar system ('s') with respect to the aether ('$\in$').

[i] (α=5.2 hrs, δ=–67°). Using the symbol '@' to mean "in an astronomical direction" (p.40).

[j] Fig. 0-9.

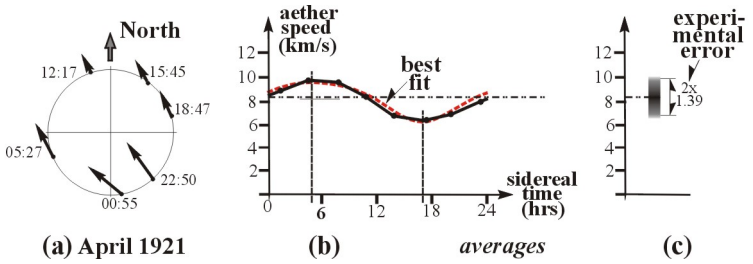

Fig. 12. Miller's results[53].

Miller had however by now realized that the aether speeds he was obtaining were far too low. Still assuming that this was due to aether entrainment, and using the Earth's orbital speed as a reference, he calculated that his measured speed of 8.22 km/s corresponded to a true value of ~208 km/s[54]. We discuss this value further later.

In 1929 Michelson, now together with Pease and Pearson, repeated his original 1887 experiment. Also on top of Mt Wilson, and with a larger interferometer[b] whose sensitivity approached that of Miller's. He reported:

> "An aether-drift of some unspecified quantity, just under 20 km/sec."[c55].

But in spite of this being *more than three times* his 1887 result, it was again attributed to experimental error. And when in 1932 Kennedy and Thorndike obtained the even higher value of 24 km/sec[56], they too dismissed it:

> "In view of relative velocities amounting to thousands of kilometers per second existing among the nebulae, this can scarcely be regarded as other than a clear null result"[57]

This amazing statement is as if to say:

> "I may weigh 180 kg. But in view of weights amounting to seven tons existing among elephants, this can scarcely be regarded as other than clearly lightweight."

So when in 1933 Miller published his final results, they got little attention since they fatally undermined Einsteinian Relativity, which by then had been almost universally adopted by the mainstream physics establishment[d]:

> "Miller's findings remained uncomfortably in the scientific background, impossible to refute, and equally impossible to accept."[58]

---

[a] Plotted against *sidereal* time (appendix p.44).

[b] With a 52-meter round-trip light path.

[c] Michelson seems to have been adverse to reporting exact numerical values! (Cf p.13.)

[d] Below.

Miller was however no scientific lightweight. A Princeton physics graduate with a doctorate in astronomy, he headed the Case School physics department from 1893 until his retirement in 1936. He served as secretary, vice president and president of the *American Physical Society*. He was elected to the *National Academy of Science*. And was a member of the *US National Research Council*, becoming chairman of its Physical Sciences Division[59].

Apart from this he was an exceptionally careful and rigorous experimenter[a], who during his lifetime successfully defended his results against all skeptics. In 1925 he was awarded $1000[b] by the prestigious *American Association for the Advancement of Science* for his detection of the aether[60] – something the scientific establishment subsequently declared not to exist!

If anyone deserved a fair hearing it was Miller. He didn't get it. Largely ignored and isolated in his later years, shortly before his death he gave all his data, more than 300 pages of interferometer readings, to his research associate Robert Shankland with the somewhat bitter comment to "Analyze them or burn them"[61].

Shankland

After Miller died in 1941, Shankland became chairman of the Case School Physics Department. He did indeed "analyze" Miller's data. But the department in the meantime having 'converted' to fundamentalist Einsteinism, his "analysis" had the express intention of discrediting his former boss's work.

After extensive consultation with Einstein, and in what has been called "One of the most perverse scientific papers ever published"[62], in 1955 Shankland et al. pronounced Miller's results to be worthless, attributing them to seasonal temperature effects[63].

The allegation was fatuous. Firstly because Miller had already exhaustively investigated and discarded this possibility in a long series of control experiments[c] – something that Shankland as Miller's assistant at the time obviously knew well.

Secondly: if temperature was the cause, *daily variations* should produce analogous effects, which they didn't.

Thirdly, temperature variations are *Sun-dependent*, varying with *solar time.* But Miller's results were functions of *sidereal time*[d]; and so on.

The so-called "analysis" wasn't even done by the paper's authors. But by a Case School graduate student, Robert Stearns, who got only a footnote credit.[64]

Shankland sent a pre-publication draft of his paper to Einstein, who wrote him a personal letter of appreciation:

---

[a] Cf the exerpt from his1925 report, appendix p.43.

[b] Worth a lot more then.

[c] p.43.

[d] Based on a direction in space with respect to the fixed stars rather than the Sun (Fig. 12, appendix p.44.).

> "I thank you very much for sending me your careful study of the Miller experiments, showing convincingly that the observed effect has nothing to do with an 'aether wind', but is due to differences of temperature."[65]

There by now being no-one left alive prepared to defend Miller, his pioneering work was interred along with his body. While fundamentalist Einsteinism grew in popularity and dominance.

Having thus betrayed his master, Shankland received his thirty pieces of silver in the form of a series of widely published interviews with Einstein, after which his academic career soared. He ended his days as a bureaucrat within the emerging governmental atomic energy infrastructure[66].

At Mt. Wilson today there is no record of the exhaustive ground-breaking work done there by Miller. But only a memorial plaque to Michelson and Einstein (!)[67]. Reginald Cahill[a] wrote:

> "It was an injustice and a tragedy that Miller's contributions to physics were not recognised in his lifetime. Not everyone is as careful and fastidious as he. He was ignored simply because it was believed then, as it is now, that 'absolute motion' [the aether][b] is incompatible with Special Relativity (it is!). It was accepted without evidence that his experiments must be wrong. This shows once again how little physics is evidence based – as Galileo discovered to his cost. Even today Miller's experiments attract a hostile reaction from the physics community."[68]

EXPERIMENTAL (2)

Length contraction

In 1889 Oliver Heaviside[c] showed from Maxwell's equations that movement though the aether at speed *v* alters electric fields by the *Lorentz factor* γ:

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \qquad \text{(eq.4)}$$

named after Hendrik Lorentz.

In the same year George FitzGerald[d] used this, and the *ad hoc* hypothesis that intermolecular forces are electrostatic, to derive the *length contraction* relation. Thereby explaining the alleged null result of the Michelson-Morley experiment:

---

[a] Reginald Cahill (1948-) Australian theoretical physicist.

[b] Another of Cahill's creative ways of avoiding the unspeakable ae-word.

[c] Oliver Heaviside (1850–1925), English engineer and mathematician.

[d] George FitzGerald (1851–1901), Irish physicist.

> "The forces binding the molecules of a solid might be modified by motion through the aether such that the base of the interferometer is shortened, neutralizing the optical effect[a]."[69]

In 1892 Lorentz, independently and more rigorously, arrived at the same conclusion:

> "There will be a contraction in the direction of motion proportional to the square of the ratio of the velocities of translation and of light, such as to annul the effect of aether drift in the Michelson-Morley interferometer."[70]

Whence its name: the "FitzGerald-Lorentz length contraction".

Cahill

In 2002 Reginald Cahill re-examined the Michelson-Morley and Miller interferometer results. He found that both experimenters had failed to take into account:

– 1) the FitzGerald-Lorentz *length contraction*[b]
– 2) the *refractive index* of the medium, in this case air

The Michelson-Morley interferometer set up is repeated in Fig. 13[c]. For an aether headwind *v*, the light speed is *c-v* on the outward leg and *c+v* on the return leg. Without length contraction this would give an average speed of c/γ^2[d]. Taking the contraction into account, the apparent average speed is γ times greater, namely c/γ.

On the perpendicular axis where the photon moves at 90° to the aether wind, the average light speed is likewise c/γ[e].

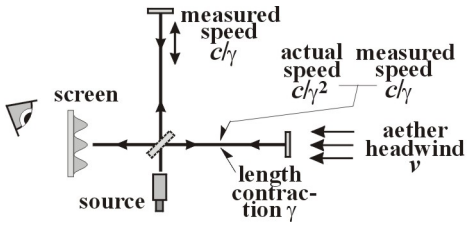

Fig. 13. Michelson-Morley (2).

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[a] Why this is not exactly so is shown in the next section.
[b] Known to Miller, but not to M&M, at the time of their experiments.
[c] Fig. 6
[d] Appendix eq.6 (p.41).
[e] Appendix eq.7 (p.42).

The *same apparent light speed* is thus obtained on *both axes*, as was predicted by FitzGerald and Lorentz[a]. Meaning that an interferometer will in principle *always give a null result*, independently of any aether wind.

The FitzGerald-Lorentz contraction, however – and this was Cahill's other crucial insight – refers to conditions *in vacuo*. But the Michelson-Morley and Miller experiments were performed *in air* where the speed of light is somewhat lower.

In this case the two effects *don't* exactly cancel out. But leave a *small residual*[b], which is what Michelson-Morley, Miller and others were measuring. We noted[c] that Miller had realized that his results were too low, but had attributed this to aether entrainment.

Making the necessary corrections, the Michelson-Morley[d] and Miller's experiments now give average aether speeds of:

$$v_{e\in} = 258\pm77 \text{ km/s}; \quad v_{s\in} = 374\pm63 \text{ km/s}^{71}$$

respectively. A detailed calculation is given in the appendix[e].

In 2006 Cahill made his own aether-wind measurement using two atomic clocks linked by an optic fibre and a coaxial cable respectively. He obtained a solar-system aether speed of:

$$v_{s\in} = 400\pm20 \text{ km/s} @ (5.5\text{h}, -70^{o})^{72}$$

compatible with Miller's values.

In the heat of the Relativity debate of the late 1920s, attempts were made to "purify" the Michelson-Morley experiment by carrying it out in helium (Illingworth in 1927[73]) and a soft vacuum (Joos in 1930[74]). Because helium has a considerably lower refractive index than air, both experiments gave smaller aether-wind values. Illingworth obtained 3.13+/-1.04 km/s; and Joos the even lower 1.5 km/s[75].

Ironically, these were taken as confirming the Michelson-Morley "null" result. In fact all they confirm is the FitzGerald-Lorentz length contraction[f].

The dependency of interferometer results on the refractive index of air was further demonstrated by an experiment carried out by Demjanov. As he gradually evacuated the air from his instrument, the fringe shifts decreased steadily and finally vanished[76].

---

[a] p.20.

[b] Some 2% of the full value.

[c] p.18.

[d] Midday readings.

[e] p.40.

[f] p.20.

deWitte

Further experimental evidence for the aether was obtained by *Roland deWitte*[a]. A technician with the Belgium Telephone Company, in 1991 he was given the task of synchronizing two caesium atomic clocks, separated by 1.5 kilometers of coaxial cable in a north-south orientation using radio frequency signals.

The tests ran for 178 days. Fig. 0-14 shows specimen transit times measured over three days. The maximum is in the sidereal direction ($\alpha \approx 5$ hr)[b], the same as that obtained by Miller half a century previously[c]. Like most others, however, deWitte seems to have been unaware of Miller's work.

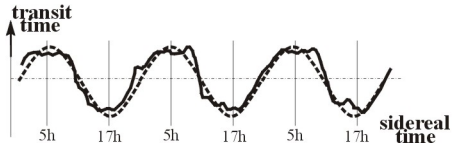

Fig. 0-14. deWitte's results.

Little of deWitte's original data has survived. But Cahill has shown that his aether speed is also compatible with Miller's.

DeWitte realized that the effect he was observing was of cosmic origin. But not being an accredited physicist, he was unable to get his results published in any physics journal. And was subsequently dismissed from his research post. With his findings censured or ignored, and without a job, deWitte became deeply depressed and suffered an early death[77].

Torr and Kolen

In another version of the deWitte set up, in 1981 Torr and Kolen[d] compared two rubidium vapor clocks separated by 500m of coaxial cable. Unfortunately they chose an east-west direction for their cable, almost perpendicular to the approximately southerly sense obtained by Miller[e] . Torr and Kolen make no reference to Miller's work, and so like deWitte were presumably unaware of it. Otherwise they would surely not have used this orientation.

---

[a] Roland deWitte (??), Belgian telephone technician,

[b] When the component of the aether wind projected onto the cable is greatest.

[c] p.17.

[d] At the University of Utah.

[e] p.17.

The small projection of the aether wind onto their cable nevertheless enabled them to estimate its velocity at 417±40 km/s in a direction (5.5h, -65^0)[78], close to Miller's and Cahill's values[a].

Wallace

In 1961 *Bryan Wallace*[b] was making radar distance measurements to the planet Venus, when he noted discrepancies in the speed of light. He submitted his findings to *Physical Review Letters*, but was refused and had to publish elsewhere[79].

> "How could NASA not have noticed this?"

he asked. He claimed that NASA *had* in fact noticed, but that:

> "Due to the unfortunate things that tend to happen to physicists rash enough to challenge Einstein's second postulate, they were reluctant to acknowledge it. Getting a physicist to say that the speed of light is not constant is like trying to exsanguinate a turnip."[80]

Wallace died in 1997 with his findings, like Miller's, neither confirmed nor refuted by the physics establishment, but simply ignored.

Marinov

The colourful *Stefan Marinov*[c] comes close to many people's idea of a scientific crackpot. A native of Bulgaria and former Assistant Professor of Physics at Sofia University, he was four times forcibly subjected to psychiatric treatment for his political views[d]. Emigrating later to the West, he became involved in the scheme of an esoteric Swiss religious sect to extract energy from the vacuum of space[81].

In 1979, now in Brussels, he made a series of measurements of the speed of light using synchronously rotating mirrors. He concluded that the solar system moves though the aether at an average speed of 350 km/s in an astronomical direction (α=12 hr, δ=-20^o)[82]. We discuss these values later.

Marinov's various submissions to *Nature* were consistently refused. As were also his letters to the editor and his paid advertisments. The editor wrote to him:

> " I am sorry to have to tell you that I am not willing to publish your papers, because in my judgement they will not persuade our readers of the validity of your claims. We also do not sell advertising space to people with unorthodox views who have failed our usual tests of acceptability, which would be quite unacceptable. (sgd) Dr. Philip Campbell, Editor."[83]

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[a] p.22.

[b] Bryan Wallace (d.1997), American radio astronomer.

[c] Stefan Marinov (1931–1997), Bulgarian physicist.

[d] Soviet communism's standard way of dealing with such cases.

In other words "Your submissions are quite unacceptable because I have deemed them quite unacceptable".

Marinov was so incensed with this that he threatened to immolate himself in front of the British Embassy in Vienna[84]. He later commented:

> "It is clear that to recognize the failure of Relativity in the third quarter of the twentieth century is a hard nut for the scientific community to crack. But it must be done, and the sooner the better."[85]

He ended his life by jumping off the top floor of the Graz University library, writing in his suicide note:

> "Having walked so many years on the thorny way of truth, I became tired. My books and papers are my scientific testament. I hope that soon the absolute space-time concepts which I restored by numerous experiments and simple mathematical theory will be accepted by the scientific community. On leaving this world I can only repeat the eternal words: *Feci quod potui* ('I did what I could')."[86]

And if, as it now seems, there is in fact an aether wind, the idea of extracting energy from it is maybe not quite so crackpot after all.

Spacecraft flyby

Further estimations of the aether speed are obtained from the radio-frequency signals emitted by spacecraft as they fly by the Earth. Due to the Doppler effect[a], when a spacecraft approaches the Earth the received signal frequency is greater than the emitted. And is conversely lower when the spacecraft recedes, Fig. 0-15.

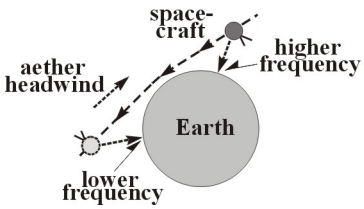

Fig. 0-15. Spacecraft flyby.

In the presence of an aether headwind both frequencies are higher than expected. In mainstream physics this is known as the *flyby anomaly*:

> "*Unexplained* signal Doppler shifts that are *not predicted* by accepted Science, and *not understood* by present-day scientists."[87]

---

[a] p.6.

The shifts are however only an "anomaly" for those who don't recognize the aether's existence. For those who do, they are not only explainable, but provide a further and independent means of estimating the aether speed.

Cahill analyzed a number spacecraft flybys at various points in the Earth's orbit, obtaining an average solar-system aether-wind speed of:

$$v_{s\in} = 420 \pm 30 \text{ km/s} @ (5\pm2h, -70\pm 10^{o})^{88}$$

compatible with Miller's and his own previous results[a].

The Doppler effect[b] in general depends on *speeds relative to a medium*, and applies to both *sources* and *observers*. A source stationary in its medium emits an equal frequency in all directions, Fig. 0-16a. When moving through its medium, the emitted frequency is higher in the direction of travel and lower in the opposite direction, Fig. 0-16b.

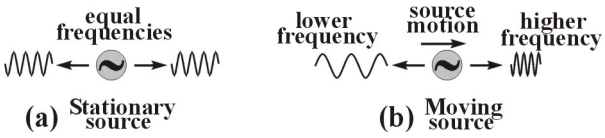

Fig. 0-16. Doppler effect (1).

Correspondingly, an observer stationary in the medium experiences an equal frequency in all directions, Fig. 0-17a. When moving, he observes a higher frequency in his direction of travel, and a lower frequency in the opposite direction, Fig. 0-17b.

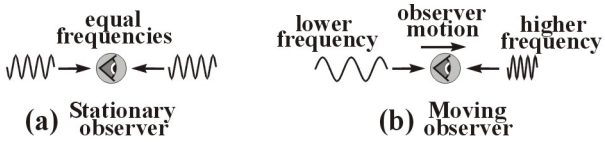

Fig. 0-17. Doppler effect (2).

That there *is* in fact a Doeppler effect for electromagnetic waves is then further evidence for the aether. No medium; no source or observer speeds relative to it; no Doppler effect[c].

Other

In 1990 the American university professors Howard Hayden[a] and Petr Beckmann[b] offered a $2,000 reward to anyone citing from the literature an experiment showing the

---

[a] p.22.

[b] Cf the cyclist example (Fig. 2).

[c] Obviously! No medium; no waves.

invariance of the speed of light in the east-to-west and west-to-east directions to within 50 m/s. Although the offer was published in *Science* magazine in November 1990[89], to date[c] there have been no takers[90]. Silence can speak louder than words.

In a further reported experiment, electromagnetic signals were found to travel faster from Washington to Los Angeles than vice versa, with a small but consistently replicable difference of 37 nanoseconds[91]. Again falsifying experimentally Einstein's 2nd postulate.

General

Resuming the above aether wind measurements:

	year	*type*	*speed*	*direction*
M&M	1887	interferometer	258±77	??
Miller	1933	- " -	374±63	(5.2h, –67°)
Torr&Kohlen	1981	coaxial cable	417±40	(5.2h, –65°)
deWitte	1991	- " -	??	(5h, ??)
Cahill	2006	- " -	400±20	(5.5±2h, –70±10°)
NASA	2008	flyby	420±30	(5±2h, –70±10°)

Taking the flyby and Torr & Kohlen results as representative then gives a solar-system velocity though the aether of the order of:

$$v_{s\in} = 420\pm30 \text{ km/s @ } (5\text{h}, -70^{o})$$

Múnera noted that of the six experiments he analyzed, carried out between 1887 and 1932[d], all without exception *obtained* non-null aether speeds. But with the notable exception of Dayton Miller, all *reported* null results[92]. An Italian proverb runs:

> "*Tra il dire e il fare, c'è di mezzo il mare*."

("Between the saying and the doing, in the middle is the sea.")

In mainstream physics, it would seem, there can be similar discrepancies between the '*fare*' (results) and the '*dire*' (reporting of them). Cahill:

> "It is now belatedly understood that numerous experiments, beginning with Michelson-Morley's, have always shown that the Einstein postulates are

---

[a] Howard Hayden (??), physics professor at the University of Connecticut.

[b] Petr Beckmann (1924-1993), Czechoslovakian professor of electrical engineering at Colorado University.

[c] May 1919.

[d] M&M (1887), Miller (1926), Piccard and Stahel (1926), Illingworth (1927), Joos (1930), Kennedy and Thorndike (1932).

false; that there is a detectable space[a]; and that motion through it has been repeatedly observed since 1887. In denying such obvious empirical facts Special Relativity is just silly. Michelson died not realising that he had observed absolute motion[b]. Ironically, he received a Nobel prize for reporting that he had not observed what he in fact had[c]."[93]

GENERAL

CMB, gravity

When the cosmic microwave background (CMB) was discovered in 1965, it was quickly realized that it could provide an 'at rest' reference for speeds[d].

Consider a spaceship out in deep space, shown in 2-d terms[e][94] in Fig. 18. When moving with respect to the CMB, due to the Doppler effect[f], the pilot experiences a higher CMB frequency in front of him and a lower frequency behind. When he observes the same CMB frequency all around him, he knows that he is at rest with respect to it.

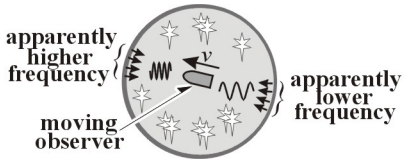

Fig. 18. Microwave background.

On this basis, the absolute velocity[g] v_s of the solar system has been calculated to be:

$$v_s = 370 \text{ km/s} @ (11.2h, -7.2^o)$$

towards the constellation Leo[95], Fig. 19a. In other words, nearly perpendicular to the solar system's velocity of ~420 km/s though the *aether* in an approximately southerly direction[h].

---

[a] Another of his creative ways of avoiding the unspeakable ae-word.

[b] Ditto.

[c] Not quite exact. Michelson reported a positive aether wind (p.13). *Others* nullified it for him. And then accused *him* of being the nullifier! (Cf the Einstein and *wikipedia* quotes).

[d] Contradicting Einstein's first postulate that there is none.

[e] SpaceTime article.

[f] p.6.

[g] Taking Cahill's aether-wind value.

[h] Determined by interferometer experiments (p.22).

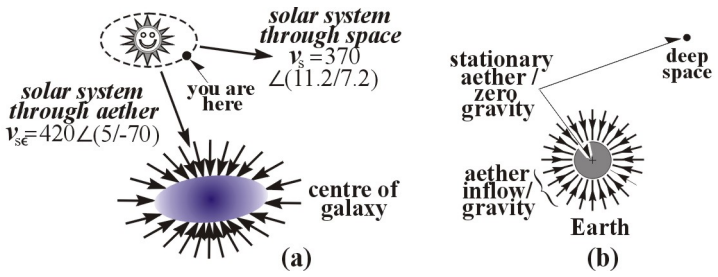

Fig. 19. Aether: absolute speeds; gravity[a].

The difference between the two is the absolute velocity of the aether through space[b] in the region of the solar system.

Cahill's re-analysis of Miller's data[c] showed the aether speed at the Earth's surface to comprise:

– 1) 30 km/s due to the Earth's orbital rotation
– 2) 42 km/s inflow towards the Sun
– 3) 420±30 km/s inflow towards the centre of the galaxy

With a further:

– 4) 11.2 km/s inflow towards the Earth's centre[96]

But that in principle[d] doesn't show up in horizontal interferometer experiments[e].

All of these except the first[f] suggest that *gravity* is associated with an *aether inflow*:

gravity ⇔ *aether inflow*

In outer space, gravity and the aether speed are presumed to be zero, Fig. 19b. But there is also a zero gravity point close to[g] the Earth's centre, meaning that the aether will be stationary there too.

This ties in with the Hafele-Keating observation that their results could be made sense of referred either to the Earth's centre, or to the distant stars (outer space)[97]. Also with the GPS system, which uses the Earth's centre as its zero velocity reference[98].

---

[a] 'Through space' =.

[b] With respect to the CMB.

[c] Ditto.

[d] Were it not for its fluctuations (below).

[e] Although variations in its direction do (below).

[f] Which causes a problem for the present thesis.

[g] Strictly: "close to it", due to the minor gravitational effects of the Sun and Moon, etc.

An aether–gravity association is likewise suggested by the fact that both motion through the aether and a gravitational potential cause *clock slowing*[a][99]. Further evidence is provided by *aether turbulence* discussed in the next section.

It is interesting that in one of his first published theories[b], Newton speculated that gravity could be due to a medium flowing continually downward toward the Earth's surface where it is partially diffused and partially absorbed[c][100].

We can also note that Marinov's rotating-mirror result[d] is close to the Earth's velocity with respect to the *CMB*[e], rather than through the aether[f] – for as yet unexplained reasons.

So the solar system moves through the aether at ~420 km/s; the Earth orbits the Sun at 30 km/s; and the aether is stationary at the Earth's centre! This "aether stuff" is evidently somewhat complex and obtuse, a far cry from the essentially static medium envisaged by Maxwell and Lorentz[g].

That the aether's essential nature should be incomprehensible to us, is however hardly surprising. If everything in the universe, including we ourselves, is made of aether, in trying to understand it we are a part trying to comprehend the whole of which it is part. This being rationally senseless[h][101], the true nature of the aether could well inherently elude us.

Aether turbulence

Cahill observed something that deWitte had noted, and is also present in the Michelson-Morley and Miller results: namely that the aether wind is not smooth but *gusty*, varying from hour to hour and from day to day in both magnitude and direction at a level of ~20km/s[102].

The same variations are seen in spacecraft flyby data[i][103]. Shankland also noticed them in Miller's readings, but used them as evidence of his inaccuracy, without considering that they could be a real effect.

Fig. 0-20 shows the fluctuations in specimen Michelson-Morley and Miller[j] measurements[104].

---

[a] Relativity article.

[b] In his "*Philosophiæ Naturalis Principia Mathematica*"

[c] He later abandoned it in favour of his inverse-square law.

[d] p.24.

[e] p.28.

[f] As measured by interferometer (p.26) .

[g] p.3.

[h] The 'self-incomprehension' principle (QM article).

[i] p.25.

[j] Fig. 12a.

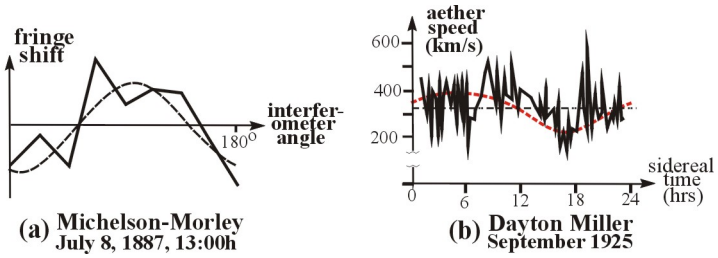

Fig. 0-20. Aether gustiness (1).

Fig. 0-21 shows those abstracted from the deWitte experiment[a][105].

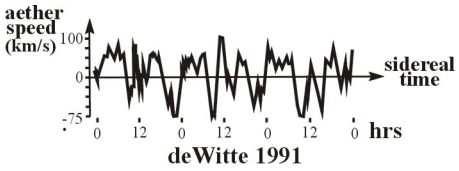

Fig. 0-21. Aether gustiness (2).

Múnera also noted that in the Michelson-Morley results:

> "There were strong variations. Over the hour of the midday session of July 9, the aether speed changed from 18.1 to 16.8 km/s, and its direction from –151.5º to –176.4º. In the evening session the speed changed from 28.4 to 29.6 km/s, and the direction from +96.0º to +86.0º."[106]

Fluctuations in the aether inflow to the Sun[b] could also explain the greater variability of the M&M evening readings[c], where they contribute to the measured result[d]. Whereas at midday[e] the inflow is perpendicular to the interferometer plane and – apart from directional variations – has no effect[f]. And since the Earth's rotation in the evenings is perpendicular to its orbital motion (Fig. 0-22b), whereas at midday it opposes it (Fig. 0-22a), this could explain the somewhat lower midday values.

---

[a] Fig. 0-14.
[b] p.29.
[c] Fig. 0-9.
[d] Fig. 0-22b.
[e] Fig. 0-22a.
[f] .

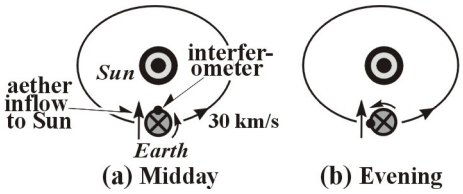

Fig. 0-22. Michelson-Morley (3).

Aether-wind fluctuations also mean that the considerable variability in the M&M and other[a] results could be not entirely due to experimental error – giving even less justification for a 'null' interpretation.

The fluctuations are also implied in the M&M and Miller experimental errors. Since Miller took many more readings[b], and used a more sensitive instrument, he should have obtained a far lower experimental error. The fact that he didn't implies that the spread in both experiments is not entirely due to experimental error, Fig. 0-23.

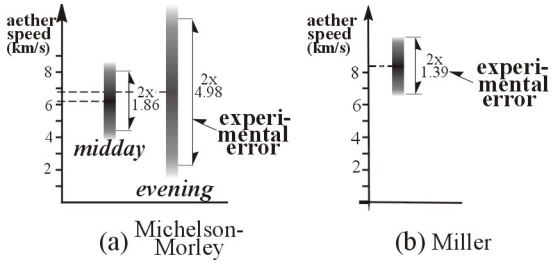

Fig. 0-23. Michelson-Morley. Miller results.

Returning to the Torr-Kolen experiment[c], with a cable direction almost perpendicular to the approximately southerly sense of the aether-wind, variations in its *direction* should produce significant effects. They in fact reported considerable day-to-day fluctuations[107].

A correlation[d] between gravity and the aether-inflow would also predict corresponding variations in the *gravitational constant* G, which seems to be the case in practice. Cahill:

> "As the precision of gravitational constant G measurements improved over the years, the disparity between the values obtained has increased. Results now differ by nearly 40 times the estimated error."[108]

Kuitkowski:

---

[a] Fig. 0-9.

[b] ~12'000 sets as opposed to M&M's 36.

[c] p.23.

[d] p.29.

> "The value of the gravitational so-called 'constant' seems to depend not only on the method used, but also on the *time* and location of the measurement[a].[109]

It would be very interesting to perform an experiment comparing simultaneous measurements of aether speed and the gravitational 'constant' G. A positive correlation would further reinforce the gravity**:**aether hypothesis. And since Cahill has now developed a small aether-speed instrument[b][110], it could be done simply and cheaply.

Mainstream physics however doesn't even recognize the aether's *existence*, let alone any possible correlation with gravity. We will maybe have to wait a bit before funding for such an experiment becomes available.

Resuming the factors indicative of a gravity**:**aether-inflow correlation are:

– 1) the aether speed at the Earth's surface comprises inflows towards *a)* the Earth's centre, *b)* the Sun, *c)* the centre of the galaxy. All these are gravity sources
– 2) the ECI[c] reference frame used by the GPS system[d][111]. The Earth's centre being a zero-gravity point, on this hypothesis it is a zero-aether-speed point
– 3) both an aether speed and a gravitational potential cause clock slowing
– 4) both the aether speed and the gravitational constant G show time-dependent fluctuations
– 4) gravity waves propagate at the aether's characteristic speed *c*

The final question then is: what does this aether turbulence *mean* in physical terms? At present there seems to be no answer. The universe is however littered with cataclysmic events – supernova explosions, neutron star and black hole mergers, galaxy collisions, etc. And since physical reality overall seems to be essentially 'aethereal'[e], the turbulence could be "cosmic weather".

LIGO

The Laser Interferometer Gravitational-wave Observatory (LIGO) comprises two large stationary vacuum laser interferometers with 4 km arms, situated 3000 km apart in Livingston-LA and Richland-WA in the USA[f].

Designed to detect gravitational waves, the instruments are exceptionally sensitive. They are capable of detecting changes in mirror spacing of one part in 10^{21} – equivalent to the width of a human hair in the distance between the Earth and Proxima Centauri![g].

---

[a] And also on the *speed* of the measured body.
[b] Using a coaxial and an optic fibre cable (p.22).
[c] Earth-Centred Inertial.
[d] Aether article.
[e] 'Electromagnetic'.
[f] Cf Fig. 6a.
[g] 4×10^{13} km away.

But since they operate in the *vacuum mode*, they are *inherently insensitive* to the everyday aether wind and its fluctuations[a112]. Initial operations between 2002 and 2010 correspondingly gave null results.

But then on September 14, 2015 a "chirp" was registered by both detectors, Fig. 0-24a. The time interval between its detection by the two devices was consistent with an effect travelling at the speed of light.

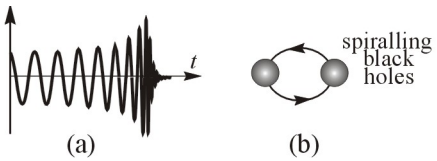

Fig. 0-24. LIGO wave.

This was interpreted as deriving from the final moments of the merger of two black holes more than a billion light years away, Fig. 0-24b. The estimated radiated power was more than ten times that of the total light emission of the observable universe!

That the disturbance travelled at the speed of light, suggests strongly that the aether was involved. But since vacuum interferometers are *insensitive* to aether disturbances, the question is: what does the result *mean* in physical terms? For the moment this remains a good question.

It would be interesting to run the LIGO in the gas mode with *air* rather than a vacuum in its tubes. This would resolve once and for all the Michelson-Morley dispute. But since it would also risk confirming Cahill's interferometer calibration[b], demonstrating the aether's existence and falsifying Special Relativity, one wonders whether it will ever be done.

NULLIFICATION (2)

General

In spite of the overwhelming conceptual and experimental evidence for the aether, mainstream physics persistently persists in denying it. Back in 1873 Maxwell was already complaining that:

> "There appears to be in the minds of some eminent men a prejudice, or *priori* objection, against the hypothesis of a medium in which the radiation of heat and light take place."[113]

---

[a] p.22.

[b] p.21.

And notwithstanding Michelson-Morley's subsequent 1887 experimental confirmation of its existence, the 'no-aether' myth continued unscathed. So Einstein could for instance write in his 1916 Relativity paper, apparently without fear of contradiction:

> "Michelson and Morley performed an interference experiment in which [an aether wind] speed should have been clearly detectable. But it gave a *negative result*. The most careful observations *have never revealed* anisotropic properties. This is very powerful argument in favour of the principle of relativity, contradictory to which *no empirical data has ever been found*."[114]

The myth has survived intact to the present day. A recent Internet search by the author for "Michelson-Morley result" gave, in order of appearance[115]:

"The result was negative."
"There is no aether."
"The Michelson-Morley is a perfect example of a null experiment."
"There was no fringe shift."
"Michelson found no evidence of the aether."
...

The *en.wikipedia*[a] similarly "informs":

> "The Michelson–Morley experiment compared the speed of light in perpendicular directions in an attempt to detect the relative motion of the stationary luminiferous aether ('aether wind'). *The result was negative*. Michelson and Morley found *no significant difference* between the speed of light in the two directions."[116]

All of which, in the face of the overwhelming conceptual and experimental contrary evidence, evidently constitutes a pretty massive – as Herbert Dingle[b] would have delicately put it:

> "Conscious departure from rectitude."[117]

But which in the vernacular could well be called "blatant lies".

The question then is: why does the Physics Establishment need to so relentlessly plug the aether's non-existence?

The problem with the aether is of course that it *refutes Einsteinian Relativity*[c], today a scientific fundamentalism that professional physicists in the area are required to "Subscribe to or else!". Meaning that its existence has to be ongoingly negated, presumably based on Joseph Goebbels'[d] eternal principle that:

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[a] Online encyclopedia.

[b] Herbert Dingle (1890–1978), English physicist.

[c] Contradicting his 2nd 'constant speed of light' postulate.

[d] Joseph Goebbels (1897–1945), Nazi propaganda minister.

"A lie repeated often enough becomes a truth."

William S.[a] could have observed[b]:

"The Establishment doth protest too much, methinks."

Absolutism

The 'eminent men' Maxwell complained of[c] were presumably the diehard Newtonians of his day, who stood firmly by the good old established corpuscular theory of light, and wanted no truck with the new-fangled wave theory and its concomitant aether. Those who Max Planck had in mind when he wrote:

> "A new scientific truth doesn't triumph by convincing its opponents. But rather: they eventually die out and a new generation familiar with it grows up."[118]

This does not, however, explain the no-aether myth's resurgence at the end of the century when the old diehards were all either retired or dead, and the aether had become the conventional wisdom, accepted by virtually all professional physicists of the time. And whose existence had by then been confirmed experimentally by Michelson-Morley.

Europe in the 18th and early 19th centuries was 'absolutist', in the sense that political power was still firmly in the hands of an established landed aristocracy. Newton's rationally ordered universe, with its Master Creator who kept Himself to Himself and didn't stick His nose into things that weren't His business, validated the structure and suited the times admirably[d][119].

The *droits du seigneur* – the "rights of the lord" (the little lord down here on planet Earth, not the Big Lord up in the sky) – were graciously delegated by the Big Lord in the sky to little lords on Earth without too many awkward questions about how they were exercised.

By the second half of the 19th century, however, things were changing radically. Growing industrialization was causing extensive migration from the countryside into the towns. And more crucially: was putting money and hence political power into the hands of a *nouveau riche* class of non-land-owning industrialists, businessmen, bankers and the like. All of which put a *pressure for change* onto the socio-political structure.

In times of change *flexibility* and *adaptability* are the order of the day. The old absolutism had to go. And together with it, anything that symbolized it.

We see this in philosophy. Nietzsche[e] declared in 1878 that:

---

[a] William Shakespeare (1564-1616), English poet, playwright and actor.

[b] Cf the famous *Hamlet* line: "The lady doth protest too much, methinks". (She wasn't protesting her chasteness, but could well have been.)

[c] p.34.

[d] The "Four Pillars of the English Establishment" were Monarchy, Church, Empire and Newton.

[e] Friedrich Nietzsche (1844-1900), German philosopher.

> "There are no eternal facts, just as there are no absolute truths".[120]

And in 1882 that:

> "God is dead"[a121]

God being nothing if not an absolute.

In art, an article on Cubism notes that:

> "In the four decades from 1870-1910, Western society witnessed more technological progress than in the previous four centuries. Artists correspondingly developed Cubism, where a painting often looks like an image seen in a broken mirror."[122]

The "broken mirror" being the old way of seeing things.

Later post-modern philosophy was similarly characterized by:

> "A general distrust of grand theories and ideologies; a general skepticism toward the assumptions of Enlightenment rationality."[123].

In Science, Newton's absolute space and time evidently had to go. And likewise the aether. In part for being another 'absolute'[b]. But principally, because it was by then a conventional wisdom, and hence a candidate for overthrow.

So when in 1905 Einstein came along "proving scientifically" that everything is relative, and that there are absolutely no absolutes[c], this was exactly what people wanted to hear. And they turned a blind eye to his theory's manifest inconsistencies and contradictions. Just as they turned an equally blind eye to the indisputably positive Michelson-Morley aether-wind result.

And when in the 1920s quantum physics went a step further, and declared that reality is not only inherently *relative*, but also inherently *indeterminate*, and can be any way one wants depending only on one's consciousness[a]: well "Wow!".

Francis Bacon[d] noted that:

> "People prefer to believe what they prefer to be true".

Agenda

At each period of its history, a society seems to have an explicit or implicit *agenda*, that can be either *'open/liberal'* or *'closed/conservative'* – effectively politically 'left' or 'right'[e]:

---

[a] The idea was not in fact Nietsche's, having been proposed 75 years earlier by Hegel in his 1807 *Phenomenology of Spirit*.

[b] Providing an absolute reference for electromagnetic phenomena.

[c] Specifically ncluding the aether.

[d] Francis Bacon (1561–1626), English statesman and polymath.

[e] 'Absolute' being "not susceptible to change", a conservative agenda is by nature absolutist.

agenda: open/liberal/left or closed/conservative/right

In times of change where flexibility and adaptability are at a premium, the agenda is open/liberal. In stable settled periods the opposite holds. The closed/conservative principle dominates, and respect for tradition and the maintainance of *status quo* are the order of the day.

A liberal agenda with its emphasis on innovation and change tends to *undermine* the existing power structure, opening it up for further change. Conversely, in conservative times where social mobility is low, the road to individual advancement lies in allying oneself with that power structure, thereby strengthening it. Each agenda is effectively *self-reinforcing*, leading to abrupt swings between them.

The late 19th C switch to an open/liberal agenda led to radical innovations in science[a] and art, that continued into the 1920s. But then came the 1929 Wall St crash and the ensuing economic depression, with a consequent lurch to the political right, fascism and ultimately World War II. It was during the 1930s that fundamentalist Einsteinism and anti-aetherism became fully entrenched in Science[b][124].

The optimism following the World War's end[c] led to another reversal to an open/-liberal agenda, with an accompanying surge in scientific and artistic innovation and creativity. But that was abruptly clamped in the late 1970s by the rise of Thatcher/-Reaganism, and the massive swing to the political right that has continued unabated till the time of writing.

More than a century after Michelson-Morley, anti-aetherism is thus again rampant. But now for the opposite reason. Its original rejection derived from a *liberal* agenda and the need to *break* with the conventional wisdom. Whereas today – Einsteinian Relativity having in the meantime become a conventional "wisdom"[d] – anti-atheism stems from a *conservative* agenda and a pressure to *conform*.

That essentially anti-authoritarian Relativity should have become a touchstone for *compliance* with authority, is evidently ironic. But history is littered with contradictions. As Einstein once said of himself, with his inimitable humour:

> "To punish me for my contempt of authority, Fate made me one."[125]

Science doesn't tell us the way things *are*. It tells us *the way we want to be told* they are:

Science tells us the way we want to be told things are

---

[a] Quantum physics, for instance.

[b] Discussed in the Einstein article.

[c] The end of every major war is heralded as the end to all major wars.

[d] So-called.

Or maybe better: we only listen to those scientists who tell us what we want to hear, ignoring those who don't. As Francis Bacon noted[a], and Dayton Miller discovered to his cost[b].

That would seem to be it. No matter how well founded a scientific thesis, its acceptance depends principally on whether it supports the current political agenda, and little on its actual scientific merits. Adam Becker[c]:

> "The course of scientific progress is dictated as much by the vagaries of the *Zeitgeist*, and the forcefulness of personalities, as by the strength of ideas themselves. When trying to understand why certain ideas are accepted as gospel and others are forgotten, dismissed or even actively suppressed, the political context is essential."[126]

Maxwell wrote in 1877:

> "Those 'eminent men', who take upon themselves the task of ignoring anything that contradicts their cherished beliefs, follow 'Scientism', a corruption of Science that is really a pseudo religion. With so many following it, and pretending it to be Science, it is little wonder the scientific world is in such a sorry state of affairs."[127]

Today's "eminent men" are fundamentalist Einsteinians who see[d] no problem in a theory that predicts that two clocks can each run slower than the other. And that light is a mediumless wonder, a disturbance of nothing propagating through nothing.

As the modern French say:

> "*Plus ça change* ..."[e].

And the ancient Celts are said to have said:

> "Omaigodd!"

---

[a] p.37.

[b] p.19.

[c] Adam Becker (??), Science writer.

[d] Strictly: *say* they see.

[e] French proverb: "The more things change, the more they remain the same".

APPENDIX

Celestial coordinates

The *celestial coordinates* of a heavenly body are its celestial longitude and latitude, the projection of earthly longitude and latitude into outer space, Fig. 0-25.

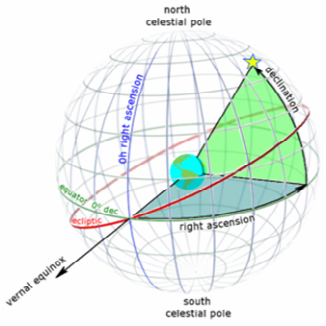

Fig. 0-25. Celestial coordinates[128].

If one stood on the equator at 0° longitude[a] at midday on the March equinox (21/03), the Sun would be immediately overhead at a *Right Ascension*[b] α=0 hrs and a *declination* δ=0°. A star 30° above the northern horizon at that point would have declination δ=+60° and coordinates (α = 0 hr, δ=60°). A star 30° above the southern horizon would have coordinates (α = 0 hr, δ=–60°); and so on.

Longitude and Right Ascension being measured eastwards, a star immediately overhead 5 hrs previously to this[c] would have coordinates (α = 5 hrs, δ=0°); and so on.

Interferometer calibrations

M&M, Miller

Both Michelson-Morley and Miller used an essentially classical calibration for their interferometers, that didn't take length contraction into account[d]. The overall layout is repeated for convenience in Fig. 26[e].

---

[a] The Greenwich meridian.

[b] 'RA'.

[c] At 07:00 hrs.

[d] Proposed by FitzGerald in 1889 and Lorentz in 1892 (p.20). Known to Miller, but not M&M, at the time of their experiments.

[e] Fig. 13.

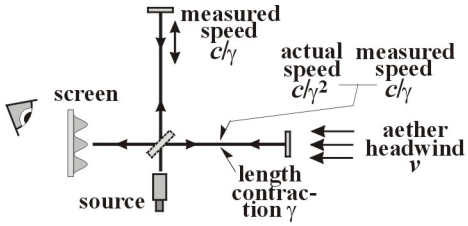

Fig. 26. Michelson-Morley (2).

The fringe-shift principle is best illustrated via Thomas Young's[a] 1803 'double-slit experiment'[b129]. A beam of light shone through two close narrow slits produces an *interference pattern* of light and dark fringes on a screen, Fig. 27a. Where the peaks of the waves from the two slits coincide there is a point of maximum intensity, shown for the central fringe in Fig. 27b. Where a positive peak from one slit coincides with a negative peak from the other, there is a zero intensity point.

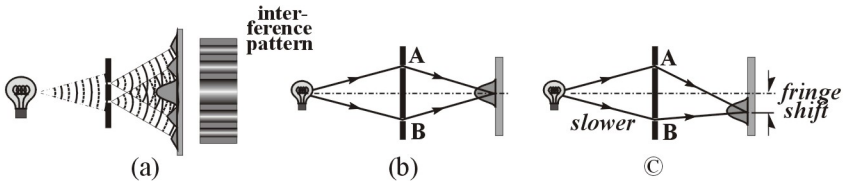

Fig. 27. Double-slit experiment.

A slower speed of light on the slit B path would cause a *fringe-shift*, Fig. 27c. From it the speed difference between the two paths can be calculated[c].

The same principle applies to an interferometer, except that here the beams derive from the main and perpendicular paths, and not separate slits.

Returning to Fig. 26, for a light path length d, and an aether headwind v, the light speeds on the main axis are $c–v$ on the upwind leg and $c+v$ on the downwind leg, giving an out-and-return time t_1:

$$t_1 = \frac{d}{c-v} + \frac{d}{c+v} = \frac{2cd}{c^2-v^2} \qquad \text{(eq.5)}$$

and an average light speed c_1 on this axis:

$$c_1 = \frac{2d}{t_1} = \frac{c}{\gamma^2} \qquad \text{(eq.6)}$$

---

[a] Thomas Young (1773–1829), English phsician and polymath.

[b] First performed by.

[c] By simple geometry.

where γ is the Lorentz factor[a].

On the perpendicular axis, let the photon take time t_2 to reach the opposite mirror. During this time it travels a distance ct_2 through the aether, and gets blown back a distance vt_2 by the aether headwind, Fig. 0-28. Giving an apparent light speed c_2 on this axis[b]:

$$c_2 = \frac{d}{t_2} = \frac{c}{\gamma} \qquad \text{(eq.7)}$$

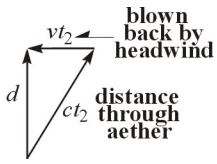

Fig. 0-28. Interferometer, p-axis{{interfer}.

The aether speed v on Earth being very much smaller than that of light c[c], the Lorentz factor γ here reduces to:

$$\gamma = \frac{1}{\sqrt{1-(v/c)^2}} \approx 1 + \frac{1}{2}(v/c)^2 \qquad \text{(eq.8)}$$

In terms of the 'MMM'[d] calculated aether speed v_m, the difference Δv between the apparent light speeds on the two axes is then[e]:

$$\Delta v = c_2 - c_1 = \frac{c}{\gamma}\left(1 - \frac{1}{\gamma}\right) \approx \frac{c}{2}\left(\frac{v_m}{c}\right)^2 \qquad \text{(eq.9)}$$

Whence:

$$v_m \approx \sqrt{2c\Delta v} \qquad \text{(eq.10)}$$

The axis speed difference Δv being obtained from the fringe shifts, 'MMM' used this relation to calculate their aether speed v_m.

Cahill

On the Cahill calibration, the speed of light c_a in air is:

$$c_a = c/n \qquad \text{(eq.11)}$$

---

[a] eq.4, p.20.

[b] Pythagoras.

[c] $(v/c)^2 << 1$.

[d] 'Michelson-Morley-Miller'.

[e] Substituting c_1, c_2 from eqs 6,7 and γ from eq.8.

where n is its refractive index.

With no length contraction, the speed difference Δv between the two axes would be[a]:

$$\Delta v = \frac{c_a}{\gamma_a}\left(1-\frac{1}{\gamma_a}\right) \quad \text{where} \quad \gamma_a \approx 1+\frac{1}{2}\left(\frac{nv}{c}\right)^2 \qquad \text{(eq.12)}$$

Length contraction foreshortens the main axis by γ, increasing the apparent speed of light on it correspondingly, and giving an axis speed difference Δv[b]:

$$\Delta v = \frac{c_a}{\gamma_a}\left(1-\frac{\gamma}{\gamma_a}\right) \approx \frac{c(n^2-1)}{2}\left(\frac{v}{c}\right)^2 \qquad \text{(eq.13)}$$

Equating the two expressions for Δv[c], the corrected aether speeds v in terms of their 'MMM' values v_m are:

$$v = \frac{v_m}{\sqrt{n^2-1}} \qquad \text{(eq.14)}$$

The refractive index of air depends on its pressure. Cleveland and Mt Wilson being at 200 m and 1740 m above sea level respectively, their relative pressures[d] are p=0.989 and p=0.821[130]. The refractive index of air at sea-level being n=1.000293[131]; and taking its 'n–1' component to be proportional to pressure[e]; the corresponding air refractive indexes at the two locations are n=1.00029 and n=1.000241 respectively.

Substituting these into eq.14 gives correction factors of 41.5 and 45.5 respectively. Applying them to the 'MMM' speeds v_m[f] then gives true aether speeds v:

M&M: $v_{e\in}$ = ~258±77 km/s[g]; Miller: $v_{s\in}$ = 374±63 km/s[h]

Miller

An exerpt from Dayton Miller's report on his 1925 Mt Wilson control experiments[i]:

> "An extended series of experiments was made to determine the influence of inequality of temperature in the interferometer room, and of radiant heat falling on the interferometer. Several electric heaters were used, of the type having a heated coil near the focus of a concave reflector. Inequalities in the

---

[a] Using eqs.8,9.

[b] Approximating n≈1.

[c] 'MMM's and Cahill's (eqs 9,13).

[d] To that at sea level.

[e] n ⇒ 1 + 0.000293p.

[f] pp 13, 17

[g] Midday readings. Substituting v_m=6.22, n=1.00029 into eq.14.

[h] Substituting v_m=8.22, n=1.000241 into eq.14.

[i] Miller 1925.

temperature of the room caused a slow but steady drifting of the fringe system to one side, but caused no periodic displacement. Even when two of the heaters were placed at a distance of three feet from the interferometer as it rotated, and were turned to throw the heat directly on the uncovered steel frame, there was no measurable periodic effect. When the heaters were turned on to the light-path which had a covering of glass, a periodic effect could be obtained only when the glass was covered with opaque material in a very non-symmetrical manner, as when one arm of the interferometer was completely protected by a covering of corrugated paper-board while the other arms were unprotected. These experiments proved that under the conditions of actual observation, the periodic displacement could not possibly be produced by temperature effects." [132]

Reading this, can anyone doubt he was a serious experimenter?.

Sidereal, solar times

For the sake of illustration, imagine standing on the equator at 0^{o} longitude on the March equinox (21/03), Fig. 29a. The Sun and some fixed star are immediately overhead. Define this instant as '12:00 hrs' in both solar and sidereal times.

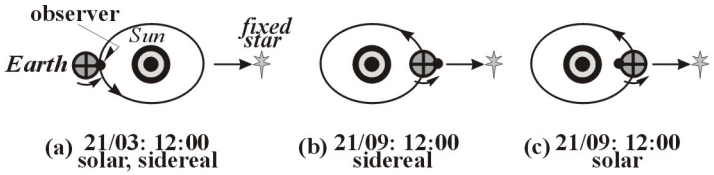

Fig. 29. Solar, sidereal times.

Six months later, 12:00 sidereal time is when the same fixed star is overhead, Fig. 29b. And 12:00 solar time is 12 hrs later, when the Sun is overhead, Fig. 29c.

A year thus has 365 solar and 366 sidereal days, making a sidereal day ~4 mins[a] shorter than a solar day.

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[a] (24 hrs)/(365 days) ≈ 4 mins.

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