

Absolute Motion and Quantum Gravity

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Abstract

A new information-theoretic modelling of reality has given rise to a quantum-foam description of space, relative to which absolute motion is meaningful. In a previous paper (Cahill and Kitto) it was shown that in this new physics Michelson interferometers show absolute motion effects when operated in dielectric mode, as indeed such experiments had indicated, and analysis of the experimental data showed that the measured speeds were all consistent with the Cosmic Microwave Background (CMB) dipole-fit speed of 369km/s. Here the new physics is applied to the Michelson-Morley 1887 interferometer rotation curve data to demonstrate that the interferometer data is in excellent agreement with the CMB direction $(\alpha, \delta) = (11.20^h, -7.22^0)$ as well. This data also reveals a velocity component caused by the in-flow of the quantum foam past the Earth towards the Sun at 30 ± 15 km/s, while analysis of the Miller interferometer data of 1933 gives 49km/s, compared to the theoretical value of 42km/s. This observed in-flow is a signature of quantum gravity effects in the new physics.

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Keywords: Michelson interferometer, Cosmic Microwave Background (CMB), preferred frame, process physics, quantum foam, quantum gravity.

***Process Physics:** http://www.scieng.flinders.edu.au/cpes/people/cahill_r/processphysics.html

1. Introduction

A new information-theoretic modelling of reality known as Process Physics [1, 2] and [14-17] has given rise to a quantum-foam description of space, relative to which absolute motion is meaningful and measurable. In Ref.[3] it was shown that in this new physics Michelson interferometers [4] reveal absolute motion when operated in dielectric mode, as indeed experiments had indicated, and analysis [3] of the experimental data using the Múnera [5] review of that data showed that the measured speeds were consistent with each other and together also consistent with the Cosmic Microwave Background (CMB) dipole-fit speed of 369km/s [6]. The new physics is here further tested against experiment by analysing the Michelson-Morley interferometer rotation data [7] of 1887 to demonstrate that the data is in excellent agreement with the CMB cosmic velocity of the Solar System through space. As well as the orbital speed of the Earth the analysis reveals a quantum-foam in-flow towards the Sun associated with quantum-gravity effects in the new physics. So the CMB preferred frame is detectable in non-microwave laboratory experiments. These results amount to a dramatic development in fundamental physics. It is also shown that analysis of the extensive 1925-1926 dielectric-mode interferometer data by Miller [8] resulted in an incorrect direction at 90° to the CMB direction.

Although the theory and experiment together indicate that absolute motion is an aspect of reality one must hasten to note that this theory also implies that the Einstein Special and General Theory of Relativity formalism remains essentially intact, although the ontology is completely different. In [1] it was shown that this formalism arises from the quantum-foam physics, but that the quantum-foam system leads to a physically real foliation of the spacetime construct. Despite this there are some phenomena which are outside the Einstein formalism, namely the detection of absolute motion. We see here the emergence of a new theoretical system which subsumes the older theory and covers new phenomena, in particular it unifies gravity and the quantum phenomena.

The new physics provides a different account of the Michelson interferometer. The main outcome is the presence of the k^2 factor in the expression for the time difference for light travelling via the orthogonal arms

$$\Delta t = k^2 \frac{L|\mathbf{v}_P|^2}{c^3} \cos(2\theta). \quad (1)$$

Here \mathbf{v}_P is the projection of the absolute velocity \mathbf{v} of the interferometer through the quantum-foam onto the plane of the interferometer, and θ is the angle of one arm relative to \mathbf{v}_P . The k^2 factor is $k^2 = n(n^2 - 1)$ where n is the refractive index of the medium through which the light passes, L is the length of each arm and c is the speed of light relative to the quantum foam. This expression follows from both the Fitzgerald-Lorentz contraction effect and that the speed of light through the dielectric is $V = c/n$, ignoring here for simplicity any drag effects. This is one of the aspects of the quantum foam physics that distinguishes it from the Einstein formalism. The time difference Δt is revealed by the fringe shifts on rotating the interferometer. In Newtonian physics, that is with no Fitzgerald-Lorentz contraction, $k^2 = n^3$, while in Einsteinian physics $k = 0$ reflecting the fundamental assumption that absolute motion is not measurable and indeed has no meaning. So the experimentally determined value of k is a key test of fundamental physics.

Table 1 summarises the 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 . 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 or foliation.

Theory	Time	Space	Gravity	Quantum	k^2
Newton	geometry	geometry	force	Quantum Theory	n^3
Einstein	curved geometry		curvature	Quantum Field Theory	0
Process	process	quantum foam	inhomogeneous flow	Quantum Homotopic Field Theory	$n(n^2 - 1)$

Table 1: Comparisons of Newtonian, Einsteinian and Process Physics.

Here we derive (1) in the new physics and then analyse the Michelson-Morley and Miller data. The results reported here are that the small effects (fractional fringe shifts) actually seen by Michelson and Morley [7] and by Miller [8] indicate speeds in agreement with the CMB speed. This amounts to the observation of absolute motion. This non-null experimental signature then clearly distinguishes between the three theories in Table 1.

In deriving (1) in the new physics it is essential to note that space is a quantum-foam system [1, 2] 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. As shown in [1] such observers will find that records of 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 light pulses. It is simplest in the new physics to work in the quantum-foam frame of reference. If there is a dielectric present at rest in this frame, such as air, then the speed of light in this frame is $V = c/n$. If the dielectric 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 drag effects. Hence this new physics requires a different method of analysis from that of the Einstein physics. With these cautions we now describe the operation of a 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.

2. The Michelson Interferometer

As shown in Fig.1 the beamsplitter/mirror when at A sends a photon $\psi(t)$ into a superposition $\psi(t) = \psi_1(t) + \psi_2(t)$, with each component travelling in different arms of the interferometer, until they are recombined in the quantum detector which results in a localisation process, and one spot in the detector is produced. Repeating with many photons reveals that the interference between ψ_1 and ψ_2 at the detector results in fringes. To simplify the analysis here assume that the two arms are constructed to have the same lengths L when they are physically parallel to each other and perpendicular to v , so that the distance BB' is $L \sin(\theta)$. The Fitzgerald-Lorentz effect in the new physics is that the distance SB' is $\gamma^{-1}L \cos(\theta)$ where $\gamma = 1/\sqrt{1 - v^2/c^2}$. The various other distances are $AB = Vt_{AB}$, $BC = Vt_{BC}$, $AS = vt_{AB}$ and $SC = vt_{BC}$, where t_{AB}

that is $k^2 = n^3$. The value of Δt is deduced from analysing the fringe shifts, and then the speed v_M (in previous Michelson interferometer type analyses) has been extracted using (5), instead of the correct form (4). Δt is typically of order 10^{-15} s in gas-mode interferometers, corresponding to a fractional fringe shift. However it is very easy to correct for this oversight. From (4) and (5) we obtain, for the corrected absolute speed v through space, and for $n \approx 1^+$,

$$v = \frac{v_M}{\sqrt{n^2 - 1}}. \quad (6)$$

Of the early interferometer experiments Michelson and Morley [7] and Miller [8] operated in air ($n = 1.00029$), while that of Illingworth [9] used Helium ($n = 1.000035$). We expect then that for air interferometers $k_{air}^2 = 0.00058$ (i.e. $k_{air} = 0.0241$) and for Helium $k_{He}^2 = 0.00007$, which explains why these experiments reported very small but nevertheless non-null and so significant effects. All non-vacuum experiments gave $k > 0$, that is, a non-null effect. All vacuum ($n = 1$) interferometer experiments, having $k = 0$, give null effects as expected, but such experiments cannot distinguish between the new physics and the Einstein physics, only dielectric-mode interferometers can do that. The notion that the Michelson-Morley experiment gave a null effect is a common misunderstanding that has dominated physics for more than a century. By “null effect” they meant that the effect was much smaller than expected, and the cause for this is only now apparent from the above. When the air and Helium interferometer data were re-analysed using the appropriate k values in [3] they gave consistent values which were also consistent with the CMB speed. So these early interferometer experiments did indeed reveal absolute motion, and demonstrated that $k \neq 0$. Of the interferometer experimentalists only Miller consistently argued that absolute motion had been detected, but failed to convince the physics community.

The Michelson-Morley 1887 Experiment

Michelson and Morley reported [7] that their interferometer experiment in 1887 gave a “null-result” which since then, with rare exceptions, has been claimed to support the Einstein assumption that absolute motion has no meaning. However to the contrary the Michelson-Morley published data [7] shows non-null effects, but much smaller than they expected. They made observations of thirty-six 180^0 turns using an $L = 11$ meter length air-interferometer in Cleveland (Latitude $41^030'N$) with six turns at 12:00 hrs (7:00 hrs ST) on each day of July 8, 9 and 11, 1887 and similarly at 18:00 hrs (13:00 hrs ST) on July 8, 9 and 12, 1887. The fringe shifts were extremely small but within their observational capabilities. The best 12:00 and 18:00 hr rotation data are shown in Table 2. The dominant effect was a uniform fringe drift caused by temporal temperature effects on the length of the arms. After correcting for this the best fringe shifts for two 180^0 turns are shown in Fig.2. The 18:00 hr data on July 9 data is particularly free of observational and vibrational errors, and was used here for detailed fitting.

	16	1	2	3	4	5	6	7	
	8	9	10	11	12	13	14	15	16
12:00	27.3	23.5	22.0	19.3	19.2	19.3	18.7	18.9	
	16.2	14.3	13.3	12.8	13.3	12.3	10.2	7.3	6.5
18:00	26.0	26.0	28.2	29.2	31.5	32.0	31.3	31.7	
	33.0	35.8	36.5	37.3	38.8	41.0	42.7	43.7	44.0

Table 2: Fringe shift micrometer readings every 22.5^0 of rotation of the Michelson-Morley interferometer [7] for July 11 12:00 hr and July 9 18:00 hr. The arms are at 45^0 to the stone slab supporting base whose orientation is indicated by the marks 16, 1, 2, ... North is mark 16. Subtracting in each case a fit to $a+bk$,

$\{k = 0, 1, 2, \dots, 16\}$ removes fringe drifts caused by small uniform temporal temperature changes. Then multiplying by 0.02 for micrometer thread calibration and division by 2 to get fringe shift per arm gives the fringe-shift data points in Fig.2, but using only the better quality 1st half rotation data.

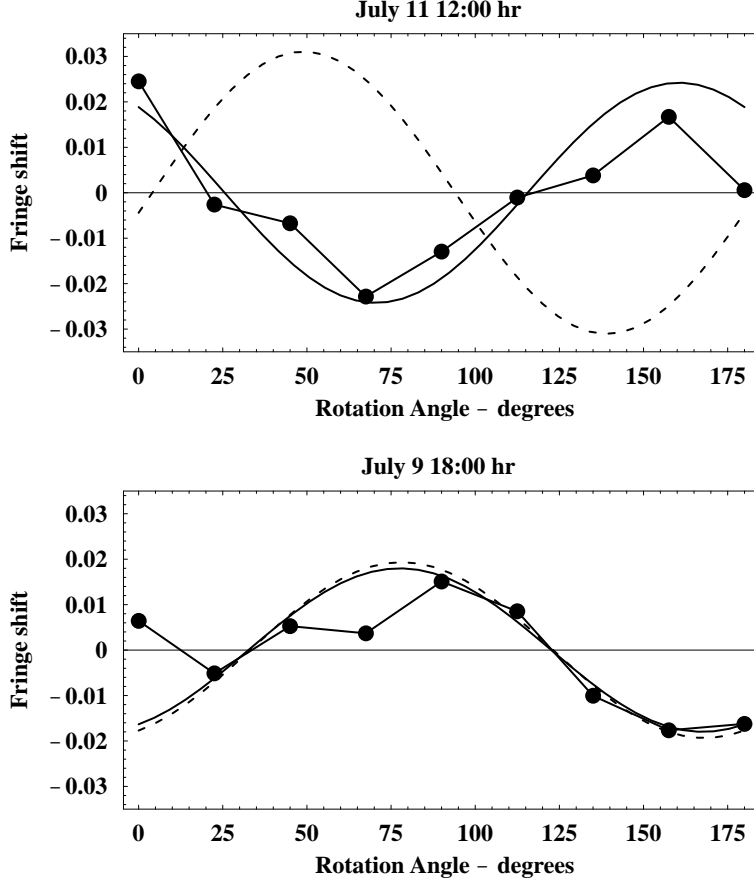


Figure 2: Data points show the 1887 Michelson-Morley fringe shifts for 12:00 hrs on July 11 and 18:00 hrs on July 9 as interferometer was rotated through 180 degrees. The full curves come from the quantum-foam theory best fit to the 18:00 hrs data. The theory curves are $\frac{0.4}{30^2} k_{air}^2 v_P^2 \cos(2(\theta - \psi - 45^\circ))$, where v_P and ψ are from Table 3 and the 45° is the offset described in Table 2. The coefficient $0.4/30^2$ arises as the apparatus would give a 0.4 fringe shift with $k = 1$ if $v_P = 30$ km/s [7]. The CMB data gives plots barely distinguishable from this best fit so long as \mathbf{v}_{in} and $\mathbf{v}_{tangent}$ are included. The dashed curves shows analogous results using the Miller direction for \mathbf{v}_{cosmic} , which is in clear disagreement with the 12:00 hr data. In the best fit to 18:00 hr data points at $\theta = 0^\circ$ and 67.5° were neglected.

In the new physics there are four main velocities that contribute to the total velocity \mathbf{v} :

$$\mathbf{v} = \mathbf{v}_{cosmic} + \mathbf{v}_{tangent} - \mathbf{v}_{in} - \mathbf{v}_E. \quad (7)$$

Here \mathbf{v}_{cosmic} is the velocity of the Solar system relative to the cosmological quantum-foam reference frame, $\mathbf{v}_{tangent}$ is the tangential orbital velocity of the Earth about the Sun, and \mathbf{v}_{in} is a quantum-gravity radial in-flow of the quantum foam past the Earth towards the Sun. Fig.3a shows $\mathbf{v}_{tangent}$ and \mathbf{v}_{in} . The corresponding quantum-foam in-flow into the Earth is \mathbf{v}_E and makes no contribution to a horizontally operated interferometer. For circular orbits the speeds

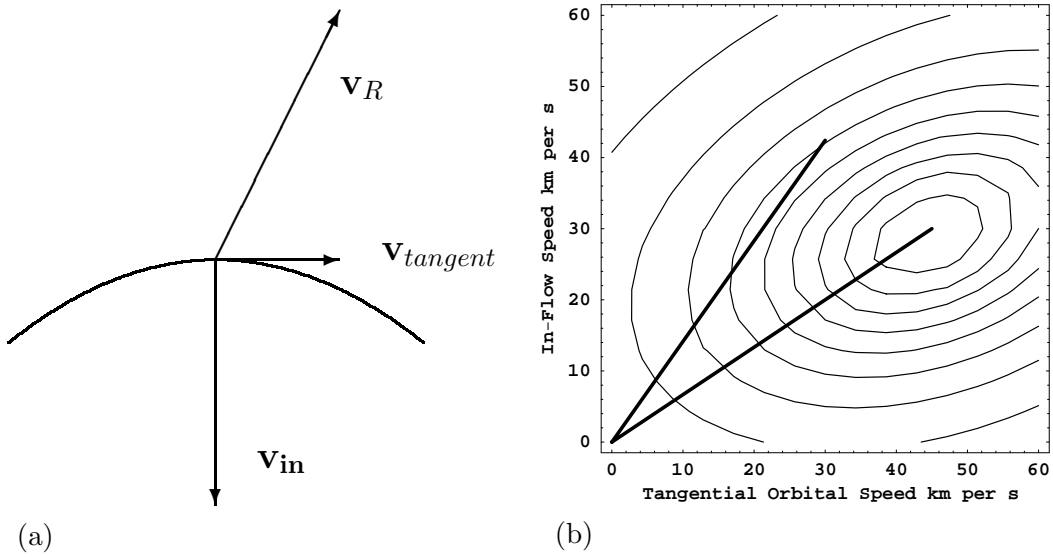


Figure 3: (a) Orbit of Earth defining plane of the ecliptic with tangential orbital velocity $\mathbf{v}_{tangent}$ and quantum-foam in-flow velocity \mathbf{v}_{in} . Then $\mathbf{v}_R = \mathbf{v}_{tangent} - \mathbf{v}_{in}$ is the velocity of Earth relative to the quantum foam, after subtracting \mathbf{v}_{cosmic} . (b) Corresponding to (a) is determination of best fit to 1887 data for \mathbf{v}_R giving $|\mathbf{v}_{in}| = 30 \pm 15$ km/s compared to theoretical value of 42.4 km/s. Firm lines show \mathbf{v}_R for best fit and for theory.

$v_{tangent}$ and v_{in} are given by [1]

$$v_{tangent} = \sqrt{\frac{GM}{R}}, \quad (8)$$

$$v_{in} = \sqrt{\frac{2GM}{R}}, \quad (9)$$

where M is the mass of the Sun, R is the distance of the Earth from the Sun, and G is Newton's gravitational constant. G is essentially a measure of the rate at which matter effectively 'dissipates' the quantum-foam. The gravitational acceleration arises from inhomogeneities in the flow and is given by $\mathbf{g} = (\mathbf{v}_{in} \cdot \nabla) \mathbf{v}_{in}$ in this quantum-foam flow physics [1]. These expressions give $v_{tangent} = 30$ km/s and $v_{in} = 42.4$ km/s.

Direction	v_c (km/s)	Sidereal Time	v (km/s)	v_p (km/s)	ψ (deg.)	v_M (km/s)
CMB: (α, δ) $= (11.20^h, -7.22^0)$	369.0	07:00 July 11 13:00 July 09	322.4 323.9	316.6 269.3	+114.2 ⁰ -151.3 ⁰	7.63 6.49
MM1887: (α, δ) $= (11.20^h, -7.22^0)$	369.0	07:00 July 11 13:00 July 09	318.6 324.1	309.7 269.6	+115.5 ⁰ -151.4 ⁰	7.46 6.49
Miller: (α, δ) $= (17.00^h, +70^0)$	369.0	07:00 July 11 13:00 July 09	366.8 366.8	348.1 274.3	+4.2 ⁰ +32.1 ⁰	8.39 6.61

Table 3: Comparisons of interferometer projected speeds v_p and azimuths ψ corresponding to the total speed $v = |\mathbf{v}|$, where $\mathbf{v} = \mathbf{v}_c + \mathbf{v}_{tangent} - \mathbf{v}_{in}$, for a cosmic speed v_c in the direction indicated by the celestial coordinates (α, δ) . The azimuth ψ is the angle of \mathbf{v}_p measured from the local meridian (\pm from N). The rows labelled MM1887 refer to the best fit to the 18:00 hr Michelson-Morley data from varying $|\mathbf{v}_{in}|$ and $|\mathbf{v}_{tangent}|$, while in rows labelled CMB the theoretical values for $|\mathbf{v}_{in}|$ and $|\mathbf{v}_{tangent}|$ were used. $v_M = k_{air} v_p$ is the speed that would be extracted from the data using the Newtonian expression (5)¹.

¹That this v_M is considerably smaller than the Earth's orbital speed of 30 km/s caused Michelson and Miller

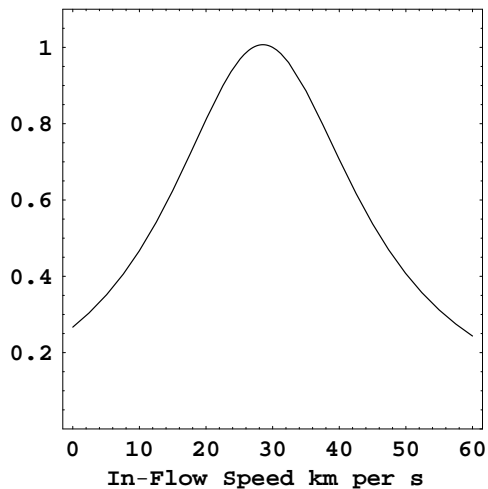


Figure 4: Plot of reciprocal of relative mean square error for fit to Michelson-Morley data versus the quantum-foam in-flow speed giving $v_{in} = 30 \pm 15$ km/s compared to theory of 42.4km/s. This is a cut through Fig.3b at fixed $v_{tangent}$, and clearly shows the quantum-gravity in-flow effect.

The corresponding fringe shifts for MM1887 and Miller as interferometer is rotated are shown in Fig.2.

Because of limited data the direction and magnitude of \mathbf{v}_{cosmic} was taken as known and a least squares fit to the data by varying $|\mathbf{v}_{in}|$ and $|\mathbf{v}_{tangent}|$ was undertaken. The results are shown in Fig.3(b) and in Table 3, and the fit is graphed in Fig.2. The fit is in excellent agreement with the data and we conclude that \mathbf{v}_{cosmic} from the interferometer is the same as \mathbf{v}_{CMB} . Hence the absolute motion detection capabilities of the Michelson interferometer are clearly evident when used in conjunction with the new physics. In finding the best fit we obtain that the magnitude of \mathbf{v}_{in} is 30 ± 15 km/s which is consistent with the theoretical value of 42 km/s. Fig.3b and Fig.4 clearly show the determination of \mathbf{v}_{in} . This shows that the quantum-foam in-flow effect is established and gives us the first signature of quantum gravity effects in the new physics. Table 3 also shows the various interferometer parameters using the CMB velocity and theoretical values for $|\mathbf{v}_{in}|$ and $|\mathbf{v}_{tangent}|$.

Miller reported [8] in 1933 a different direction and magnitude for \mathbf{v}_{cosmic} . That direction is at 90^0 to the CMB/MM direction and is clearly inconsistent with the 12:00 hr Michelson-Morley rotation curve in Fig.2, but it does agree with the 18:00 hr data. This incorrect analysis resulted from the intrinsic 90^0 directional ambiguity of the interferometer if continuity of the phase is not carefully followed during a day².

Nevertheless Miller's extensive Mt.Wilson air-interferometer data with $L = 64$ m is capable of confirming some of the above results. Miller reported in [8] particular observations over four days in 1925/26 recording the time variation of the projection \mathbf{v}_P of the velocity \mathbf{v} onto the interferometer throughout each of these days. Miller's idea was that \mathbf{v} should have only two components: (i) a cosmic velocity of the Solar system through space, and (ii) the orbital velocity of the Earth about the Sun. Over a year this vector sum would result in a changing \mathbf{v} , as was in fact observed. Further, since the orbital speed was known, Miller was able to extract from the

to incorrectly report their "null-result".

²The Miller data was analysed in [10]. It now appears that Miller failed to carefully track the diurnal changes in the azimuth ψ . Around 11:00 hrs sidereal time there is a rapid change in ψ , and this was not detected by Miller.

data the magnitude and direction of \mathbf{v} as the orbital speed offered an absolute scale. Miller was led to the conclusion that for reasons unknown the interferometer did not indicate true values of v_P , and for this reason he introduced the parameter k (we shall denote his values by \bar{k}). Miller noted, in fact, that $\bar{k}^2 \ll 1$. Fitting his data Miller found $\bar{k} = 0.046$ and $v = 210\text{km/s}$ and the direction shown in Table 3. However that $\bar{k} > k_{air}$ now confirms that another velocity component has been overlooked. Miller only knew of the tangential orbital speed of the Earth, whereas the new physics predicts that as-well there is a quantum-gravity radial in-flow \mathbf{v}_{in} of the quantum foam. We can re-analyse Miller's data to extract the speed of this in-flow component. We easily find that it is $v_R = \sqrt{v_{in}^2 + v_{tangent}^2}$ that sets the scale and not $v_{tangent}$, and so we obtain that the value of v_{in} implied by $\bar{k} > k_{air}$ is given by

$$v_{in} = v_{tangent} \sqrt{\frac{\bar{k}^2}{k_{air}^2} - 1} \quad (10)$$

Using the above \bar{k} value and the value of k_{air} we obtain $v_{in} = 49\text{ km/s}$, which is again in good agreement with the theoretical value of 42 km/s . Since it is $v_R = \sqrt{3}v_{tangent}$ and not $v_{tangent}$ that sets the scale we must re-scale Miller's value for v to be $\sqrt{3} \times 210 = 364\text{km/s}$, which now compares favourably with the CMB speed. Hence Miller did indeed observe absolute motion as he claimed but again, as for the Michelson-Morley data, the quantum gravity in-flow effect is required in the analysis.

So the Michelson-Morley experiment actually amounted to the first quantum gravity experiment, and the ability of dielectric-mode interferometers to measure absolute motion made this possible.

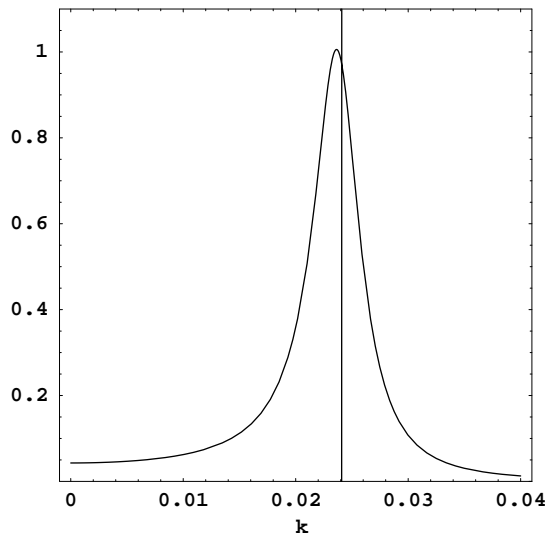


Figure 5: Plot of reciprocal of relative mean square error for fit to Michelson-Morley data as k only is varied with $\mathbf{v} = \mathbf{v}_{CMB} + \mathbf{v}_{tangent} - \mathbf{v}_{in}$ fixed. Best value from comparison is $k = 0.02363$, compared to $k_{air} = 0.02410$ (vertical line).

In Fig.5 is shown best value for k if \mathbf{v} is fixed at $\mathbf{v}_{CMB} + \mathbf{v}_{tangent} - \mathbf{v}_{in}$ (with $\mathbf{v}_{tangent}$ and \mathbf{v}_{in} set to theoretical values) in fit to data, giving $k = 0.02363$ compared to $k_{air} = 0.02410$. This corresponds to $n = 1.00028$ compared to $n_{air} = 1.00029$, demonstrating that the dielectric con-

stant of air may be extracted from the Michelson-Morley data when all three major components of \mathbf{v} are included. The results here and above all show that $k \neq 0$.

Conclusions

The various dielectric-mode interferometer experiments were never null and their data can now be fully analysed within the new physics. This analysis reveals various aspects of the new quantum-foam phenomena. The incorrect reporting by Michelson and Miller of a “null effect” was based on using the Newtonian value of $k = 1$ and on v being atleast 30km/s due to the Earth’s orbital motion, and so predicting fringe shifts 10 times larger than actually seen (the true value for v^2 in (1) is some 10^2 larger but the dielectric effect gives a reduction of approximately 1/1000). Of course that Michelson and Morley saw any effect is solely due to the presence of the air in their interferometer. Vacuum interferometer experiments of the same era by Joos [11] gave $v_M < 1\text{km/s}$, and are consistent with a null effect as predicted by the quantum-foam physics. If Michelson and Morley had more carefully reported their results the history of physics over the last 100 years would have been totally different.

The experimental results analysed herein and in [3] show that absolute motion is detectable. This is motion with respect to a quantum-foam system that is space. As well quantum matter effectively acts as a sink for the quantum-foam, and the flow of that quantum-foam towards the Sun has been confirmed by the data. These results are in conflict with the fundamental assumption by Einstein that absolute motion has no meaning and so cannot be measured. Vacuum interferometer experiments do give null results, for example see [11, 12, 13, 14], but they only check the Lorentz contraction effect, and this is common to both theories. So they are unable to distinguish the new physics from the Einstein physics. As well that the interferometer experiments and their results fall into two classes, namely vacuum and dielectric has gone unnoticed. The non-null results from dielectric-mode interferometers have always been rejected on the grounds that they would be in conflict with the many successes of the Special and General Theory of Relativity. However this is not strictly so, and it turns out that these successes survive in the new physics, which actually subsumes the Einstein formalism, even though the absolute motion effect is not in the Einstein physics. Einstein essentially arrived at a valid formalism from a wrong assumption. The new more encompassing process physics [1-3, 14-17] allows the determination of a physically real foliation of the spacetime construct (the Panlevé-Gullstrand foliation) and so it actually breaks the diffeomorphism symmetry of General Relativity.

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