The Michelson and Morley 1887 Experiment and the Discovery of Absolute Motion

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Physics textbooks assert that in the famous interferometer 1887 experiment to detect absolute motion Michelson and Morley saw no rotation-induced fringe shifts - the signature of absolute motion; it was a null experiment. However this is incorrect. Their published data revealed to them the expected fringe shifts, but that data gave a speed of some 8km/s using a Newtonian theory for the calibration of the interferometer, and so was rejected by them solely because it was less than the 30km/s orbital speed of the earth. A 2002 post relativistic-effects analysis for the operation of the device however gives a different calibration leading to a speed > 300km/s. So this experiment detected both absolute motion and the breakdown of Newtonian physics. So far another six experiments have confirmed this first detection of absolute motion in 1887.

1 Introduction

The first detection of absolute motion, that is motion relative to space itself, was actually by Michelson and Morley in 1887 [1]. However they totally bungled the reporting of their own data, an achievement that Michelson managed again and again throughout his life-long search for experimental evidence of absolute motion.

The Michelson interferometer was a brilliantly conceived instrument for the detection of absolute motion, but only in 2002 [2] was its principle of operation finally understood and used to analyse, for the first time ever, the data from the 1887 experiment, despite the enormous impact of that experiment on the foundations of physics, particularly as they were laid down by Einstein. So great was Einstein's influence that the 1887 data was never re-analysed post-1905 using a proper relativistic-effects based theory for the interferometer. For that reason modern-day vacuum Michelson interferometer experiments, as for example in [3], are badly conceived, and their null results continue to cause much confusion: only a Michelson interferometer in gas-mode can detect absolute motion, as we now see. So as better and better vacuum interferometers were developed over the last 70 years the rotation-induced fringe shift signature of absolute motion became smaller and smaller. But what went unnoticed until 2002 was that the gas in the interferometer was a key component of this instrument when used as an 'absolute motion detector', and over time the experimental physicists were using instruments with less and less sensitivity; and in recent years they had finally perfected a totally dud instrument. Reports from such experiments claim that absolute motion is not observable, as Einstein had postulated, despite the fact that the apparatus is totally insensitive to absolute motion. It must be emphasised that absolute motion is not inconsistent with the various well-established relativistic effects; indeed the evidence is that absolute motion is the cause of these relativistic effects, a proposal that goes back to Lorentz in the 19th century. Then of course one must use a relativistic theory for the operation of the Michelson interferometer. What also follows from these experiments is that the Einstein-Minkowski spacetime ontology is invalidated, and in particular that Einstein's postulates regarding the invariant speed of light have always been in disagreement with experiment from the beginning. This does not imply that the use of a mathematical spacetime is not permitted; in quantum field theory the mathematical spacetime encodes absolute motion effects. An ongoing confusion in physics is that absolute motion is incompatible with Lorentz symmetry, when the evidence is that it is the cause of that dynamical symmetry.

2 Michelson Interferometer

The Michelson interferometer compares the change in the difference between travel times, when the device is

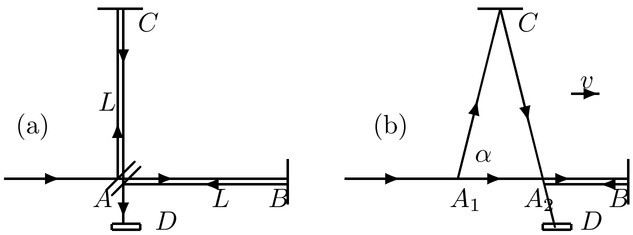

Figure 1: Schematic diagrams of the Michelson Interferometer, with beamsplitter/mirror at A and mirrors at B and C on arms from A, with the arms of equal length L when at rest. D is the detector screen. In (a) the interferometer is at rest in space. In (b) the interferometer is moving with speed v relative to space in the direction indicated. Interference fringes are observed at D. If the interferometer is rotated in the plane through 90^o, 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 measuring fringe shifts the speed v may be determined.

rotated, for two coherent beams of light that travel in orthogonal directions between mirrors; the changing time difference being indicated by the shift of the interference fringes during the rotation. This effect is caused by the absolute motion of the device through 3-space with speed v, and that the speed of light is relative to that 3-space, and not relative to the apparatus/observer. However to detect the speed of the apparatus through that 3-space gas must be present in the light paths for purely technical reasons. A theory is required to calibrate this device, and it turns out that the calibration of gas-mode Michelson interferometers was only worked out in 2002. The post relativistic-effects theory for this device is remarkably simple. The Fitzgerald-Lorentz contraction effect causes the arm AB parallel to the absolute velocity to be physically contracted to length

$$L_{||} = L\sqrt{1-\frac{v^2}{c^2}}. \tag{1}$$

The time t_{AB} to travel AB is set by $Vt_{AB} = L_{||}+vt_{AB}$, while for BA by $Vt_{BA} = L_{||} - vt_{BA}$, where $V = c/n$ is the speed of light, with n the refractive index of the gas present (we ignore here the Fresnel drag effect for simplicity - an effect caused by the gas also being in absolute motion). For the total ABA travel time we then obtain

$$t_{ABA} = t_{AB} + t_{BA} = \frac{2LV}{V^2 - v^2}\sqrt{1-\frac{v^2}{c^2}}. \tag{2}$$

For travel in the AC direction we have, from the Pythagoras theorem for the right-angled triangle in Fig.1 that $(Vt_{AC})^2 = L^2+(vt_{AC})^2$ and that $t_{CA} = t_{AC}$. Then for the total ACA travel time

$$t_{ACA} = t_{AC} + t_{CA} = \frac{2L}{\sqrt{V^2 - v^2}}. \tag{3}$$

Then the difference in travel time is

$$\Delta t = \frac{(n^2-1)L}{c}\frac{v^2}{c^2} + O\left(\frac{v^4}{c^4}\right). \tag{4}$$

after expanding in powers of v/c. This clearly shows that the interferometer can only operate as a detector of absolute motion when not in vacuum ($n = 1$), namely when the light passes through a gas, as in the early experiments (in transparent solids a more complex phenomenon occurs and rotation-induced fringe shifts from absolute motion do not occur). A more general analysis [2, 9, 10], including Fresnel drag, gives

$$\Delta t = k^2\frac{Lv_P^2}{c^3}\cos(2(\theta-\psi)). \tag{5}$$

where $k^2 \approx n(n^2-1)$, while neglect of the Fitzgerald-Lorentz contraction effect gives $k^2 \approx n^3 \approx 1$ for gases, which is essentially the Newtonian calibration that Michelson used. All the rotation-induced fringe shift data from the 1887 Michelson-Morley experiment, as tabulated in [1], is shown in Fig.2. The existence of this data continues to be denied by the world of physics.

The interferometers are operated with the arms horizontal, as shown by Miller's interferometer in Fig.3. Then in (5) θ is the azimuth of one arm (relative to the local meridian), while ψ is the azimuth of the absolute motion velocity projected onto the plane of the interferometer, with projected component v_P. Here the Fitzgerald-Lorentz contraction is a real dynamical effect of absolute motion, unlike the Einstein spacetime view that it is merely a spacetime perspective artefact, and whose magnitude depends on the choice of observer. The instrument is operated by rotating at a rate of one rotation over several minutes, and observing the shift in the fringe pattern through a telescope during the rotation. Then fringe shifts from six (Michelson and Morley) or twenty (Miller) successive rotations are averaged, and the average sidereal time noted, giving in the case of Michelson and Morley the data in Fig.2, or the Miller data like that in Fig.4. The form in (5) is then fitted to such data, by varying the parameters v_P and ψ. However Michelson and Morley implicitly assumed the Newtonian value $k = 1$, while Miller used an indirect method to estimate the value of k, as he understood that the Newtonian theory was invalid, but had no other theory for the interferometer. Of course the Einstein postulates have that absolute motion has no meaning, and so effectively demands that $k = 0$. Using $k = 1$ gives only a nominal value for v_P, being some 8km/s for the Michelson and

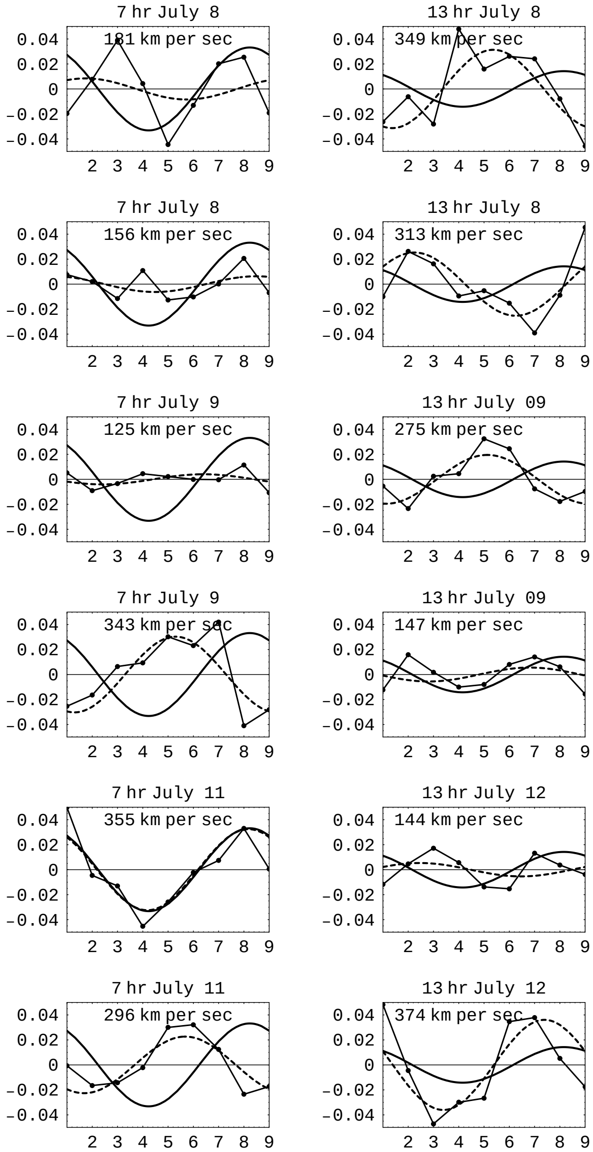

Figure 2: Shows all the Michelson-Morley 1887 data after removal of the temperature induced fringe drifts. The data for each 360^0 full turn (the average of 6 individual turns) is divided into the 1st and 2nd 180^0 parts and plotted one above the other. The dotted curve shows a best fit to the data using (5), while the full curves show the expected forms using the Miller direction for $\mathbf{v}$ and the location and times of the Michelson-Morley observations. While the amplitudes are in agreement in general with the Miller based predictions, the phase varies somewhat. This may be related to the Hick's effect [4] when, necessarily, the mirrors are not orthogonal. We see that this data corresponds to a speed in excess of 300km/s, and not the 8km/s reported in [1], which was based on using Newtonian physics to calibrate the interferometer.

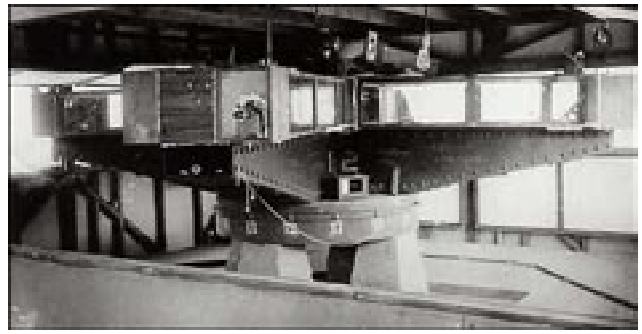

Figure 3: Miller's interferometer with an effective arm length of $L = 32$m achieved by multiple reflections. Used by Miller on Mt.Wilson to perform the 1925-1926 observations of absolute motion. The steel arms weighed 1200 kilograms and floated in a tank of 275 kilograms of Mercury. From Case Western Reserve University Archives.

Morley experiment, and some 10km/s from Miller; the difference arising from the different latitude of Cleveland and Mt. Wilson. The relativistic theory for the calibration of gas-mode interferometers was first used in 2002,[2].

3 Michelson-Morley Data

Fig.2 shows all the Michelson and Morley air-mode interferometer fringe shift data, based upon a total of only 36 rotations in July 1887, revealing the nominal speed of some 8km/s when analysed using the prevailing but incorrect Newtonian theory which has $k = 1$ in (5); and this value was known to Michelson and Morley. Including the Fitzgerald-Lorentz dynamical contraction effect as well as the effect of the gas present as in (5) we find that $n_{air} = 1.00029$ gives $k^2 = 0.00058$ for air, which explains why the observed fringe shifts were so small. We then obtain the speeds shown in Fig.2. In some cases the data does not have the expected form in (5); because the device was being operated at almost the limit of sensitivity. The remaining fits give a speed in excess of 300km/s. The often-repeated statement that Michelson and Morley did not see any rotation-induced fringe shifts is completely wrong; all physicists should read their paper [1] for a re-education, and indeed their paper has a table of the observed fringe shifts. To get the Michelson-Morley Newtonian based value of some 8km/s we must multiply the above speeds by $k = \sqrt{0.00058} = 0.0241$. They rejected their own data on the sole but spurious ground that the value of 8km/s was smaller than the speed of the earth about the sun of 30km/s. What their result really showed was that (i) absolute motion had been detected because fringe shifts of the correct form, as in (5), had been detected, and (ii) that the theory giving

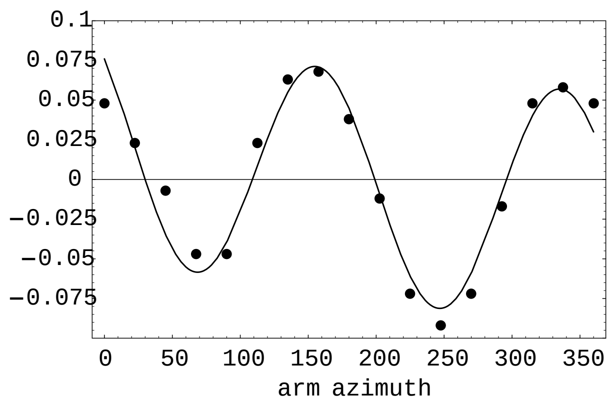

Figure 4: Typical Miller rotation-induced fringe shifts from average of 20 rotations, measured every 22.5^0, in fractions of a wavelength $\Delta\lambda/\lambda$, vs azimuth θ (deg), measured clockwise from North, from Cleveland Sept. 29, 1929 16:24 UT; 11:29 average sidereal time. This shows the quality of the fringe data that Miller obtained, and is considerably better than the comparable data by Michelson and Morley in Fig.2. The curve is the best fit using the form in (5) but including a Hick's [4] $\cos(\theta - \beta)$ component that is required when the mirrors are not orthogonal, and gives $\psi = 158^0$, or 22^0 measured from South, and a projected speed of $v_P = 351$ km/s. This value for v is different from that in Fig.2 because of the difference in latitude of Cleveland and Mt. Wilson. This process was repeated some 12,000 times over days and months throughout 1925/1926 giving, in part, the data in Fig.5.

$k^2 = 1$ was wrong, that Newtonian physics had failed. Michelson and Morley in 1887 should have announced that the speed of light did depend of the direction of travel, that the speed was relative to an actual physical 3-space. However contrary to their own data they concluded that absolute motion had not been detected. This bungle has had enormous implications for fundamental theories of space and time over the last 100years, and the resulting confusion is only now being finally corrected.

4 Miller Interferometer

It was Miller [4] who saw the flaw in the 1887 paper and realised that the theory for the Michelson interferometer must be wrong. To avoid using that theory Miller introduced the scaling factor k, even though he had no theory for its value. He then used the effect of the changing vector addition of the earth's orbital velocity and the absolute galactic velocity of the solar system to determine the numerical value of k, because the orbital motion modulated the data, as shown in Fig.5. By making some 12,000 rotations of the interferometer at Mt. Wilson in 1925/26 Miller determined the first estimate for k and for the absolute linear velocity of the solar system. Fig.4

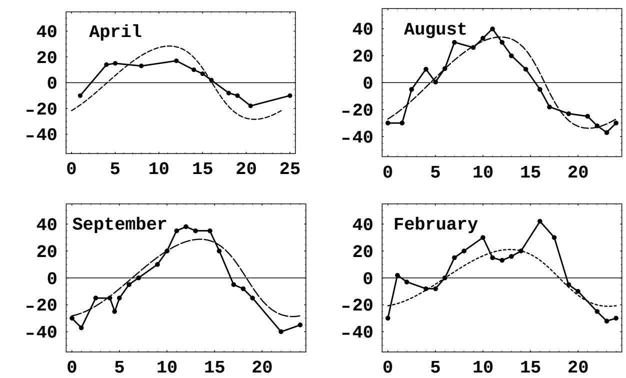

Figure 5: Miller azimuths ψ, measured from south and plotted against sidereal time in hrs, showing both data and best fit of theory giving $v = 433$ km/s in the direction ($\alpha = 5.2^{hr}, \delta = -67^0$), using $n = 1.000226$ appropriate for the altitude of Mt. Wilson. The variation form month to month arises from the orbital motion of the earth about the sun: in different months the vector sum of the galactic velocity of the solar system with the orbital velocity and sun in-flow velocity is different. As shown in Fig.6 DeWitte using a completely different experiment detected the same direction and speed.

shows typical data from averaging the fringe shifts from 20 rotations of the Miller interferometer, performed over a short period of time, and clearly shows the expected form in (5) (only a linear drift caused by temperature effects on the arm lengths has been removed - an effect also removed by Michelson and Morley and also by Miller). In Fig.4 the fringe shifts during rotation are given as fractions of a wavelength, $\Delta\lambda/\lambda = \Delta t/T$, where Δt is given by (5) and T is the period of the light. Such rotation-induced fringe shifts clearly show that the speed of light is different in different directions. The claim that Michelson interferometers, operating in gas-mode, do not produce fringe shifts under rotation is clearly incorrect. But it is that claim that lead to the continuing belief, within physics, that absolute motion had never been detected, and that the speed of light is invariant. The value of ψ from such rotations together lead to plots like those in Fig.5, which show ψ from the 1925/1926 Miller [4] interferometer data for four different months of the year, from which the RA = 5.2hr is readily apparent. While the orbital motion of the earth about the sun slightly affects the RA in each month, and Miller used this effect do determine the value of k, the new theory of gravity required a reanalysis of the data [9, 11], revealing that the solar system has a large observed galactic velocity of some 420±30km/s in the direction (RA=5.2hr, Dec= -67deg). This is different from the speed of 369km/s in the direction (RA=11.20hr, Dec= -7.22deg) extracted from the

Cosmic Microwave Background (CMB) anisotropy, and which describes a motion relative to the distant universe, but not relative to the local 3-space (The Miller velocity is explained by galactic gravitational in-flows; see [12].)

Two old interferometer experiments, by Illingworth [5] and Joos [6], used helium, enabling the refractive index effect to be recently confirmed, because for helium, with $n = 1.000036$, we find that $k^2 = 0.00007$. Until the refractive index effect was taken into account the data from the helium-mode experiments appeared to be inconsistent with the data from the air-mode experiments; now they are seen to be consistent. Ironically helium was introduced in place of air to reduce any possible unwanted effects of a gas, but we now understand the essential role of the gas. The data from an interferometer experiment by Jaseja *et al* [7], using two orthogonal masers with a He-Ne gas mixture, also indicates that they detected absolute motion, but were not aware of that as they used the incorrect Newtonian theory and so considered the fringe shifts to be too small to be real, reminiscent of the same mistake by Michelson and Morley. The Michelson interferometer is a 2nd order device, as the effect of absolute motion is proportional to $(v/c)^2$, as in (5).

5 1st Order Experiments

However much more sensitive 1st order experiments are also possible. Ideally they simply measure the change in the one-way EM travel-time as the direction of propagation is changed. Fig.6 shows the North-South orientated coaxial cable Radio Frequency (RF) travel time variations measured by DeWitte in Brussels in 1991, [9, 10, 11], which gives the same RA of absolute motion as found by Miller. That experiment showed that RF waves travel at speeds determined by the orientation of the cable relative to the Miller direction. That these very different experiments show the same speed and RA of absolute motion is one of the most startling discoveries of the twentieth century. Torr and Kolen [8] using an East-West orientated nitrogen gas-filled coaxial cable also detected absolute motion. It should be noted that analogous optical fibre experiments give null results for the same reason, apparently, that transparent solids in a Michelson interferometer also give null results, and so behave differently to coaxial cables.

Modern resonant-cavity interferometer experiments, for which the analysis leading to (5) is applicable, use vacuum with $n = 1$, and then $k = 0$, predicting no rotation-induced fringe shifts. In analysing the data from these experiments the consequent null effect is misinterpreted, as in [3], to imply the absence of absolute motion. But it is absolute motion which causes the dynamical effects of length contractions, time dilations and other relativistic effects, in accord with Lorentzian interpretation of relativistic effects. The detection of absolute motion is not incompatible with Lorentz symmetry; the contrary belief was postulated by Einstein, and has persisted for over 100 years, since 1905. So far the experimental evidence is that absolute motion and Lorentz symmetry are real and valid phenomena; absolute motion is motion presumably relative to some substructure to space, whereas Lorentz symmetry parameterises dynamical effects caused by the motion of systems through that substructure. To check Lorentz symmetry we can use vacuum-mode resonant-cavity interferometers, but using gas within the resonant-cavities would enable these devices to detect absolute motion with great precision. As well there are novel wave phenomena that could also be studied, see [9, 10].

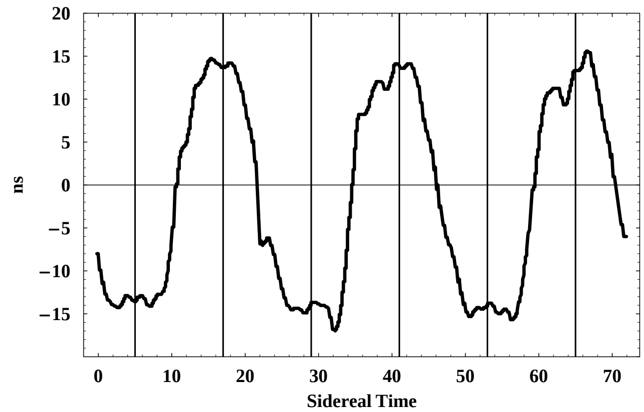

Figure 6: Variations in twice the one-way travel time, in ns, for an RF signal to travel 1.5 km through a coaxial cable between Rue du Marais and Rue de la Paille, Brussels. An offset has been used such that the average is zero. The cable has a North-South orientation, and the data is the difference of the travel times for NS and SN propagation. The sidereal time for maximum effect of ~5hr and ~17hr (indicated by vertical lines) agrees with the direction found by Miller. Plot shows data over 3 sidereal days and is plotted against sidereal time. DeWitte recorded such data from 178 days, and confirmed that the effect tracked sidereal time, and not solar time. Miller also confirmed this sidereal time tracking. The fluctuations are evidence of turbulence in the flow.

6 Conclusions

So absolute motion was first detected in 1887, and again in at least another six experiments over the last 100 years. Had Michelson and Morley been as astute as their younger colleague Miller, and had been more careful in reporting their *non-null* data, the history of physics over the last 100 years would have totally different, and the spacetime ontology would never have been introduced. That ontology was only mandated by the mistaken belief that absolute motion had not been detected. By the time Miller had sorted out that bungle, the world of physics had adopted the spacetime ontology as a model of reality because that model appeared to be confirmed by many relativistic phenomena, mainly from particle physics, although these phenomena could equally well have been understood using the Lorentzian interpretation which involved no spacetime. We should now understand that in quantum field theory a mathematical spacetime encodes absolute motion effects upon the elementary particle systems, but that there exists a physically observable foliation of that spacetime into a geometrical model of time and a separate geometrical model of 3-space.

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