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Michelson-Morley Experiments Revisited and the Cosmic Background Radiation Preferred Frame

Reginald T. Cahill and Kirsty Kitto
School of Chemistry, Physics and Earth Sciences
Flinders University GPO Box 2100, Adelaide 5001
Australia
(Reg.Cahill@flinders.edu.au)

A new information-theoretic physics has given rise to a quantum-foam description of space relative to which absolute motion is meaningful and measurable. In this new physics Michelson interferometers operating in gas mode are capable of revealing absolute motion. We analyse the old results from gas-mode Michelson interferometer experiments which always showed small but significant effects. Analysis of the Illingworth (1927) experimental data, after correcting for the refractive index effect of the helium used, reveals an absolute speed of the Earth of $v = 369 \pm 123$ km/s, while the Miller experiment (1933), after correcting for the refractive index effect of the air, now gives a speed of $v = 335 \pm 57$ km/s, which are in agreement with the speed of $v = 365 \pm 18$ km/s determined from the dipole fit, in 1991, to the NASA COBE satellite Cosmic Background Radiation (CBR) observations. The new physics also implies that vacuum interferometers will

give null results, as has been observed many times. These experimental results imply that absolute motion is observable and that there is a preferred foliation of spacetime coinciding with the CBR frame.

Keywords: Michelson interferometer, Cosmic Background Radiation (CBR), preferred frame, process physics.

Introduction

It is fundamental assumption in physics that experiments using the well known Michelson interferometer [1] give null results. This interferometer was designed to reveal absolute motion. Michelson conceived of his two-arm interferometer as exploiting geometrical changes in path lengths of two beams of light when the interferometer is in motion (see below). However Michelson and Morley reported [2] that there was an experimental “null effect,” though their published data actually shows a non-null effect. By the poor choice of the words “null-effect” they actually meant only that the effect was smaller than expected. Fitzgerald and Lorentz responded to this reported ‘null effect’ by suggesting that a dynamical contraction of the arm parallel to the direction of the motion would cancel out the geometrical effects. This null effect and the length contraction are now incorporated into the foundations of the Special and General Theory of Relativity, which builds upon the assumption that there is no preferred frame, that all foliations of spacetime are equivalent. Special and General Theory of Relativity effects have of course been well established through many experiments and observations.

However, as discussed below, whether or not there is a preferred frame of reference is not in conflict with the successes of the Special and General Theory of Relativity. One possible frame is that revealed by the NASA COBE satellite observations of the Cosmic Background

Radiation (CBR) dipole component [3]. This revealed that the Earth had a speed of 365 ± 18 km/s relative to the CBR frame of reference.

However *both* absolute motion and the Special and General Theory of Relativity arise from a new information-theoretic modelling of reality [4, 5]. This theory is known as Process Physics because it uses a non-geometric iterative modelling of time. In this theory absolute motion is detectable by a Michelson interferometer if it operates in gas mode. Significantly all such gas-mode interferometer experiments did give non-null effects, contrary to popular beliefs. Hence gas-mode interferometers provide a key test that can distinguish between the new physics and the Einsteinian physics, but that vacuum interferometers cannot do this as both theories predict that they give null effects.

Michelson Interferometer

Michelson's original analysis [1] (this analysis contained an error which was corrected in [2]) for his interferometer assumed Newtonian physics and gave that the difference in propagation times when one arm of length L is rotated through 90° from being parallel to the direction of motion is

$$\Delta t = k^2 \frac{Lv^2}{c^3} \quad (1)$$

with $k = 1$. Here v is the projection onto the plane of the interferometer of the velocity of the interferometer through space. When comparing the times of the two orthogonal arms a factor of 2 is required in (1).

The Einstein physics, on the other hand, is built around the core assumption that absolute motion has no meaning, that only motion of one object relative to another has meaning. Therefore for Einstein

$k = 0$ in both the gas-mode and vacuum mode, and so in both modes a null effect is predicted. However in the new physics, as we derive below, $k = \sqrt{n(n^2 - 1)}$ where n is the dielectric constant of the gas in which the interferometer operates and this gives $k = 0$ only for the vacuum ($n = 1$) mode. When operating in gas the Newtonian k value is different from $k = 1$, namely $k = \sqrt{n^3}$, as we shall see. We show here that interferometer experimental data excludes both the Newtonian and Einsteinian treatment of absolute motion.

Table 1 shows the key differences between the three fundamental theories in their modelling of time, space, gravity and the quantum, together with their distinctive values for the interferometer parameter k^2 , which was introduced by Miller [6] on phenomenological grounds. In particular the Process Physics uses a non-geometric iterative modelling of time in a pre-geometric system from which a quantum foam description of space is emergent. This quantum foam and quantum matter are together described by a Quantum Homotopic Field Theory. Gravity in this modelling is caused by the inhomogeneous flow of the quantum foam. So Process Physics is a unification of the quantum and gravity. Each theory subsumes and accounts for the theory above it in the table. In particular the Einstein spacetime modelling arises as an approximation to the Process Physics, but with a preferred frame of reference.

Here we derive expression (1) in the new physics and then analyse data from various gas-mode interferometers. The results reported here are that the small effects (fractional fringe shifts) actually seen by Michelson and Morley [2], by Illingworth [8], and by Miller [6] indicate speeds in agreement with the CBR speed (see Fig.2). This amounts to the observation of absolute motion. This non-null dielectric effect is a key experimental signature that clearly distinguishes between the three theories in Table 1.

Theory	Time	Space	Gravity	Quantum	k^2
Newton	geometry	geometry	force	quantum theory	n^3
Einstein	curved geometry		curvature	quantum field theory	0
Process Physics	process	quantum foam	Inhomogeneous flow	quantum homotopic field theory	$n(n^2 - 1)$

Table 1: Comparisons of Newtonian, Einsteinian and Process Physics

In deriving (1) in the new physics it is essential to note that space is a quantum-foam system [4,5] which exhibits various subtle features. In particular it exhibits real dynamical effects on clocks and rods. In this physics the speed of light is only c relative to the quantum-foam, but to observers moving with respect to this quantum-foam the speed appears to be still c but only because their clocks and rods are affected by the quantum-foam. This corresponds to the Lorentzian interpretation of relativity. As shown in [4] such observers will find that observations of distant events will be described by the Einstein spacetime formalism, but only if they restrict measurements to those achieved by using clocks, rods and reflected light pulses. It is simplest in the new physics to work in the quantum-foam frame of reference. If there is a gas present at rest in this frame, such as air, then the speed of light in this frame is $V = c/n$. If the gas is moving with respect to the quantum foam, as in an interferometer attached to the Earth, then the speed of light relative to the quantum-foam is still $V = c/n$ up to corrections due to Fresnel drag. But this dragging is a very small effect and is not required in the present analysis. Hence this new physics requires a different method of analysis from that of

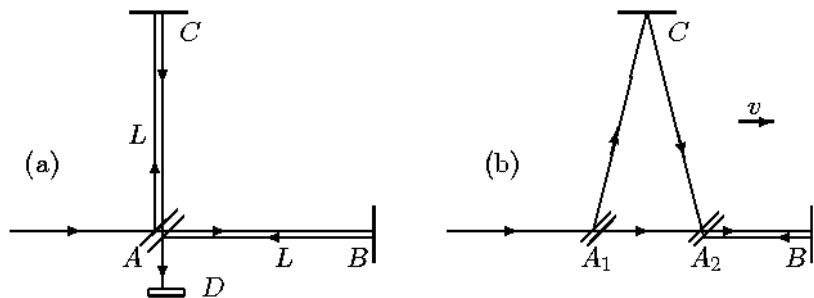


Fig.1 Schematic diagrams of the Michelson Interferometer with beam splitter/mirror at A and mirrors at B and C on equal length arms when parallel, from A. D is a quantum detector (not drawn in (b)) that causes localisation of the photon state by a collapse process. In (a) the interferometer is at rest in space. In (b) the interferometer is moving with speed v relative to space in the direction indicated. Interference fringes are observed at the quantum detector D. If the interferometer is rotated in the plane through 90° the roles of arms AC and AB are interchanged, and during the rotation shifts of the fringes are seen in the case of absolute motion, but only if the apparatus operates in a gas. By counting fringe changes the speed v may be determined.

Einstein physics. With these cautions we now describe the operation of the Michelson interferometer in this new physics, and show that it makes predictions different to that of the Einstein physics. Of course experimental evidence is the final arbiter in this conflict of theories.

As shown in Fig.1 the beamsplitter/mirror A sends a photon $\mathbf{y}(t)$ into a superposition $\mathbf{y}(t) = \mathbf{y}_1(t) + \mathbf{y}_2(t)$ with each component travelling in different arms of the interferometer, until they are recombined in the quantum detector D which results in a localisation process, and one spot in the detector is produced. Repeating with many photons reveals that the interference between \mathbf{y}_1 and \mathbf{y}_2 at the detector results in fringes. To simplify the analysis here assume that

the two arms are constructed to have the same lengths when they are physically parallel to each other. The Fitzgerald-Lorentz effect in the new physics is that the arm AB parallel to the direction of motion is shortened to

$$L_{\parallel} = L\sqrt{1 - \frac{v^2}{c^2}} \quad (2)$$

by motion through space at speed v .

Following Fig.(1) we consider the case when the apparatus is moving at speed v through space, and that the photon states travel at speed $V = c/n$ relative to the quantum-foam which is space, where n is the refractive index of the gas and c is the speed of light, in vacuum, relative to the space. Let the time taken for \mathbf{y}_1 to travel from $A \rightarrow B$ be t_{AB} and that from $B \rightarrow A$ be t_{BA} . In moving from the beamsplitter at A to B the photon state \mathbf{y}_1 must travel an extra distance because the mirror B travels a distance vt_{AB} in this time, thus the total distance that must be traversed is

$$Vt_{AB} = L_{\parallel} + vt_{AB}. \quad (3)$$

Similarly on returning from B to A the photon state \mathbf{y}_1 must travel the distance

$$Vt_{BA} = L_{\parallel} - vt_{BA}. \quad (4)$$

Hence the total time t_{ABA} taken for \mathbf{y}_1 to travel $A \rightarrow B \rightarrow A$ is given by

$$t_{ABA} = t_{AB} + t_{BA} = \frac{L_{\parallel}}{V - v} + \frac{L_{\parallel}}{V + v}, \quad (5)$$

$$= \frac{L_{\parallel}(V+v) + L_{\parallel}(V-v)}{V^2 - v^2}, \quad (6)$$

$$= \frac{2LV \sqrt{1 - \frac{v^2}{c^2}}}{V^2 - v^2}. \quad (7)$$

Now let the time taken for the photon state \mathbf{y}_2 to travel from $A \rightarrow C$ be t_{AC} , but in that time the apparatus travels a distance vt_{AC} . Pythagoras' theorem then gives

$$(Vt_{AC})^2 = L^2 + (vt_{AC})^2, \quad (8)$$

which gives

$$t_{AC} = \frac{L}{\sqrt{V^2 - v^2}}, \quad (9)$$

and including the return trip $C \rightarrow A$, $t_{CA} = t_{AC}$, $t_{ACA} = t_{AC} + t_{CA}$ results in

$$t_{ACA} = \frac{2L}{\sqrt{V^2 - v^2}}, \quad (10)$$

giving finally for the time difference for the two orientations

$$\Delta t = \frac{2LV \sqrt{1 - \frac{v^2}{c^2}}}{V^2 - v^2} - \frac{2L}{\sqrt{V^2 - v^2}}. \quad (11)$$

Now trivially $\Delta t = 0$ if $v = 0$, but also $\Delta t = 0$ when $v \neq 0$ but only if $V = c$. This then would result in a null result on rotating the apparatus. Hence the null result of the Michelson apparatus in the new

physics is only for the special case of photons travelling in vacuum for which $V = c$.

However if the Michelson apparatus is immersed in a gas then $V < c$ and a non-null effect is expected on rotating the apparatus, since now $\Delta t \neq 0$. It is essential then in analysing data to correct for this refractive index effect. Putting $V = c/n$ in (11) we find for $v \ll V$ that

$$\Delta t = L.n(n^2 - 1) \frac{v^2}{c^3} + O(v^4). \quad (12)$$

This gives $\Delta t = 0$ for vacuum experiments. However if the data from gas mode interferometers is (incorrectly) analysed using the Newtonian modelling, that is not using the Fitzgerald-Lorentz contraction (2) then, as done in the old analyses, the estimated time difference is

$$\Delta t = \frac{2LV}{V^2 - v^2} - \frac{2L}{\sqrt{V^2 - v^2}}, \quad (13)$$

which again for $v \ll V$ gives

$$\Delta t = L.n^3 \frac{v^2}{c^3} + O(v^4). \quad (14)$$

Analysis of Interferometer Data

The value of Δt is deduced from analysing the fringe shifts, and then the speed v_M (in previous Michelson interferometer analyses) has been extracted using (14) instead of the correct form (12). Δt is typically of order 10^{-17} s corresponding to a fractional fringe shift. However it is very easy to correct for this oversight. From (12) and

(14) we obtain, for the corrected absolute speed v through space, and for $n \approx 1^+$

$$v = \frac{\sqrt{n^3}}{\sqrt{n^2 - 1}} v_M \approx \frac{v_M}{\sqrt{n^2 - 1}}. \quad (15)$$

Note that for air at STP $n = 1.00029$, while for helium at STP $n = 1.000036$, and so the correction factor of $1/\sqrt{n^2 - 1}$ is large.

The corrected speeds v for four MM experiments are shown in Fig.2, and compared with the CBR speed determined from the COBE data [3]. Munera [7] has reviewed these interferometer experiments and uncovered systematic errors and as well applied standard statistical tests to the values originally reported. He has noted that the Michelson-Morley experiments and subsequent repetitions never were null, and that correcting for invalid inter-session averaging leads to even larger non null results. Munera's new results are as follows, using the Newtonian physics (14) to extract v_M : The original Michelson-Morley data [2] now gives $v_M = 6.22$ km/s with a standard deviation on the mean of 0.93 km/s for one set of noon sessions, while giving $v_M = 6.80$ km/s with a standard deviation on the mean of 2.49 km/s for 18^h observations. The Illingworth [8] data (from a helium-filled interferometer) gives smaller values of $v_M = 3.13$ km/s with an upper bound at 95% CL of $v_M = 4.17$ km/s and a lower bound at 95% CL of $v_M = 2.09$ km/s. For Miller [6], from results at Mt Wilson, the new result is $v_M = 8.22$ km/s with an upper bound at 95% CL of $v_M = 9.61$ km/s and a lower bound at 95% CL of $v_M = 6.83$ km/s.

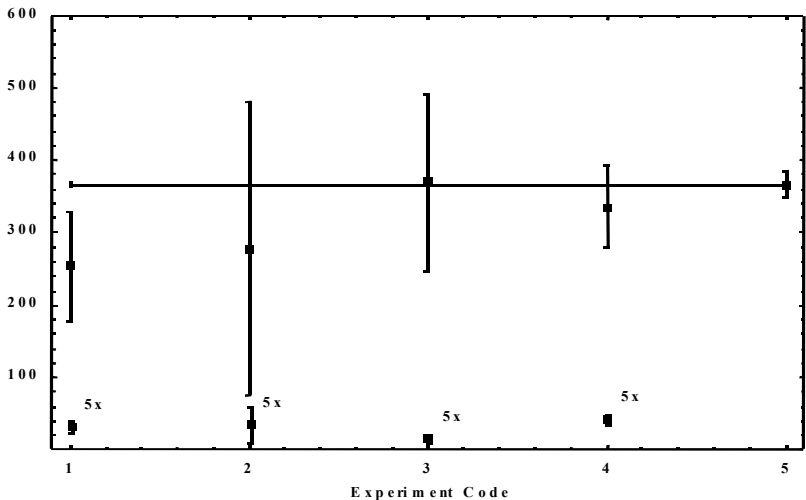


Fig.2 Speeds v , in km/s, determined from various Michelson interferometer experiments (1)-(4) and COBE (5): (1) Michelson-Morley (noon observations) [2], (2) Michelson-Morley (18th observations) [2], (3) Illingworth [8], (4) Miller, Mt.Wilson [6], and finally in (5) the speed from the COBE satellite observation of the CBR microwave spectrum dipole term [3]. All MM data shows 2 standard deviation error bars. The results (1)-(4) are not corrected for the ± 30 km/s of the orbital motion of the earth about the sun, though this correction was made, as well as that for the satellite orbital speed, in the case of (5). The horizontal line at $v = 365$ km/s is to aid comparisons with the COBE data. Due to any angle between velocity vector and plane of interferometer, the MM apparatus will always give speeds less than or equal to the v_{CBR} speed, unless a search procedure is adopted. The lower data, magnified by a factor of 5, are the original speeds v_M [7] determined from fringe shifts using the incorrect Newtonian physics (14).

Hence the Miller value for v_M appear to differ significantly from the value from Illingworth. But this is now an expected outcome as Illingworth used helium (to control temperature variations) instead of air. Because of the very different refractive indices of air and helium the correction factors are substantially different, and as shown in Fig.2

the air and helium filled interferometers now give comparable results, when corrected.

The presence of gases in these early experiments, rather than high vacuum, was of course an experimental expediency, but only because of this can we now realise the full implications of these long forgotten experiments.

The horizontal line at $v_M = 365$ km/s in Fig.2 is to aid comparisons with the COBE data. Due to any non-zero angle between the velocity vector and the plane of interferometer, the MM apparatus will always give speeds less than or equal to the v_{CBR} speed plus the Earth's orbital speed of ± 30 km/s, unless a search procedure is adopted to find maximum effect. The results in Fig.2 conform with that expectation.

Conclusions

Hence the old interferometer data was small but significant and the re-analysis here gives extracted speeds that agree, within errors, with the speed determined from analysis of the CBR dipole component observed by the COBE mission. These results demonstrate that absolute motion has a meaning and is measurable. It does not imply, however, that the Special and General Relativity formalism is completely incorrect, it merely indicates the requirement for a re-interpretation, and this essentially is that there is a preferred frame, which amounts to a special foliation of the spacetime construct. The results also indicate that interferometers operating in gas mode will become useful research tools.

It is remarkable that these experiments were carried out with such diligence and care so long ago that their data, when now properly analysed, yield speeds consistent with those found from satellite technology 104 years later, and even more so when we understand that some of the experimenters themselves believed they had failed to

detect non-null effects. Vacuum interferometer experiments [9-12] have always given null-effects, but they test only the Lorentz contraction effect. To detect quantum foam effects, such as absolute motion, we must use gas-mode interferometers, for in this case the cancellation of the Lorentz contraction effect and the Michelson geometrical effect is incomplete. This observed effect is inconsistent with Einstein's assumption of no absolute motion, but nevertheless his formalism remains essentially intact, for it turns out that the formalism follows from other effects of the quantum foam. The new information-theoretic process physics [4, 5, 13-17] subsumes the older Einstein and quantum physics and as well predicts new phenomena.

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