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HISTORICAL PERSPECTIVE

Does a Cosmic Ether Exist? Evidence from Dayton Miller and Others

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I believe that I have really found the relationship between gravitation and electricity, assuming that the Miller experiments are based on a fundamental error. Otherwise, the whole relativity theory collapses like a house of cards.

—Albert Einstein, in a letter to Robert Millikan, June 1921 (Clark 1971:328)

The effect [of ether-drift] has persisted throughout. After considering all the possible sources of error, there always remained a positive effect. —Dayton Miller (1928:399)

Abstract—The author reviewed the experimental ether-drift experiments and publications of Michelson–Morley, Dayton Miller, Michelson–Pease–Pearson, and more recent others, from the late 1800s through the present. Many of these historical studies presented positive results in detecting a cosmic ether, and ether-drift through space. Among these experiments, the most widely cited Michelson–Morley experiment of 1887, which did show a slight positive result (and never the claimed "null"), was found to be the least significant or robust in terms of experimental procedures and actual data collected, as compared with the far more important 1920s' study by Miller on Mount Wilson near Los Angeles, California. Most ether-drift experiments yielding claimed negative results were plagued by various unwarranted assumptions about the capacity of an ether-drift to penetrate dense materials such as stone buildings or metal shielding, or that ether flow would "contract" matter, including measuring instruments, leaving the ether-drift undetectible. Some obtained positive results, but the authors chose to interpret them as "negative" due to unwarranted assumptions demanding extremely fast ether-drift velocities near to the Earth's surface. Miller was the first to experimentally account for these issues, his most important study made atop Mount Wilson in a thermal shelter, with the largest light-beam interferometer ever constructed, and where the light-beam path was enclosed only by light glass or cardboard. His procedures accounted for a matter-retarded cosmic ether-drift with a reduced velocity closer to the Earth's surface. Miller thereby obtained significant positive results over four epochs of study. Albert Einstein also was aware of these issues, and admitted openly that if Miller was correct, then his own relativity theory would "collapse like a house of cards." In subsequent years, however, the followers of Einstein defeated this evidence for the cosmic ether by public ridicule and political tactics, not too different from the modern "skeptic" movement. The Shankland, McCuskey, Leone, and Kuerti article claiming to have reviewed Miller's Mount Wilson data, well after all the old ether-drift experimenters were dead and could no longer defend their findings, were also specifically reviewed and found to *not* support their own stated conclusions, thereby leaving the question of a cosmic ether and ether-drift as an open and unresolved question, or one which positive evidence indicates has been proven out. More recent ether-drift experiments from the last quarter of the 20th and early 21st Centuries, notably by Galaev, Múnera, and others, using radiofrequencies, light-beam interferometery, and other novel methods, have provided further proof for the existence of a cosmic ether in space.

Introduction

The history of science records the 1887 ether-drift experiment of Albert Michelson and Edward Morley as a pivotal turning point, where the energetic *ether of space* was discarded by mainstream physics. Thereafter, the postulate of "empty space" was embraced, along with related concepts that demanded constancy in light-speed, such as Albert Einstein's relativity theory. The now-famous *Michelson–Morley Experiment* is widely cited, in nearly every physics textbook, for its claimed "null" or "negative" results. Less known, however, is the far more significant and detailed work of Dayton Miller.

Dayton Miller's 1933 paper in *Reviews of Modern Physics* details the positive results from more than 20 years of experimental research into the question of ether-drift, and remains *the most definitive body of work on the subject of light-beam interferometry*. Other positive ether-detection experiments have been undertaken, such as the work of Sagnac (1913) and Michelson–Gale (1925), documenting the existence of light-speed variations ($c + v > c - v$), but these were not adequately constructed for detection of a larger cosmological *ether-drift*, of the Earth and Solar System moving through the background of space. Dayton Miller's work on ether-drift was so constructed, however, and yielded *consistently positive results*.

Miller's work, which ran from 1906 through the mid-1930s, most strongly supports the idea of an ether-drift, of the Earth moving through a cosmological medium, with calculations made of the actual direction and magnitude of drift (Miller 1930, 1934). By 1933, Miller concluded that the

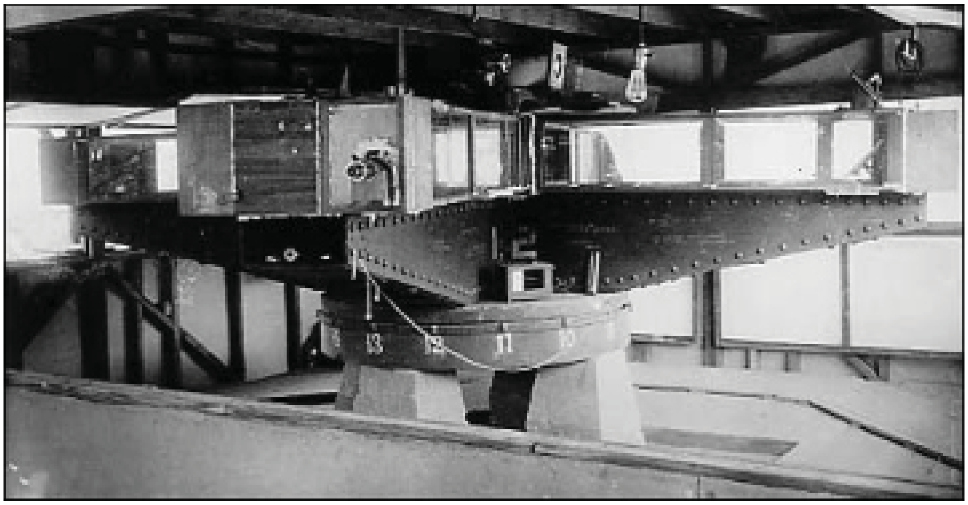

Figure 1. Dayton Miller's light-beam interferometer, at 4.3 meters across, was the largest and most sensitive of this type of apparatus ever constructed, with a mirror-reflected roundtrip light-beam path of 64 meters. It was used in a definitive set of ether-drift experiments on Mt. Wilson, 1925–1926. Protective insulation is removed in this photograph, and windows were present all around the shelter at the level of the interferometer light-path (see below).

Earth was drifting at a speed of 208 km/sec toward an apex in the Southern Celestial Hemisphere, toward Dorado, the swordfish, right ascension 4 hrs 54 min, declination of −70° 33′, in the middle of the Great Magellanic Cloud and 7° from the southern pole of the ecliptic (Miller 1933:234). This is based upon a measured displacement of around 10 km/sec. at the interferometer, and assuming the Earth was pushing through a stationary but Earth-entrained ether in that particular direction, which lowered the velocity of the ether from around 200 to 10 km/sec at the Earth's surface. Today, however, Miller's work is hardly known or mentioned, as is the case with nearly all the experiments that produced positive results for an ether in space. Modern physics today points instead to the much earlier and less significant 1887 work of Michelson–Morley as having "proved the ether did not exist."

While Miller had a rough time convincing some of his contemporaries about the reality of his ether measurements, he clearly could not be ignored in this regard. As a graduate of physics from Princeton University, President of the American Physical Society and Acoustical Society of America, Chairman of the Division of Physical Sciences of the National

Research Council, Chairman of the Physics Department of Case School of Applied Science (today Case Western Reserve University), and Member of the National Academy of Sciences well-known for his work in acoustics, Miller was no "outsider." While he was alive, he produced a series of papers presenting solid data on the existence of a measurable ether-drift, and he successfully defended his findings to not a small number of critics, including Einstein. His work employed light-beam interferometers of the same type used by Michelson–Morley, but of a more sensitive construction, with a significantly longer light-beam path (Figure 1). He periodically took the device high atop Mount Wilson (above 6,000′ elevation) in Los Angeles, California, where Earth-entrained ether-theory predicted the ether would move at a faster speed than close to sea level. While he was alive, Miller's work could not be fundamentally undermined by the critics. However, toward the end of his life, he was subject to isolation as his ether-measurements were simply ignored by the larger world of physics, which was then captivated by Einstein's relativity theory.

After his death in 1941, Miller's work was finally "put to rest" in the publication of a critical 1955 paper in *Reviews of Modern Physics* by Robert S. Shankland, S. W. McCuskey, F. C. Leone, and G. Kuerti (hereafter referred to as the "Shankland team" or "Shankland" paper), which purported to make a fair and comprehensive review of Miller's data, finding substantial flaws.

Lloyd Swenson's *Ethereal Aether* (1972) presents a cursory discussion of Miller and his "inexplicable" positive results, giving a high degree of significance to the Shankland team's critique. Swenson wrote:

> . . . . Shankland, after extensive consultation with Einstein, decided to subject Miller's observations to a thoroughgoing review. . . . Einstein saw the final draft [of Shankland's pre-publication manuscript] and wrote a personal letter of appreciation for having finally explained the small periodic residuals from [Miller's] Mount Wilson experiments. (Swenson 1972:243)

In August of 1954, Einstein replied to Shankland:

> I thank you very much for sending me your careful study about the Miller experiments. Those experiments, conducted with so much care, merit, of course, a very careful statistical investigation. This is more so as the existence of a not trivial positive effect would affect very deeply the fundament of theoretical physics as it is presently accepted. You have shown convincingly that the observed effect is outside the range of accidental deviations and must, therefore, have a systematic cause [having] nothing to do with 'ether wind', but with differences of temperature of the air traversed by the two light bundles which produce the bands of interference. (Shankland 1973a:2283)

From the above accounts, it certainly would appear that the case was finally closed on Miller, and that all the lose ends were finally cleaned up. With the strongest support for cosmological ether-drift swept aside as the alleged product of temperature errors, Einstein's theory of relativity continued to grow in popularity and dominance.

Here, I will compare the Shankland team's 1955 criticisms to what is actually contained in Miller's published works, notably his 1933 paper which summarized his work on the subject. It is my contention that the Shankland paper, published 14 years after Miller's death, attempted to resurrect speculative criticisms which had previously been raised and rebutted when Miller was alive and not given serious credibility except among anti-ether fundamentalists. The Shankland paper also misrepresented Miller's data in several ways, and furthermore misrepresented itself as a definitive rebuttal, which it most certainly was not. In order to properly address this major issue of science history, I will also recount the central facts of Miller's work.

The basic principles of light-beam interferometry for detection of ether-drift are described in most textbooks, albeit with typical factual errors (i.e. the slight positive result of the Michelson–Morley experiment is nearly always misrepresented as a "null" or "zero" result) and so will not be repeated here. However, there were novel methods introduced by Miller into the discussion of ether-drift, along with interferometer construction features and principles of operation that are not widely known—these will be detailed.

Miller's Work with Interferometry

Miller began his work on the question of ether-drift and light-beam interferometry with Edward Morley, from 1902 to 1906, using an apparatus three times as sensitive as the original interferometer used by Michelson–Morley in 1887 (Morley & Miller 1905, 1907). In later years, from 1921 through 1928, Miller made additional refinements for sensitivity in his interferometer, obtaining increasingly significant positive results. His interferometer was the most massive and sensitive ever constructed, with iron cross-arms 4.3 meters across, and standing 1.5 meters in height. Four sets of mirrors were mounted on the end of each cross-arm to reflect light beams back and forth 16 times horizontally with a total roundtrip light path of 64 meters, starting from the same light source, and finally recombined to form interference fringes whose movement relative to a pointer was read through a magnifying telescope. The large apparatus was floated inside a circular tank of liquid mercury, providing a frictionless base for rotation. Fringe-shift movements (in tenths of a fringe, plus or minus in direction) were observed by one person who walked around with the apparatus while

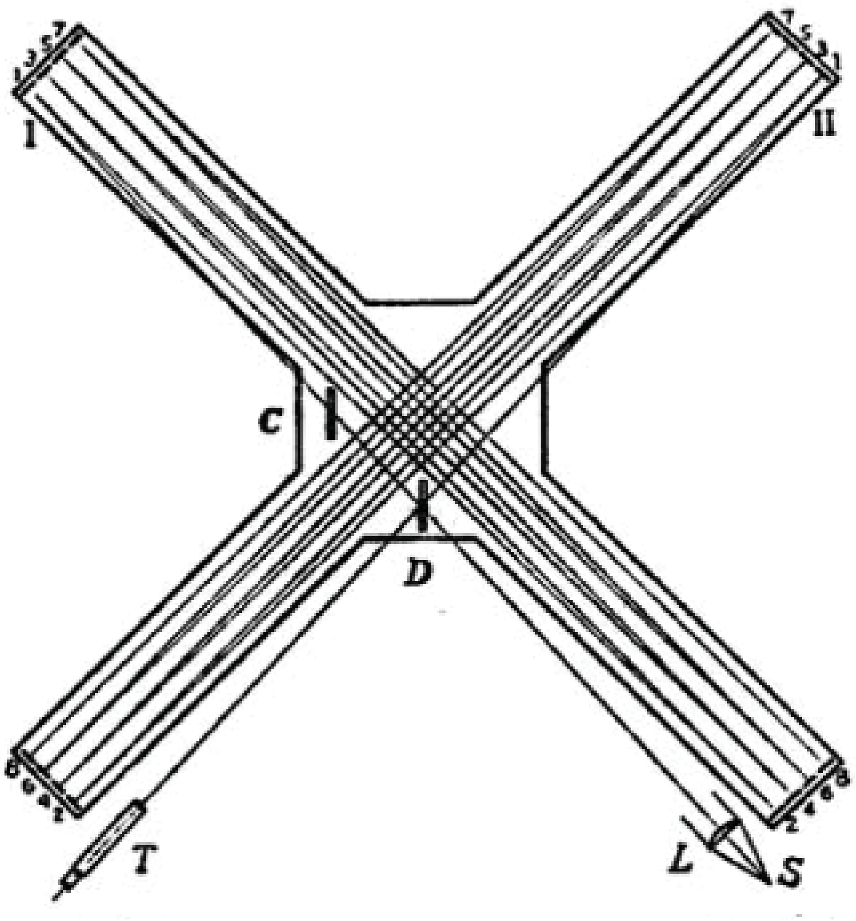

Figure 2. Light Paths of the Michelson–Morley and Miller Interferometers, as seen from above. Source (S) generates light which passes through lens (L) and is then split by half-silvered mirror (D). Beams then reflect back and forth along beams (I and II) to mirrors (numbered 1–8) before finally being recombined by half-silvered mirror (D) and reflected to small telescope eyepiece (T) where interference fringes are observed.

it turned, speaking out the readings at the ring of a bell which automatically sounded when electrodes made contact at 24° intervals (dividing the circle into 15 parts). An assistant then noted the readings on paper. The readings from consecutive turns of the apparatus were then organized into "sets," which were made at different times of day and at different seasons of the year. Datasets were then averaged according to a sidereal time clock, which

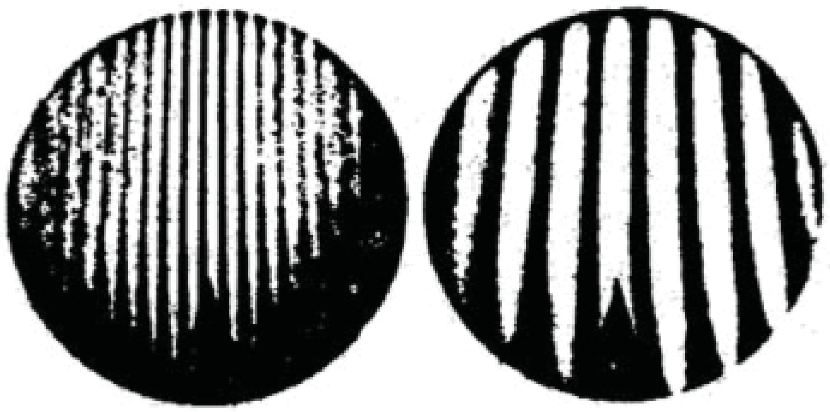

Figure 3. Light-interference fringes as seen in the interferometer telescope. Magnified by an eyepiece with precise graduated markings, one could observe the lateral movement or shifting of fringes as the instrument was rotated. Miller's larger apparatus used a 50x telescope, allowing magnified readings down to hundredths of a fringe, though readings were typically recorded in tenths.

was correlated with external celestial coordinates. Miller became convinced of an ether Earth-entrainment effect, which necessitated using the apparatus at higher altitudes (to reduce the anticipated entrainment-effect of sea-level environments), and he additionally undertook the experiments in structures where the walls at the level of the light-path were open to the air, covered with canvas (Figure 2, Figure 3). Only glass or glass and light paper covers were used along the light-beam paths, with all wood or metal shielding removed. By contrast, the original Michelson–Morley interferometer (Figure 4) had a roundtrip light-path of around 22 meters (Michelson 1927:153), and the experiments were undertaken with an opaque wooden cover over the instrument, situated in the basement of one of the large stone buildings at the Case School in Cleveland.

In his 1933 paper, Miller published the most comprehensive summary of his work, and the large quantity of data which supported his conclusions. A total of more than 200,000 individual readings were made, from more than 12,000 individual turns of the interferometer, undertaken at different months of the year, starting in 1902 with Edward Morley at the Case School in Cleveland, and ending in 1926 with his Mount Wilson experiments (Figure 5). These data do not include many rigorous control experiments undertaken at the Case School Physics Department from 1922 to 1924 (Miller 1922, 1925). More than half of Miller's readings were made at Mount Wilson using the most sophisticated and controlled procedures, with

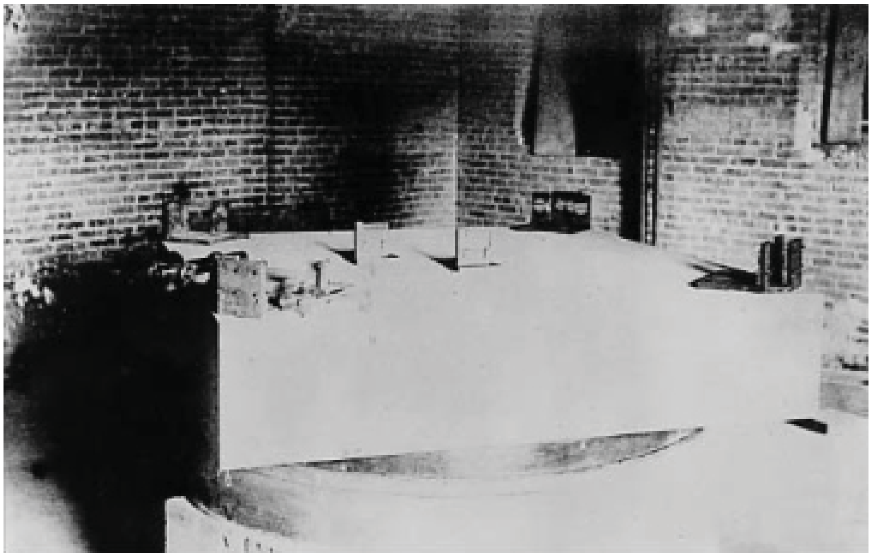

Figure 4. The original Michelson-Morely interferometer with an approximate 22-meter roundtrip light-beam path, mounted on a concrete platform in the basement of the old Case School Physics building (today, Case Western Reserve University). This interferometer was about one-third as sensitive as the 64-meter interferometer constructed later by Miller. A protective wood cover over the light-beam paths is removed for this photograph. Such dense coverings and stone-basement shielding, as Miller showed, slowed down the movement of the ether. These problems, along with a relatively short light-path, and placement at a relatively low altitude basement location, virtually guaranteed only a small (but never "null") measured result.

the most telling set of experiments in 1925 and 1926. By contrast, we can mention here, the original Michelson–Morley experiment of 1887 involved only *six hours of data collection* over four days (July 8, 9, 11, and 12 of 1887), with a grand total of only 36 turns of their interferometer. Even so, as shown below, Michelson–Morley originally obtained *a slight positive result* which has been systematically ignored or misrepresented by modern physics. As stated by Michelson–Morley:

> . . . the relative velocity of the earth and the ether is probably less than one-sixth the earth's orbital velocity, and certainly less than one-fourth. . . . The experiment will therefore be repeated at intervals of three months, and thus all uncertainty will be avoided. (Michelson–Morley 1887)

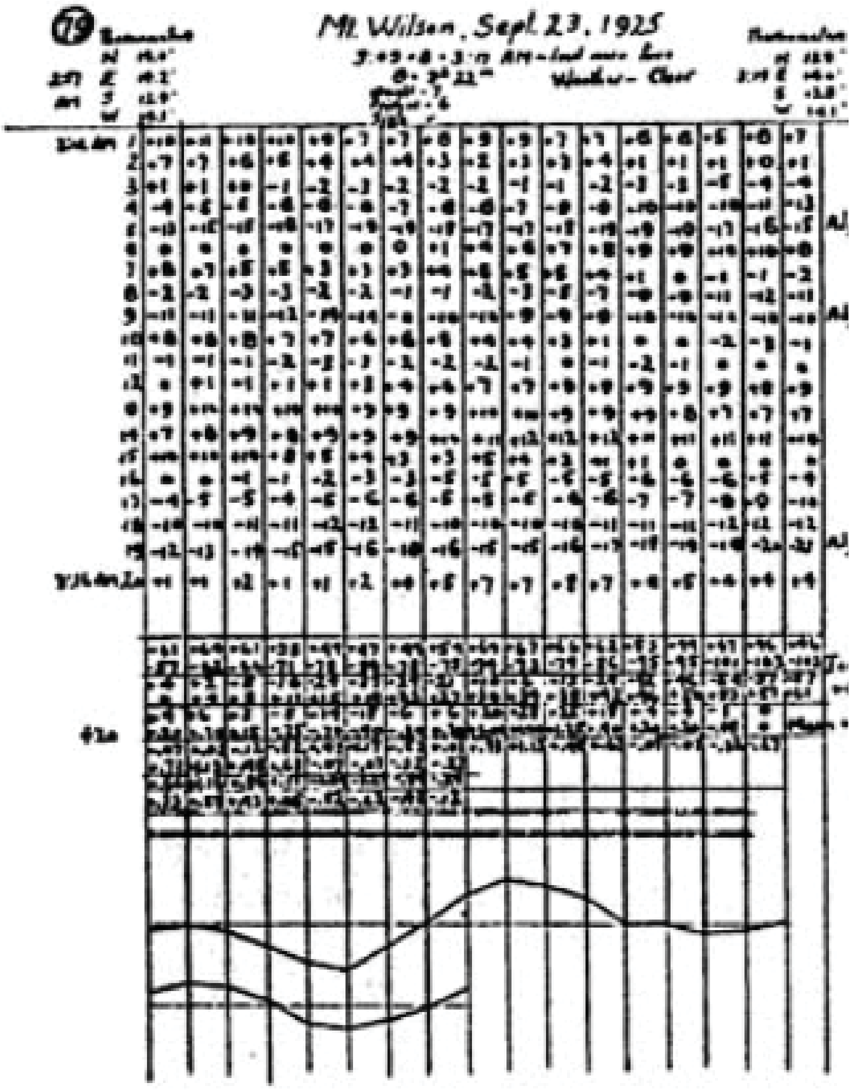

Figure 5. A typical datasheet recording 20 turns of the interferometer, in this case, on 23 September 1925, 3:09 to 3:17 a.m. at Mount Wilson. More than 300 of these datasheets were recorded by Miller at Mt. Wilson alone, covering more than 6,000 turns of the interferometer.

Unfortunately, and in spite of all claims to the contrary, Michelson–Morley never undertook those additional experiments at the different seasonal configurations, to "avoid all uncertainty." However, Miller did. Over many years, he developed increasingly sensitive apparatuses, using them at higher altitudes and in open structures, making clear and positive detection of the ether. His experiments yielded systematic periodic effects which pointed to a similar identifiable axis of cosmic ether-drift, though of a variable magnitude, depending upon the season, time of day, density of materials shielding or surrounding the apparatus, and altitude at which the experiment was undertaken. He argued that basement locations, or interferometers shielded with opaque wood or metal housings, yielded the most tiny and insignificant effects, while those undertaken at higher altitudes and in less dense structures yielded more readily observable effects. The Michelson–Morley experiment, by comparison, was undertaken in the basement of a stone building closer to sea level. Even so, it produced a slight positive result which was in agreement with Miller's results.

Miller's observations were also consistent through the long period of his measurements. He noted, when his data were plotted on sidereal time, they produced

> *. . . a very striking consistency of their principal characteristics . . . for azimuth and magnitude . . . as though they were related to a common cause. . . . The observed effect is dependent upon sidereal time and is independent of diurnal and seasonal changes of temperature and other terrestrial causes, and . . . is a cosmical phenomenon.* (Miller 1933:231)

Debates with Einstein

There are several newspaper accounts indicating a certain tension between Albert Einstein and Dayton Miller, since the early 1920s at least. In June of 1921, Einstein wrote to the physicist Robert Millikan:

> *I believe that I have really found the relationship between gravitation and electricity, assuming that the Miller experiments are based on a fundamental error. Otherwise, the whole relativity theory collapses like a house of cards.* (Clark 1971:328)

Privately, in letters and in spoken words, there was a struggle going on for philosophical dominance, and occasionally this struggle surfaced into public view:

> **GOES TO DISPROVE EINSTEIN THEORY**
> **Case [School] Scientist Will Conduct Further Studies in Ether Drift**
> *Einstein Discounts Experiments*
> Speaking before scientists at the University of Berlin, Einstein said the ether drift experiments at Cleveland showed zero results, while on Mount Wilson they showed positive results. Therefore, altitude influences results. In addition, temperature differences have provided a source of error. "The trouble with Prof. Einstein is that he knows nothing about my results," Dr. Miller said. "He has been saying for thirty years that the interferometer experiments in Cleveland showed negative results. We never said they gave negative results, and they did not in fact give negative results. He ought to give me credit for knowing that temperature differences would affect the results. He wrote to me in November suggesting this. I am not so simple as to make no allowance for temperature." (*Cleveland Plain Dealer*, 27 January 1926)

The above newspaper account is significant, as it demonstrates that Einstein was pushing the "thermal artifact" argument against Miller's results as early as 1926. There are other accounts of Einstein's discontent with Miller's results in "Conversations with Albert Einstein" written by Robert Shankland in the years after Miller's death (Shankland 1963, 1973b).

Miller's Control Experiments

Miller was fully aware of the criticisms being made against his findings, that his interferometer was responding to one or another mechanical, magnetic, or thermal influence. Given its large size and sensitivity, it required a careful setup procedure prior to each use. Setting screws with extremely fine threads were used to adjust the mirrors, and the final adjustment could isolate 100 wavelengths of light by just a 16° turn of the screw. Even this was insufficient for the final adjustment, which was made by adding small weights of around 100 grams to the ends of the cross-beam, which was sufficient to cause a micro-flexing of the iron supports by only a few wavelengths. Only then would the interference fringes come into view. And once in view, additional care had to be taken to prevent distortions from mechanical vibrations. Consequently, from the very beginning of the ether-drift experiments, Miller undertook extensive control experiments and procedures to guard against laboratory artifacts, and to objectively determine just how sensitive his apparatus was to external influences.

Especially between 1922 and 1924, Miller's control experiments were most rigorous, aimed at addressing the criticisms he had received following the earlier work, to make the apparatus as sensitive as possible only to ether-drift. A special interferometer of aluminum and brass was constructed, to

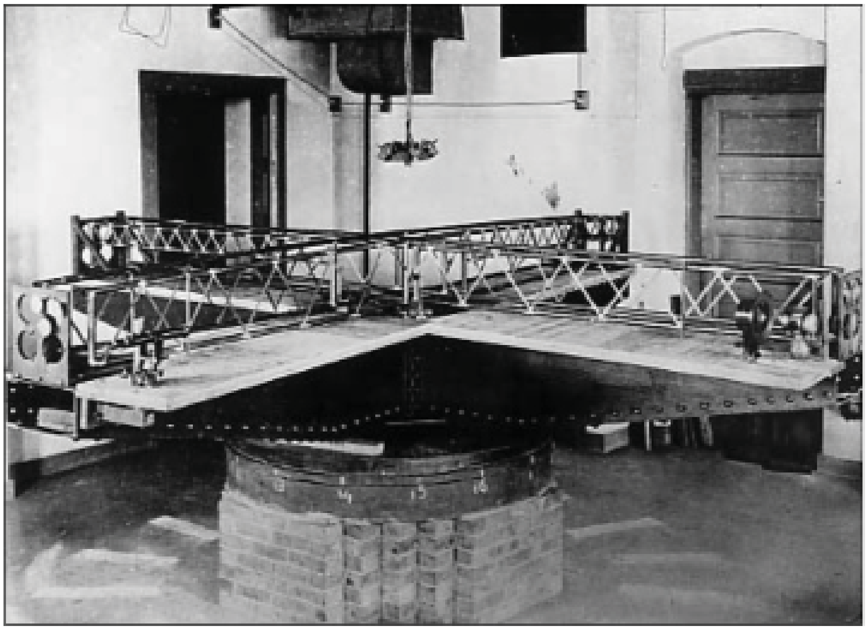

Figure 6. Miller's Control Experiments. A wooden platform has been supplied for the mirrors and optics of the interferometer, inside a building at the Case School.

guard against the possible effects of magnetoconstriction (the measured periodic ether-drifting was the same as with the original iron interferometer). Procedures were made to judge the effects of mechanical vibration—such as using a loose or tight centering pin. Bases made of wood, metal, or concrete were floated in the mercury tank, to judge and correct for the effects of strain and deformation (Figure 6, Figure 7). The apparatus was not touched when operating, but rather gently pulled in a circle by a thin string, slowly accelerated to the desired velocity of rotation while floating in the mercury tank. Different light sources were tried, mounted at different locations on the apparatus. Light sources outside the structure were also tried, including sunlight, but finally an artificial light source located above the central axis of the instrument was used.

Possible temperature effects were evaluated by using radiant parabolic heaters to artificially heat the apparatus and the air through which the light-beam passed. These experiments showed that the interferometer clearly was sensitive to artificial heating, and so steps were taken to eliminate the effect. Strong radiant heat sources, it was learned, would badly skew the apparatus if focused upon only one arm or pair of arms of the iron cross-

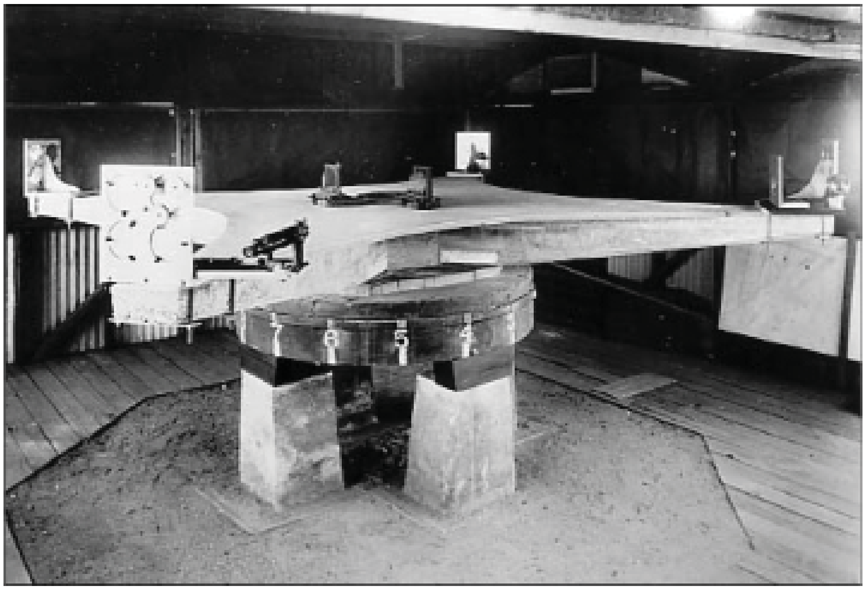

Figure 7. Miller's Control Experiments. A concrete platform supports the mirrors and optics of the interferometer inside a small shelter on the grounds at the Case School.

beams. Equal heating of the apparatus had no such effect, but the metal arms were nevertheless covered with a one-inch cork insulation to guard against radiant thermal effects (Figure 8). The lightpath was given a glass housing, which stabilized the temperature inside, and later a light corrugated paper cover was added over the glass cover, which did not affect the ether-drift but further protected against possible temperature variations. Low-level thermal effects were also evaluated, as from human body heat, by having the recording assistant stand in different locations while the apparatus was turned and operated.

Temperature effects from the larger environment were evaluated as well. Early ether-drift experiments, including those of Michelson–Morley and Morley–Miller, were undertaken inside basement locations with relatively stabilized temperatures, but shielded from the ether-drift as well due to heavy and dense building materials. Miller's ether-drift experiments atop Mount Wilson required a different approach, and a special house was constructed to shelter the interferometer. It had a floor, walls, and roof, and canvas-covered windows all around at the level of the interferometer light-beam. During his last set of Mount Wilson experiments in 1925–1926, a tent-like covering was erected over the roof and walls to provide additional

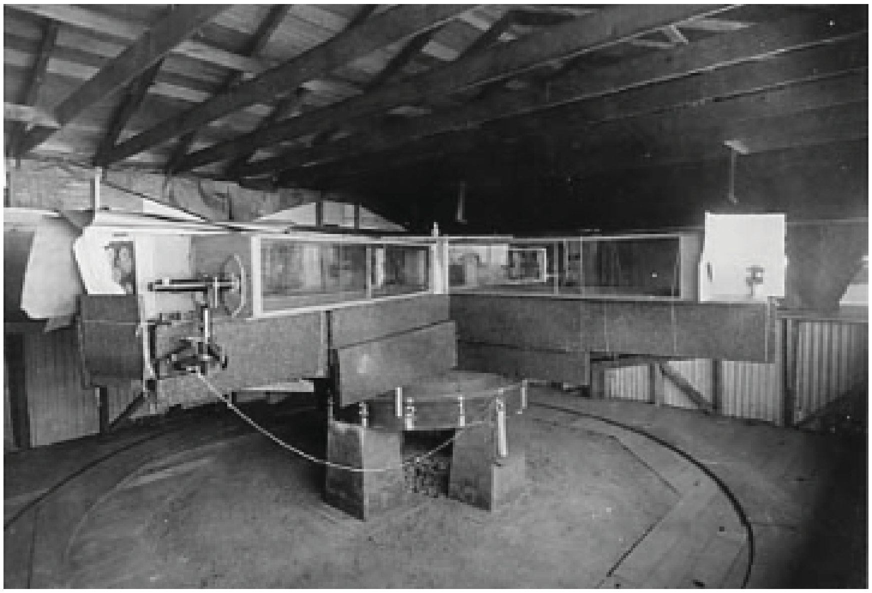

Figure 8. Miller's fully-insulated interferometer as it was finally employed at Mt. Wilson, c. 1925, fitted with 1″ insulating cork panels covering the metal support structure, and glass and light paper coverings along the light-beam path (paper removed for the photograph). These steps eliminated any significant influences of ambient temperature differences upon the apparatus and the air within the light-beam path, but still allowed the movement of ether-drift.

shielding from direct sunlight, to diminish thermal variations or radiant heating effects from the walls (Figure 9).

Miller noted that at no time during his entire work on the question did he ever observe any periodic effects expressing themselves according to civil time coordinates, as would be present if a thermal effect was radiating from a specific wall, related to solar heating. Since the measurements were made at different times of day, and at different seasons, their amplitude would vary, but the direction of the ether-drift would shift only to the same average points along a sidereal azimuth. This is graphically demonstrated in Figures 10, 11, and 12. The measurements were latitude-dependent as well, and when analyzed with attention to the Earth's rotation, axial tilt, movement around the Sun, and the Sun's movement through galactic space, finally revealed a common sidereal cosmological axis of ether-drift (Figure 13).

From reading his publications, one gets the impression of Dayton

Figure 9. Miller's interferometer house on Mt. Wilson. With canvas-covered windows all around, insulating "beaver-board" walls (wood fiber composite), and fitted with a tent cover to further stabilize temperatures.

Miller as a very careful and exceptionally patient experimentalist, someone who took every possible precaution to ensure his apparatus was detecting only the phenomenon of interest. He also appeared to be quite content with the possibility that, having undertaken all the various controls to shield the apparatus from thermal effects in the measurement room, he might finally get a true "null" or "zero" effect—he did not appear to be a "believer" in ether-drift who would succumb easily to bias. He was a genuine scientist, dedicated to finding the truth of the matter. A null result was not observed, however, and his efforts to control out mechanical and thermal artifacts never eliminated the observed periodic sidereal variations, which persisted throughout his experimental work. More will be said about Miller's control procedures below.

Michelson, and Others, Confirm an Ether-Drift

Miller's work did finally receive indirect support from Albert Michelson in 1929, with the publication of "Repetition of the Michelson–Morley Experiment" (Michelson, Pease, & Pearson 1929). The paper reported on three attempts to produce ether-drift fringe shifts, using light-beam interferometry similar to that originally employed in the Michelson–Morley

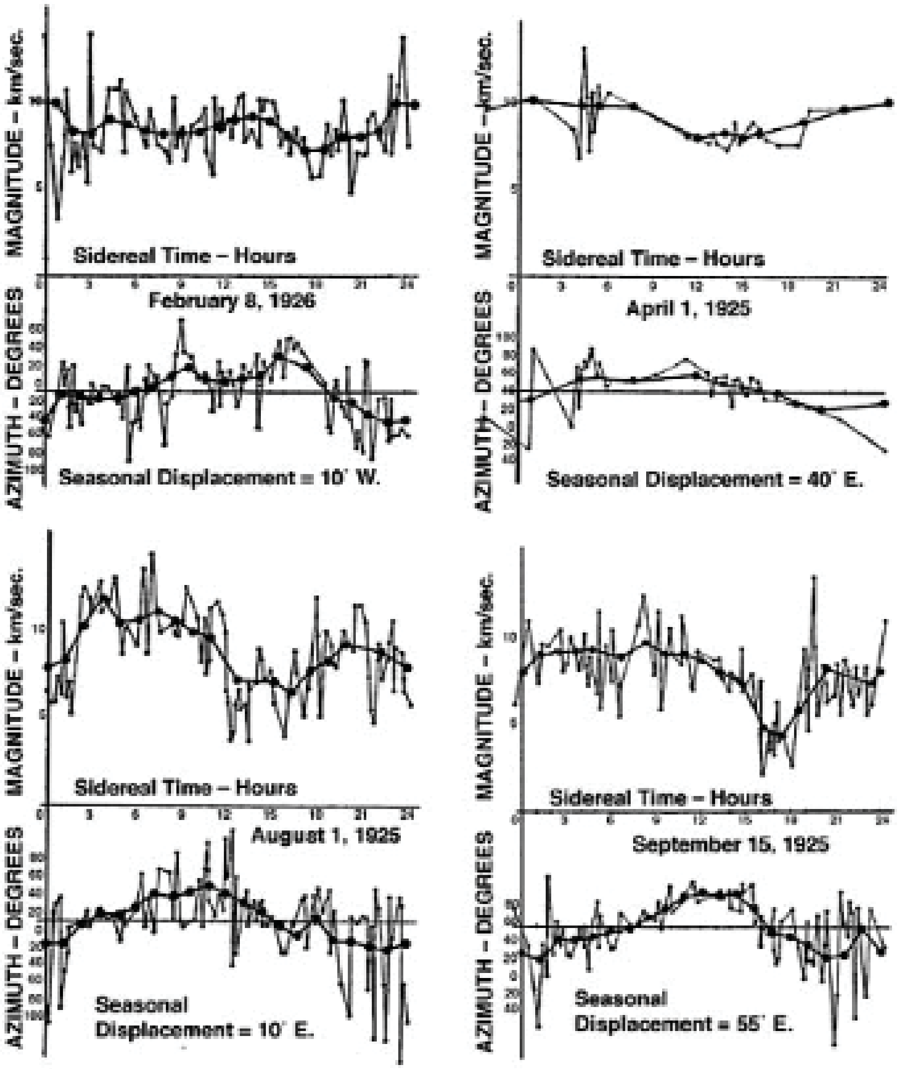

Figure 10. VELOCITIES AND AZIMUTHS OF ETHER-DRIFT, from the four 10-day epochs of measurement at Mt. Wilson, 1925–1926. The caption is redrafted from the original in Miller (1933:229).

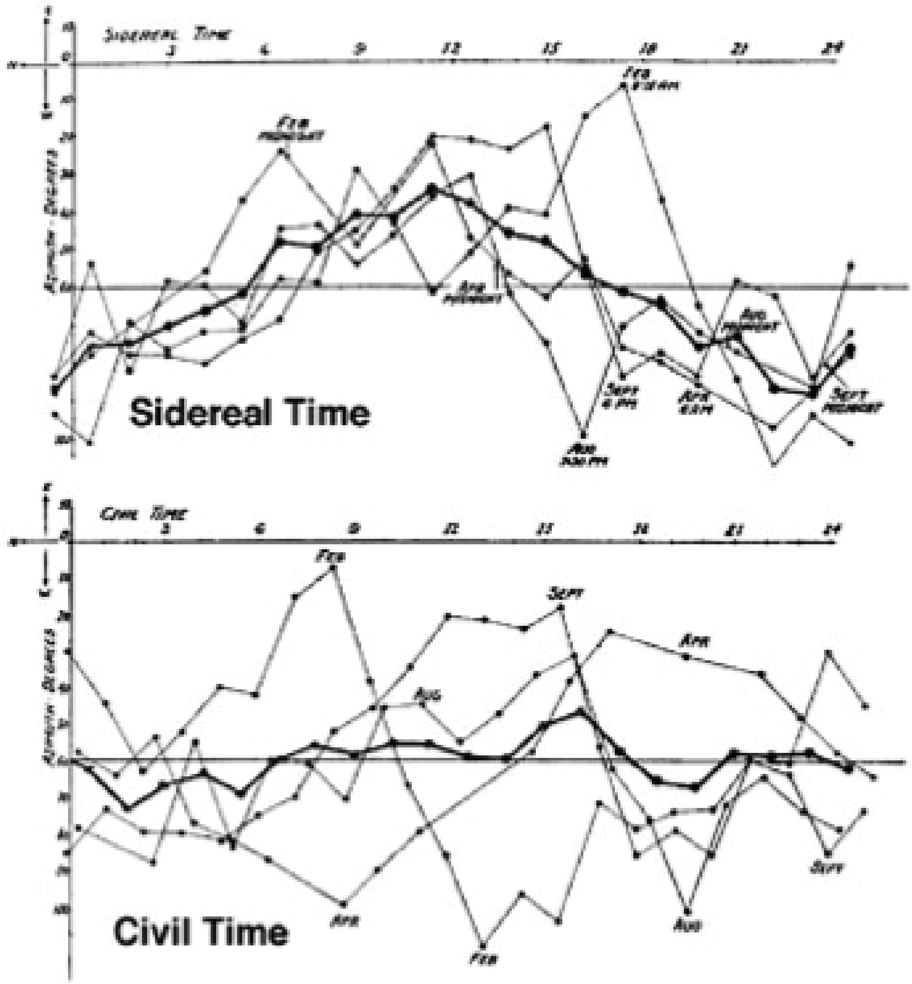

Figure 11. PERIODICITY OF GLOBAL ETHER-DRIFT, from Dayton Miller's Mount Wilson Ether-Drift Experiments, 1925–1926. The *Top Graph* above plots data from four separate months or epochs, measured at different times of the year and organized by sidereal time, showing a definite periodic curve. The heavy line is the mean of all four epochs. The *Bottom Graph* above plots the same data organized by civil clock time coordinates; here the plotted data spreads out along the graph, without apparent periodicity. This demonstrates that the detected axis and periodicity of ether-drift is the same for different times of year, but can only be seen when the data is viewed within a cosmological, sidereal coordinate system (from Miller 1928:362). These data curves are organized along azimuthal means that were later recomputed for Miller's 1933 publication, as given in Figure 10.

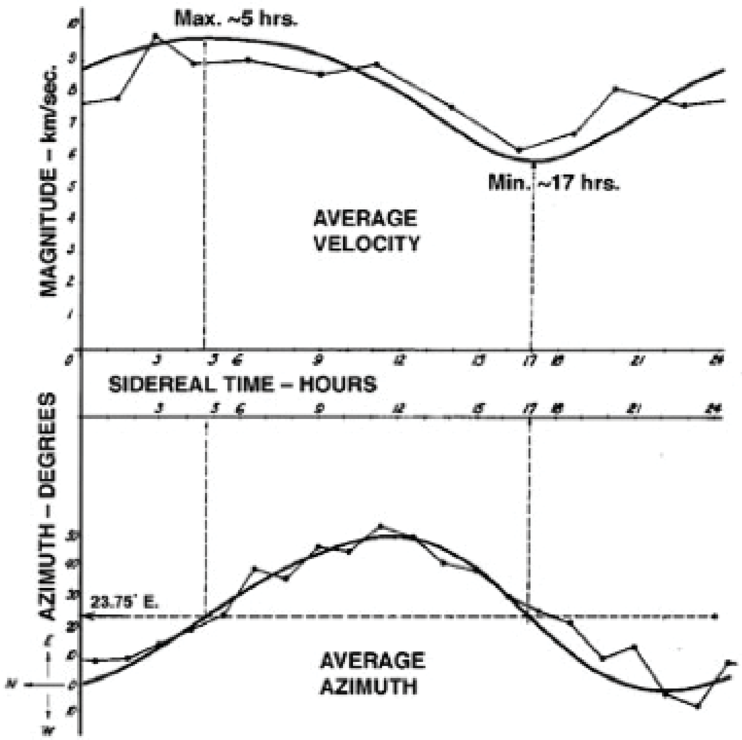

Figure 12. AVERAGE VELOCITY AND AZIMUTH OF GLOBAL ETHER-DRIFT from Dayton Miller's Mount Wilson ether-drift Experiments, 1925–1926. *Top Graph:* Average variations in observed magnitude of ether-drift from all four epochs of measurement. Maximum velocity occurs at about 5 hours sidereal time and minimum velocity occurs at about 17 hours sidereal. While Miller's 1933 paper assumed the Earth was *pushing through the ether* and moving toward Dorado, near the southern pole of the Plane of the Ecliptic, the movement and direction of ether-drift past the interferometer was *exactly opposite* to this, toward Draco near the northern pole of the Plane of the Ecliptic (17 hours right ascension, declination of +68°). It is important, *from the standpoint of his working theory,* to clarify the concepts of the "net motion of the Earth" versus the "direction of ether-drift." However, *if the ether itself is in motion, acting as a cosmic prime-mover, the direction of ether-drift and the net motion of the Earth would be identical, though at different velocities. Bottom Graph:* Average variations in observed azimuth readings according to sidereal time. This graph uses the same average data curve from Figure 11 (top graph) published by Miller (1928:363) but at the time was given a different baseline average. The same graph is presented here, for the first time, using Miller's revised seasonal averages as published in 1933 (p. 235), which help define the axis of ether-drift. Amazingly, the independent averages for the four epochs provided by Miller (Feb. = –10° west of north, April = +40° east, Aug. = +10° east, Sept. = +55° east) together yield *a mean displacement 23.75° east of north* (Figure 13). This is close to the Earth's axial tilt of 23.5°, and can hardly be coincidental. More discussion is in DeMeo (2002). Adapted from Miller (1928:363, 1933:235).

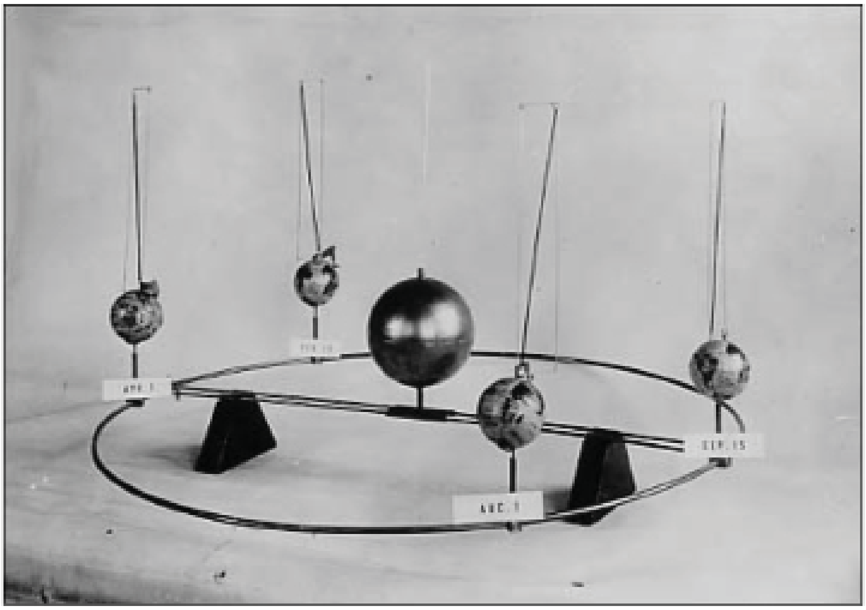

Figure 13. A model constructed by Miller, displaying the axis of ether-drift for the four seasonal epochs of the Earth moving around the Sun. The axis of drift, in this model, appears to be roughly perpendicular to the plane of the ecliptic.

(M–M) experiments. In the first experiment, undertaken in June of 1926, the interferometer was the same dimensions as the original M–M apparatus, with a roundtrip light path of around 22 meters. A fringe shift displacement of 0.017 was predicted, but the conclusions stated *“No displacement of this order was observed.”* The second experiment, undertaken on unspecified “autumn” dates in 1927, employed a slightly longer roundtrip light path of around 32 meters (given as 53′ for an assumed one-way distance). Again, *“no displacement of the order anticipated was obtained,”* and the short report did not give details about the experimental surroundings or locations.

The third experiment was undertaken on an unspecified date (probably 1928) in *“a well-sheltered basement room of the Mount Wilson Laboratory.”* The roundtrip light path was further increased to approximately 52 meters (given as 85′ for an assumed one-way distance). This time, having moved the apparatus to a higher altitude and using a longer light-path, a small quantity of ether-drift was detected which approximated the result observed by Miller, although *the results were unjustifiably reported in negative terms:*

> . . . precautions taken to eliminate effects of temperature and flexure disturbances were effective. The results gave no displacement as great as one-fifteenth of that to be expected on the supposition of an effect due to a motion of the solar system of three hundred kilometers per second. These results are differences between the displacements observed at maximum and minimum at sidereal times, the directions corresponding to . . . calculations of the supposed velocity of the solar system. A supplementary series of observations made in directions half-way between gave similar results. (Michelson, Pease, & Pearson 1929)

One fifteenth of 300 km/sec. is 20 km/sec., a result the authors dismissed as they apparently had discarded the concept of an Earth-entrained ether, which would move more slowly closer to sea level. A similar result of 24 km/sec was achieved by the team of Kennedy–Thorndike in 1932, however they also dismissed the concept of an entrained ether and, consequently, their own measured result:

> *In view of relative velocities amounting to thousands of kilometers per second known to exist among the nebulae, this can scarcely be regarded as other than a clear null result.* (Kennedy & Thorndike 1932)

This incredible statement serves to illustrate how deeply ingrained was the concept of a static ether.

Michelson, Pease, and Pearson went on to make speed-of-light measurements in a one-mile-long partially evacuated steel tube lying flat on the ground, oriented roughly southwest to northeast. While the purpose of these experiments was not to measure any ether-drift or variation in the speed of light, such variations in fact were observed and reported in their paper (Michelson, Pease, & Pearson 1935). A newspaper account of these experiments, published after Michelson's death in 1931 but prior to their final publication of results reported:

> *Dr. Pease and Mr. Pearson say the entire series of measures, made mostly between the hours of 7 and 9 p.m., show fluctuations which suggest a [variation] of about 20 kilometers per second.* (Dietz 1933)

Miller commented on these results, suggesting they would have measured a stronger ether-drift variation if they had taken their interferometers outside of the basement structures and steel pipes (Figure 14):

> If the question of an entrained ether is involved in the investigation, it would seem that such massive and opaque shielding is not justifiable. The experiment is designed to detect a very minute effect on the velocity of light, to

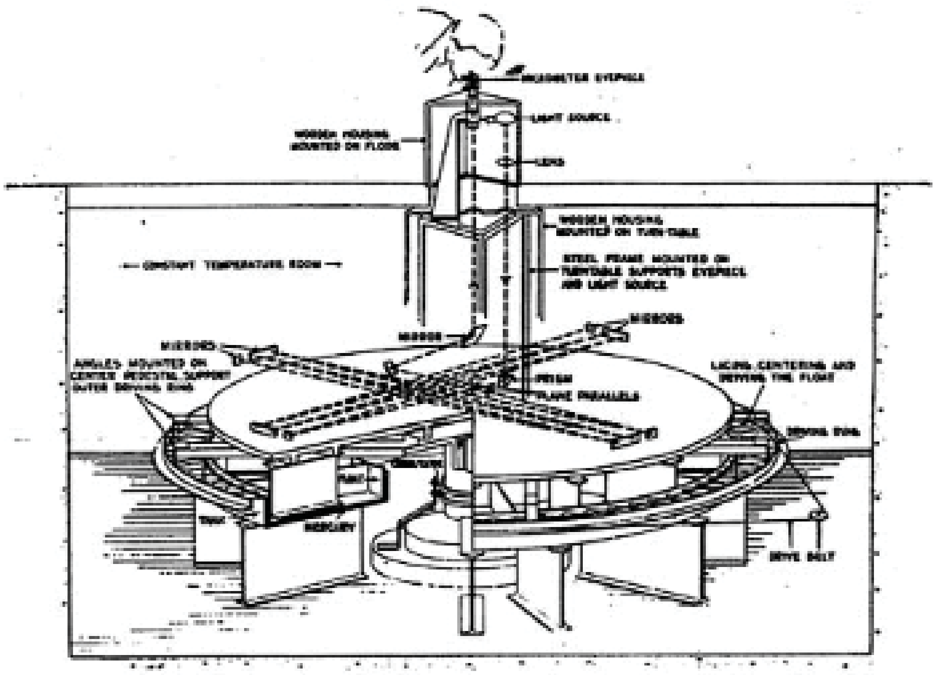

Figure 14. Apparatus used by Michelson–Pease–Pearson in their successful detection of an ether-drift of some unspecified quantity just under 20 km/sec. at Mt. Wilson, as reported in their 1929 paper. This positive result was inappropriately dismissed as a "negative" result because the experimenters had prematurely discarded the conceptual implications of an *Earth-entrained ether*. This experiment used the largest light-beam interferometer ever constructed by Michelson, with a 52-meter round-trip light path, coming close to the sensitivity found in Miller's 64-meter interferometer. It is shown here, situated in a basement location, in the ground, which, by itself, would also predictably reduce the measured result.

> be impressed upon the light through the ether itself, and it would seem to be essential that there should be the least possible obstruction between the free ether and the light path in the interferometer. (Miller 1933:240)

Miller had, by this time, acquired a lot of experience working on Mount Wilson, using his large interferometer in the specially constructed interferometer house. With a light path of 64 meters, Miller's apparatus was still significantly more sensitive than the best apparatus of Michelson–Pease–Pearson. Given that Michelson–Pease–Pearson did make some small detection of an ether-drift from their efforts at Mount Wilson, in spite of the fact that it was located in a basement location, their report of detectable sidereal fringe displacements supports Miller's findings. It is also notable that this was the second time Michelson's work had significantly detected an ether, though in the first instance of Michelson–Gale (1925) the apparatus could only measure light-speed variations along the rotational axis of the Earth. These papers by Michelson and also by Kennedy–Thorndike have conveniently been forgotten by modern physics, or misinterpreted as being totally negative in result, even though all were undertaken with far more precision, with a more tangible positive result, than the celebrated Michelson–Morley experiment of 1887. Michelson went to his grave convinced that light speed was inconstant in different directions, and also convinced of the existence of the ether. The modern versions of science history have rarely discussed these facts.

Shankland Team's 1955 Critique of Miller

As previously pointed out by Swenson, Shankland's 1955 critique of Miller's work was undertaken with "extensive consultations" with Einstein, who like Newton and others before him had assumed only a static or stagnant ether, through which the Earth passed without material affect and, hence, without entrainment close to the Earth's surface. Shankland in fact was Miller's student for many years, and only emerged to become a professional advocate of Einstein's relativity after the death of Miller in 1941. Shankland became Chairman of the Physics Department at Case following Miller's retirement and death, building his professional career upon publications misrepresenting the Michelson–Morley experiments as the most solid evidence on the question, and publishing widely read interviews with Einstein (Shankland 1963, 1964, 1973a, 1973b). Shankland later took up administrative positions within government agencies developing nuclear energy—he rarely discussed Miller's positive ether-drift measurements in any of these papers except in the 1955 paper under discussion here. In this sense, it is legitimate to view Shankland and other members of his team (all Einstein advocates from Case) as biased reviewers of Miller's work.

The very first sentence in the Shankland team's 1955 paper began with the falsehood, now widely parroted in nearly every physics textbook, that the Michelson–Morley experiments had a "null" result. The third sentence in the Shankland paper was similarly false, claiming that *"All trials of this experiment except those carried out at Mount Wilson by Dayton C. Miller yielded a null result within the accuracy of the observations."* This kind of chronic misrepresentation of the slight positive results of many interferometer experimenters, including Michelson–Morley, Morley–Miller, Sagnac, Michelson–Gale, and Michelson–Pease–Pearson, suggests an extreme bias and deliberate misrepresentation. The fact that this is a popular bias does not excuse it. By redefining all the positive results observed by what may in fact have been the majority of ether-drift researchers, as mere expressions of "observational inaccuracy," Shankland narrowed his task considerably.

These and other sentences in the Shankland paper revealed its bias from the get-go, and gave it the spirit of an autopsy, where Miller was dissected without careful concern, and certainly where no advocate of ether theory appeared to be involved in the process. It is possible that by the 1950s there was nobody left who could fill Miller's shoes to make an adequate defense. Ether-theory was then being compared to "the search for perpetual-motion machines" (Swenson 1972:239), and such ridicule surely must have had a silencing effect upon the entire fields of physics and astronomy. Swenson also suggests that, during his later years, Miller was largely ignored and isolated. This appears to be correct, as according to an interview with Shankland made in 1981, shortly before Miller died, he gave all of his interferometer datasheets—hundreds of pages of measurements—to his one-time student Shankland, with the somewhat bitter statement that he should "either analyze the data, or burn it" (Kimball 1981:2). In that same interview, Shankland also blamed Miller for having blocked the awarding of a Nobel Prize to Einstein for his relativity theory—clearly, Miller's work was a major obstacle to the Einstein theory of relativity, and for that reason may have given Einstein and his followers sleepless nights.

The title of the Shankland paper, and its overall representation suggests the authors had made a serious review of "*the* interferometer observations" of Miller, to include some kind of comprehensive and inclusive evaluation—but this was not the case. There were two basic approaches to the Shankland team's analysis: 1) a search for random errors or statistical fluctuations in Miller's data, and 2) a review of selected datasets which they claimed demonstrated significant thermal artifacts in the data. We can review these claims.

Shankland Team's Evaluation for Random-Statistical Variations

The Shankland paper did present a statistical analysis of a portion of Miller's published 1925–1926 Mount Wilson data, concluding that his observations *". . . cannot be attributed entirely to random effects, but that systematic effects are present to an appreciable degree*" and that *"the periodic effects observed by Miller cannot be accounted for entirely by random statistical fluctuations in the basic data"* (Shankland et al. 1955:170). Also, the Shankland team admitted they *". . . did not embark on a statistically* *sound recomputation of the cosmic solution, but rather [looked for] . . . local disturbances such as may be caused by mechanical effects or by nonuniform temperature distributions in the observational hut"* (Shankland et al. 1955:172). In short, they admitted the harmonic patterns in Miller's data could not be due to any systematic measurement error, nor result from any mechanical flaws in the interferometer apparatus itself—while simultaneously admitting a disinterest in computation of any potentially validating ether-drift axis ("cosmic solution") from his data. These were important admissions, as the suggestion is that unless they could find some other fatal flaw in his data, Miller had really got it right, and measured a real Earth-entrained ether-drift.

Of interest from the perspective of the politics of science, is the fact that *this statistical analysis was not undertaken by any of the four members of the Shankland team listed as authors of the paper!* The analysis was in fact undertaken by Case physics student Robert L. Stearns, for his Master's Thesis (Stearns 1952)—Stearns was given only a footnote credit in the Shankland paper.

Stearns, who performed the analysis, informs us about the large amount of data gathered by Miller. He mentions (Stearns 1952:15–17) the existence of "316 sets of data . . . by Miller in 1925–1926" for the centrally important Mount Wilson experiments. Each dataset was composed of 20 turns of the interferometer, with sixteen data points per turn (a total of 320 data points per dataset). Miller noted his work at Mount Wilson was undertaken at four different seasonal "epochs," each of which encompassed a period of around ten days, centered on the following dates: April 1st, August 1st, and September 15th, 1925, and February 8th, 1926 (Miller 1926, 1933). It must be kept in mind, that these Mount Wilson data from 1925 and 1926 provided the most conclusive and foundational observations for Miller's ether-drift calculations and conclusions, as presented most clearly in his 1933 paper. As detailed below, the Shankland team mentions these Mount Wilson data, but in a manner which confuses them with his earlier and less significant efforts, including various control experiments conducted at the Case School. The significance of this confusion of dates will be highlighted momentarily.

Shankland Team's Assertion of Temperature Artifacts

Regarding possible temperature artifacts in Miller's data, this objection was raised early on in the history of ether-drift interferometry, and specifically rebutted by Miller when he was still alive. A letter exchange between Miller and Georg Joos from a 1934 issue of *Physical Review* records part of this debate, and appears to be one of the few *published* criticisms on the temperature issue Miller ever received while still alive. Miller had this to say about the problem: *"When Morley and Miller designed their interferometer in 1904 they were fully cognizant of this . . . and it has never since been neglected. Elaborate tests have been made under natural conditions and especially with artificial heating, for the development of methods which would be free from this [thermal] effect"* (Joos & Miller 1934). The Shankland critique never made any systematic evaluation of possible thermal artifacts using a larger set of Miller's data, as was done with the statistical evaluation. Instead, they appear to have "gone fishing" in Miller's data for something by which they could simply dismiss him. For example, Miller's own 1923 temperature-control experiments were brought into discussion, where radiant parabolic heaters were used to artificially create a general doubling of the size of interference fringes. Miller describes these experiments:

> Several electric heaters were used, of the type having a heated coil near the focus of a concave reflector. Inequalities in the temperature of the room caused a slow but steady drifting of the fringe system to one side, but caused no periodic displacements. Even when two of the heaters, placed at a distance of three feet from the interferometer as it rotated, were adjusted to throw the heat directly on the uncovered steel frame, there was no periodic effect that was measurable. When the heaters were directed to the air in the light-path which had a covering of glass, a periodic effect could be obtained only when the glass was partly covered with opaque material in a very nonsymmetrical manner, as when one arm of the interferometer was completely protected by a covering of corrugated paperboard while the other arms were unprotected. These experiments proved that under the conditions of actual observation, the periodic displacements could not possibly be produced by temperature effects. (Miller 1933:220)

Perhaps without intending to do so, after examining Miller's laboratory notes for the Cleveland temperature control experiments, the Shankland team confirmed Miller on this point:

> In the experiments where the air in the optical paths was directly exposed to heat, large second harmonics (0.35 fringe for one heater, and about twice this value for two heaters) were always observed in the fringe displacements, and with the expected phase. Shifting the heaters to a different azimuth produced a corresponding change in the phase of the second harmonics. *When the optical paths and mirror supports were thermally insulated, the second harmonics were greatly reduced to about 0.07 fringe.* (Shankland 1955:174; emphasis added)

This statement confirmed the wisdom of Miller's approach. The added insulation reduced the thermal effects from a nearby radiant heater to only

20% of the un-insulated readings. I have an ordinary commercially available electric radiant parabolic heater at my home, and it gets so hot you cannot stand closer than 12″ without burning yourself, or possibly catching your clothing on fire. If Miller had used a parabolic heater even half as strong as this, it would certainly have been a source of heat much stronger than anything present in his Mount Wilson experiments, particularly at night, during foggy or overcast conditions, and when the entire interferometer house was covered over with a tent, with the apparatus and light-beam path covered with cork, glass, and paper insulation. Consider a radiant heater at several hundred degrees C, creating a steep thermal gradient but only a 0.07 fringe shift in the insulated interferometer. How much *less* of an effect would be produced by a human body, or even from the inside of a solar-heated wall? Assuming an environmental thermal effect only one-tenth that seen with the parabolic heater (a wood composite wall radiating inside the structure at perhaps 50 °C?), fringe shifts of *only 0.007* would have been produced, *well below observational detection*. Miller's datasheets, for example, recorded observations *"in units of a tenth of a fringe width,"* though readings down to hundredths of a fringe were possible with care. Overall accuracy of the ether-drift measurements approached a hundredth of a fringe after mathematical averages of many readings were extracted. The Shankland paper nevertheless used these control experiments as a weapon against Miller, claiming without evidence that heater-type effects *might* have occurred in his Mount Wilson experiments, even where no such heater or remotely similar heat source was present. But why would the Shankland team shy away from undertaking a more systematic evaluation for temperature artifacts? They could have, for example, evaluated only Miller's daytime interferometer experiments, and looked for a thermal effect from the southerly wall of the structure during the various epochs—if they could have shown an effect present in daytime data which was not present at night, it would have devastated Miller's claim, and proved their case. However, this obvious analytic procedure was not performed, or, if it was done, not reported.

The Shankland paper also resurrected the temperature criticisms by Joos and Miller (1934), but without reference to Miller's rebuttal in the same published exchange. If the periodic effects observed by Miller were the product of temperature variations, as was claimed by Shankland and Joos, then why would that variation systematically point to the same set of azimuth coordinates along the celestial *sidereal clock*, but *not* to any single terrestrial coordinate linked to civil time (see Figure 11)? Miller repeatedly asked this question of his critics, who had no answer for it. The Shankland team likewise evaded the question.

It is clear Miller had been deeply engaged in the problem of temperature effects, and worked hard to know exactly how they might be produced, and how to eliminate them. The Shankland paper, however, seized upon Miller's open acknowledgment of fringe-shifts from air heating by powerful radiant heaters during control experiments, and a few other sentences written in his lab book, and tried to claim thermal anomalies were probably the source of whatever periodic effects were subsequently measured by Miller at Mount Wilson, when no radiant heaters were used, and when the empirically developed control procedures were put in place. Without some kind of independent experimental evidence to support such a claim of a thermal influence, their dismissal was illogical.

The Shankland paper also went through a series of arguments about the interferometer house, how the wall materials, roof angles, interferometer glass housing, etc., might result in a definable effect upon the air temperature in the light-beam path, concluding only that they could not rule out such an influence—that it *". . . is not in quantitative contradiction with the physical conditions of the experiment"* (Shankland et al. 1955:175). Given their ignoring the sidereal nature of the periodicities, this statement could hardly be taken seriously, and certainly did not constitute a rebuttal of Miller's data.

The Shankland paper finally attempted to correlate several selected daytime interferometer runs with temperature measurements made at the same time. They acknowledged difficulty in correlating low fringe-shift values with low temperature differentials, but found one set of high fringe-shift values correlated with slightly higher temperatures, even while noting another set where high values correlated with lower temperatures. Finally, they complain that *". . . no temperature data are available to reveal thermal conditions at the roof, which may be responsible for the large fringe displacements at the times of highest altitudes of the Sun"* (Shankland et al. 1955:176). If this sounds confusing, a reading of the full original text provided little clarification.

Failing to show anything damning from daytime datasets, when temperature gradients inside the interferometer house might be expected to be at a maximum, they turned their focus to nighttime datasets. Once again, only a few of Miller's datasheets were selected out to prove their case. Data from two nights (30 August 1927 and 23 September 1925) with stable air temperatures were reviewed—these nights showed very clear and systematic fringe variations (Figure 4 in Shankland et al. 1955:176), but because the azimuth of the fringes changed minimally over the approximate 5 hours of observation, the critics complained "it *would be extremely unlikely if the fringe shifts were due to any cosmic effect"* (Shankland et al. 1955:177). Apparently, the Shankland team was so locked into the older "static ether" assumptions of the original Michelson–Morley experiment, they were unclear about what they should have seen in Miller's data. In 1927, at a *Conference on the Michelson–Morley Experiment* held at Mount Wilson Observatory, where Michelson, Lorentz, Miller, and others made presentations and engaged in open debate, Miller addressed this question: *"Observations were made for verifying these [static ether] predictions . . . but it did not point successively to all points of the compass, that is, it did not point in directions 90° apart at intervals of six hours. Instead of this, the direction merely oscillated back and forth through an angle of about 60° . . ."* (Miller 1928:356–357). The reason for this is that Miller's detected axis of ether-drift is oriented reasonably close (within 60°) to both the Earth's axis of rotation and the axis of the plane of the ecliptic.

Another important fact which nearly escapes detection in the Shankland paper is that the 30 August data were made in Cleveland, while the 23 September data were from Mount Wilson, and *neither were a part of the published Mount Wilson data Miller used for calculations of the ether-drift*—both dates are well outside of the 10-day epochal periods identified by Miller. Furthermore, not all of the interferometer datasheets for a given date—which presumably would have had similar weather and temperature conditions—were included by the Shankland team for critical review. They selected only those datasets that appeared to support their argument of a claimed thermal anomaly. For example, they selected *"ten sets of observations, Nos. 31 to 40 inclusive, made in the hut on the Case campus between midnight and 5:00 a.m. on August 30, 1927"* and *". . . runs 75 to 83 inclusive taken from 12:18 a.m. to 6:00 a.m. on September 23"* (pp. 176–177). Other than making the *claim* that these selected data gave them the *impression* of being the result of temperature errors, they had no other stated criterion for bringing them into discussion. This biased data selection, or rather *data exclusion,* procedure forces one to ask*: What about datasets No. 1 to 30, and runs 1 to 74?* Similar unexplained data selections or data exclusions occur throughout the Shankland paper, leaving one to wonder if the *unselected and excluded* data, which constituted the overwhelming majority of it, simply could not provide support for their criticisms. One can imagine the howl of protest which would have occurred if Miller had taken this approach, arbitrarily excluding data from his calculations which superficially suggested something other than a real ether-drift. A third dataset from 30 July 1925 was highlighted by the Shankland team as it contained one extremely large peak where Miller noted "Sun shines on interferometer." This data does appear to have been a part of Miller's published Mount Wilson analysis. However, the Shankland team extracted only *"observations Nos. 21 to 28 inclusive, made between 1:43 a.m. and 6:04 a.m. on July 30, 1925."* Obviously, at around 6:00 *a.m.* the sun rose and caught Miller and his assistant off-guard. What about observations Nos. 1 to 27, or other early-morning data, where the sun *didn't* shine on the interferometer? These other data were not brought into discussion, except they did note that the runs prior to the sunshine incident demonstrated *". . . an extremely erratic behavior . . . we have no ready explanation for this apparent departure . . . "* Here, the Shankland team basically confesses their grab-bag of "ready" explanations was empty, and the idea that those data were expressing a real ether-drift was simply too "impossible" for them to consider. The fact that Miller included the note about the Sunlight on this datasheet speaks to his honesty.

The Shankland team also identified datasets Nos. 56–58 from 8 July 1924, which was part of Miller's control experiments made in a basement location at Case physics laboratory—the temperatures were very stable, and the fringe oscillations were quite small, and they argued these data were a proof for thermal effects on the apparatus. However, it was this very problem of basement and dense surrounding materials that led Miller on the path to use the apparatus in locations not subject to significant ether shielding or Earth entrainment. After 1921, Miller only used the Case School laboratory to undertake control experiments, and that is why those particular data were never published.

The Shankland paper concluded its temperature criticisms by discussing a few additional datasets: Nos. 113–118 from April 2nd, Nos. 88–93 from August 8th, 1925, and Nos. 84–91 from February 11th, 1926, (Shankland et al. 1955:177). Here, the amplitudes and phases were claimed to have been "nearly alike," but insufficient detail was given to allow a review of the critic's claims, and it did appear they were once again incorrectly misinterpreting Miller's data along the lines of static ether assumptions.

As in almost all the cases given above, *none of these data were analyzed systematically*, nor were they presented in such a manner that the author's criticisms could be factually reviewed. I got the impression that they simply scanned through a pile of Miller's datasheets, and with a wave of the hand, picking and pointing to only selected parts, dismissed it all as the product of thermal artifacts. Miller's detailed control experiments were basically ignored, as was the fact that, for all these experiments, the interferometer was enclosed in a small house covered over with a tent, while the apparatus was shielded with cork insulation, and the light-beam path covered with glass and paper panels—with a full rotation occurring in less than a minute, one is left to wonder how any observable thermal variations could develop within Miller's data, especially variations with a sidereal-cosmic component.

For the casual reader, who had not undertaken a careful review of Miller's original experiments, the Shankland paper might appear to make a reasoned argument. However, the Shankland paper basically obfuscated and concealed from the reader most of the central facts about what Miller actually did, and in any case was so unsystematic and biased in its approach, excluding from discussion perhaps 90% or more of Miller's extensive Mount Wilson data, as to render its conclusions meaningless.

As a final note, after undertaking my research into the archives of both Miller and Shankland at Case University, and urging them and the faculty of the CWRU Physics Department on the importance of the original Miller datasheets, they were finally located and placed into the CWRU Archive.

Conclusions

My review of this important but sad chapter in the history of science left me both astonished and frustrated. Miller's work on ether-drift was clearly undertaken with more precision, care, and diligence than any other researcher who took up the question, including Michelson, and yet his work has basically been written out of the history of science. When alive, Miller responded concisely to his critics, and demonstrated the ether-drift phenomenon with increasing precision over the years. He constantly pointed out to his critics the specific reasons why he was getting larger positive results, while others got only small results, or no results. Michelson and a few others of the period took Miller's work seriously, but Einstein and his followers appeared to view Miller only as a threat, something to be "explained away" as expeditiously as possible. Einstein in fact was catapulted into the public eye following the end of World War II. Nuclear physics was then viewed as heroic, and Einstein fast became a cultural icon whose work could not be criticized. Into this situation came the Shankland team, with the apparent mission to nail down the lid on Miller's coffin. In this effort, they nearly succeeded.

The Shankland conclusions against Miller were clearly negative, but the one systematic statistical analysis of his Mount Wilson data merely confirmed what Miller said all along, that there was a clear and systematic periodic effect in the interferometer data. The Shankland paper also confirmed Miller's contention that this periodic effect was *not the product of random errors or mechanical effects.* The Shankland team subsequently searched for temperature artifacts in Miller's data, but they failed to undertake any systematic analysis of his centrally important Mount Wilson data in this regard. Instead, they made biased selections of a few published datasets and unpublished datasets obtained from different periods in Miller's research, from different experimental locations, and including from his control experiments at the Case School.

Miller's most conclusive 1925–1926 Mount Wilson experiments encompassed a total of 6,402 turns of the interferometer, recorded on more than 300 individual datasheets. That was the data the Shankland team should have focused on and evaluated systematically. Instead, only a few of Miller's datasheets from these most centrally important experiments were selected—certainly less than 10% of the data available to them was brought into discussion—and then only after being firstly dissected to extract only those data that could most easily be misconstrued as evidence for presumed temperature anomalies. For certain, some of the data held up for public critique came from Miller's control experiments at Case, or possibly from trial runs when technical "bugs" were being worked out in the apparatus and building. Miller is no longer alive to inform us about his data, but the Shankland team willy-nilly lumped together both published and unpublished data, without comment.

Even though they were content to pick and choose data as they wished, they could not come up with a coherent and solid critique by which Miller's work could be conclusively dismissed—some of the data they selected merely confirmed Miller, though the Shankland group seemed ignorant of the basic ether-drift astronomy by which such an interpretation could be made. When alive, Miller openly stated he had addressed and corrected for thermal effects upon the apparatus, and yet the periodic elements of his measurements persisted—the Shankland paper ignored Miller on this important point.

The Shankland group undertook no new experiments of their own, neither on the question of ether-drift, nor on the subject of thermal perturbations of light-beam interferometry—they made essentially an "armchair analysis" of Miller's data. Only *some* of Miller's original data was carefully selected to make a rather unbelievable claim that small natural ambient temperature gradients in Miller's Mount Wilson observation hut *might* produce fringe shifts in the insulated interferometer similar to what Miller himself previously observed in his control experiments using strong radiant heaters. The Shankland paper argued there *must have been* "thermal effects" in Miller's Mount Wilson measurements, but provides no direct evidence of this.

At no time did the Shankland group present evidence that temperature was a factor in creating the periodic cosmic-sidereal fringe shifts observed by Miller in his published data, even though this was their stated conclusion. In fact, they presented evidence from Miller's own lab notebooks which implied thermal gradients in the Mount Wilson interferometer house would have been *below the observational limits* of the insulated apparatus.

The larger issue of periodic or harmonic effects in the data, expressed in nearly identical cosmic sidereal coordinates at different seasons and at all hours of the day, was never addressed or evaluated by the Shankland group. Neither was any attempt made to show *exactly how* an external temperature phenomenon could affect the interferometer readings to yield such a systematic sidereal effect. This issue was almost totally avoided by the Shankland team.

A reading of Miller's 1933 paper shows the picayune and biased nature of the Shankland team procedure, as the systematic sidereal periodicities observed by Miller expressed themselves nearly uniformly across the board, though at differing magnitudes. From 1906 to 1926, Miller undertook more than 200,000 separate readings, more than 12,000 turns of the interferometer demonstrating harmonic periodicities constantly pointing to the same general axis of ether-drift in the cosmos—a factor which was completely independent of the time of day or season of year in which the experiments were undertaken. At best, the critics provided only an *ad hoc argument*, a claim or suggestion without substance, that some small part of Miller's data *might* contain an undefined temperature effect.

From all the above, it appears the Shankland group, with some degree of consultation with Einstein, decided that "Miller must be wrong" and then set about to see what they could cherry-pick in his archive to support their *a priori* conclusion—which is not a scientific method.

As I have discussed previously, Miller found the ether-drift effect to be stronger at higher altitudes and also to be small when the experiment was undertaken in heavy stone buildings or when the interferometer light-path was encased in wood or metal shielding. In my studies over the last 40+ years, I've found many examples from the fields of biology, meteorology, and physics that independently support the assertion of a subtle energetic force with similar altitude-dependent and metal-reflective properties—notably in the works of Wilhelm Reich, Giorgio Piccardi, and Frank Brown (DeMeo 1979, 1989a, 1989b, 2000, 2002, 2004). Likewise, there are many new findings in astrophysics, where anisotropy of cosmological factors have been discovered, which are congruent with Miller's identified axis of ether-drifting (Miller 1933:241, Allais 1997, 2002).

Notable in this respect are the experiments of Cahill (2006a, 2007) of the Chemistry, Physics, and Earth Science Department at Flinders University in Australia; DeWitte (in Cahill 2006b) working with the Belgian telecommunications company Belgacom in Brussels; Galaev (2000a, 2000b, 2001, 2002) at the Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine; Múnera (2002, 2009) of the Physics

Department, Universidad Nacional de Colombia at Bogotá; and Múnera, Deckers, Arenas, and Alfonso (2006) and Múnera, Deckers, Arenas, Alfonso, and Lopez (2009) from diverse institutions including the Physics Department at Bogotá and the Max Planck Research Center in Hamburg, Germany.

All of these newer studies have basically confirmed the Miller results, including its general axis of ether-drift and sidereal-day velocity components, *"down to the details"* (as expressed by Galaev).

To close, I ask the reader to imagine that Michelson–Morley's 1887 experiment, which ran over only 6 hours on four days, had resulted in a claim that "the ether has been detected," and that Dayton Miller had undertaken his years of work with 200,000 observations showing "the ether cannot be detected." It does not take much consideration to conclude that—in such a fictional case—Miller would today be cited in every physics textbook as having "proved the ether did not exist," and nobody would refer to Michelson–Morley. The fact that the present-day situation is totally opposite of this fictional example is a testament to the intensely political nature of modern science, and how major theories often develop into *belief-systems*, which demand the automatic suppression of any new finding which might undermine the faith and "popular wisdom" of politically dominant groups of academics. And that "wisdom" today is: *Space is empty and immobile, and the universe is dead.* I submit that these are unproven, and even *disproven* assertions, challenged in large measure by Dayton Miller's exceptional work on the ether-drift.

I should also add how modern astrophysics today accepts without hesitation many theoretical concepts which basically fill the vacuum of cosmic space, and appear either superficially or dramatically similar to the Miller type of tangible and measurable cosmic ether, in spite of their detection difficulties. Examples are the "dark matter," the "neutrino sea," the "intergalactic or interstellar medium," and "cosmic plasmas" (DeMeo 2011). The fields of parapsychology also could find a potent explanatory mechanism in such a cosmic medium, for transmission of sensory or inertial impulses via as-yet-unclear excitations or mechanisms more similar to old wave-theory than modern particle-based or consciousness-based "intentional" postulates.

By Ocam's Razor, if not also by the similarities of their properties, I postulate these are all one and the same thing, as per the well-known example of ten blind scientists in a room with an elephant, each one grabbing ahold of, and describing what only *appear* to be uniquely different parts of a unitary cosmic anatomy.

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References

Allais, M. (1997). *L'Anisotropie de L'Espace:La nécessaire révision de certains postulats desthéories contemporaines.* Paris: Clément Juglar, Paris.

Allais, M. (2002). Experiments of Dayton C. Miller (1925–1926) and the Theory of Relativity. *Pulse of the Planet #5,* 132–137.

Cahill, R. T. (2006a). A new light-speed anisotropy experiment: Absolute motion and gravitational waves detected. *Progress in Physics,* October 2006, 73–92.

Cahill, R. T. (2006b). The Roland DeWitte 1991 Experiment (to the Memory of Roland DeWitte). *Progress in Physics,* July, 60–65; also in: *arXiv:physics*/0608205v, 21 Aug.

Cahill, R. T. (2007). Optical-fiber gravitational wave detector: Dynamical 3-space turbulence detected. *Progress in Physics*, Oct., 63–68.

Clark, R. W. (1971). *Einstein: The Life and Times*. New York: World Publishing.

DeMeo, J. (1979). Evidence for the Existence of a Principle of Atmospheric Continuity. Appendix to *Preliminary Analysis of Changes in Kansas Weather Coincidental to Experimental Operations with a Reich Cloudbuster.* Thesis, University of Kansas, Lawrence, Geography–Meteorology Dept.; Republished, Orgone Biophysical Research Lab, Ashland, Oregon, 2010.

DeMeo, J. (1989a). Independent Discovery of An Unusual Energy. In *The Orgone Accumulator Handbook ,* Ashland, Oregon: Natural Energy Works. See Third Revised Edition, 2010.

DeMeo, J. (1989b). The orgone energy continuum: Some old and new evidence. *Pulse of the Planet*, *1*(2), 3–8.

DeMeo, J. (2000). Critical Review of the Shankland et al. Analysis of Dayton Miller's Ether-Drift Experiments. Presented to the *Natural Philosophy Alliance,* Berkeley, California.

DeMeo, J. (2002). Reconciling Miller's ether-drift with Reich's dynamic orgone. *Pulse of the Planet #5,* 138–147.

DeMeo, J. (2004). A dynamic and substantive cosmological ether. *Proceedings of the Natural Philosophy Alliance* (Cynthia Whitney, Editor), *1*(1), 15–20.

DeMeo, J. (2011). Water as a resonant medium for unusual external environmental factors. *Water Journal, 3*, 1–47.

Dietz, D. (1933). Case's Miller seen hero of 'Revolution'. New Revelations on Speed of Light Hint Change in Einstein Theory. *Cleveland Press*, 30 Dec.

Galaev, Y. M. (2000). Ether-drift experiment in the band of radio wave. *Petit, Zhukovsky*. (in Russian).

Galaev, Y. M. (2000). Ether-drift effects in the experiments on radio wave propagation. *Radiophysics and Electronics, 5*(1), 119–132. Institute for Radiophysics and Electronics of the National Academy of Sciences of Ukraine. (in Ukrainian)

Galaev, Y. M. (2001). Ethereal wind in experience of millimetric radiowaves propagation. *Spacetime and Substance, 2*(5)(10), 211–225. (English translation of Galaev 2000)

Galaev, Y. M. (2002). The measuring of ether-drift velocity and kinematic ether viscosity within optical waves band. *Spacetime and Substance, 3*(5)(15), 207–224.

Joos, G., & Miller, D. (1934). Letters to the Editor. *Physical Review*, *45*, 114.

Kennedy, R. J., & Thorndike, E. M. (1932). Experimental establishment of the relativity of time. *Physical Review, 42,* 400–418.

Kimball, M. (1981). An Interview with Dr. Robert S. Shankland, Subject: Dayton Miller. Transcript of audio tape, 15 December, original with hand-corrections, Case Western Reserve University Archive, Cleveland, Ohio.

Michelson, A. A. (1927). *Studies in Optics.* Chicago: University of Chicago Press.

Michelson, A. A., & Morley, E. W. (1887. On the relative motion of the Earth and the luminiferous ether. *American Journal of Science*, Third Series, Vol. XXXIV (203).

Michelson, A. A., & Gale, H. (1925). The Effect of the Earth's rotation on the velocity of light (Parts I and II). *Astrophysical Journal*, *61*, 137–14l. Also see Letters to the Editor: The effect of the earth's rotation on the velocity of light, *Nature*, *115*, 566, 18 April 1925.

Michelson, A. A., Pease, F. G. & Pearson, F. (1929). Repetition of the Michelson–Morley experiment. *Nature*, *123*, 88, 19 January. Also in *Journal of the Optical Society of America*, *18*, 181.

Michelson, A., Pease, F. G., & Pearson, F. (1935). Measurement of the velocity of light in a partial vacuum. *Astrophysical Journal, 82*, 26–61.

Miller, D. (1922). The ether-drift experiments at Mount Wilson Solar Observatory. *Physical Review*, *19*, 407–408.

Miller, D. (1925). Ether-drift experiments at Mount Wilson. *Proceedings of the National Academy of Sciences USA, 11,* 306–314.

Miller, D. (1926). Significance of the ether-drift experiments of 1925 at Mount Wilson. *Science*, *63*, 433–443.

Miller, D. (1928). Lecture in the Conference on the Michelson–Morley Experiment. *Astrophysical Journal*, *LXVIII*, 341–402; also in *Contributions from the Mount Wilson Observatory* No. 373, Carnegie Institution of Washington.

Miller, D. (1930). Ether drift experiments in 1929 and other evidences of solar motion. *Journal of the Royal Astronomy Society of Canada*, *24*, 82–84.

Miller, D. (1933). The ether-drift experiment and the determination of the absolute motion of the Earth. *Reviews of Modern Physics*, 5(2), 203–242.

Miller, D. (1934). The ether-drift experiment and the determination of the absolute motion of the Earth. *Nature, 133*, 16–27.

Morley, E. W., & Miller, D. (1905). Report of an experiment to detect the FitzGerald–Lorentz Effect. *Proceedings, American Academy of Arts & Sciences, 41,* 321–328.

Morley, E. W., & Miller, D. (1907). Final report on ether-drift experiments. *Science*, *25*, 525.

Múnera, H. A. (2002). The effect of solar motion upon the fringe-shifts in a Michelson–Morley interferometer á la Miller. *Annales de la Fondation Louis de Broglie, 27*(3), 463–484.

Múnera, H. A. (2009). Towards the reinstatement of absolute space: Some possible cosmological implications. *ICFAI University Journal of Physics*, *2*(2&3), 9–24.

Múnera, H. A., Deckers, D. H., Arenas, G., & Alfonso, E. (2006). Observation during 2004 of periodic fringe-shifts in an adialeiptometric stationary Michelson–Morley experiment. *Electromagnetic Phenomena, 6*(1), 70–92. Kharkov, Ukraine: Institute for Electromagnetic Research.

Múnera, H. A., Deckers, D. H., Arenas, G., Alfonso, E., & López, I. (2009). Observation of a non-conventional influence of Earth's motion on the velocity of photons, and calculation of the velocity of our galaxy. *Progress in Electromagnetics Research Symposium PIERS-2009*, Beijing, China, 23–27 March.

Sagnac, M. G. (1913). L'Ether lumineux Demonstre par l'effet du vent relatif d'aether dan interferometre en rotation uniforme. *Comptes Rendus, 157*, 710; and Sur la preuve de la realite de l'ether lumineux par l'experience de l'interferographe tournant, *Comptes Rendus*, *157*, 1410–1413. Also see Chappell, J. (1965), Georges Sagnac and the discovery of the ether, *Archives Internationale d'Histoire des Sciences*, *18*, 175–190.

Shankland, R. (1963). Conversations with Albert Einstein. *American Journal of Physics*, *31*, 47–57.

Shankland, R. (1964). The Michelson Morley Experiment. *American Journal of Physics*, 32:16–35, 1964; The Michelson-Morley Experiment, *Scientific American*, *211*, 107–114.

Shankland, R. (1973a). Michelson's role in the development of relativity. *Applied Optics, 12*(10), 2280–2287.

Shankland, R. (1973b). Conversations with Albert Einstein, II. *American Journal of Physics*, *41*, 895–901.

Shankland, R. S., McCuskey, S. W., Leone, F. C., & Kuerti, G. (1955). New analysis of the interferometer observations of Dayton C. Miller. *Reviews of Modern Physics*, *27*(2), 167–178.

Stearns, R. L. (1952). *A Statistical Analysis of Interferometer Data*. Thesis, Case Institute of Technology Physics Department.

Swenson, L. (1972. *The Ethereal Aether: A History of the Michelson–Morley–Miller Aether-Drift Experiments*. Austin: University of Texas Press.