English translation of [1]

Analysis of D. C. Miller's Measurements in Cleveland 1927–1929

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6th January 2022 / 1.1

After the experiments on Mount Wilson, Dayton C. Miller carried out further experiments with the same interferometer. These data are analysed to confirm the results of an analysis of the Mount Wilson data. Confirmation is not found, but there is evidence of the expected theoretical signal.

1. Introduction

After a signal of cosmic origin was found [2] in the data of the measurements [3] on Mount Wilson in 1925–1926, the question arises whether the signal can also be found in other data. In 1927 and 1929 Miller carried out further experiments in Cleveland in Ohio in the United States of America. These data [4] are analysed.

From 1927, the interferometer was set up in a hut on the campus of the *Case School of Applied Science*, now *Case Western Reserve University*. The hut was made of metal and had an octagonal floor plan with a pointed roof.[1] The geographical coordinates were 41.504°N 81.608°W. The elevation of the site was about 210 m.[2]

2. Data analysis

Miller used the same interferometer as on Mount Wilson. The characteristic values are known. I also assume that the measuring procedure was the same. Among others, the methods from [2] are used. All data can be found in the Aetherise project.[3] The expected theoretical signal results from Lorentz's aether theory, given the following assumptions: The motion in the cosmic microwave background radiation corresponds to the motion in the aether and there is a break in Lorentz symmetry, produced by the anisotropic refractive index of gases [2].

2.1. Data sheets

The observations are divided into three epochs. A total of 71 data sheets were produced.[4]

Table 1: Data sheets

Epoch	Time period	Number
Apr	12.04.1927 – 15.04.1927	20
Aug	02.08.1927 – 30.08.1927	40
Sep	29.09.1929 – 13.10.1929	11

When transcribing the data sheets, some data were corrected or added.[5] In addition, some differences from the Mount Wilson data sheets are noticeable. Miller again had an assistant, but there is no indication of the location of a desk or the assistant's whereabouts. A tent does not appear to have been used, but there are also no remarks about disturbances from sunlight shining on the interferometer. Instead, there are now sometimes remarks on the strength of traffic. Between the individual turns of the interferometer there are often interruptions of several minutes. A time is then noted on the data sheets. In the CSV files[6] the interruptions are treated as adjustments and marked with the character *a*. The analysis tool *aetherise* does not take these gaps into account. Therefore, in the overview generated with `-aggregate list`, the values for the duration of one turn are too large. The values for the duration of the measurement for a data sheet, including the interruptions, are correct and on average increased by $\sim 9\,\text{min}$.

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[1] `https://case.edu/its/archives/Buildings/ethdri.htm`

[2] `https://apps.nationalmap.gov/viewer/viewer/index.html?extent=-9085995.6824%2C5086053.3179%2C-9082735.1654%2C5087945.1343%2C102100`

[3] `https://github.com/aetherise/aetherise`

[4] Miller writes that '41 Sets' were created in August, but I only have 40 data sheets.

[5] `dcm/csv27/changes.txt`

[6] `dcm/csv27/`

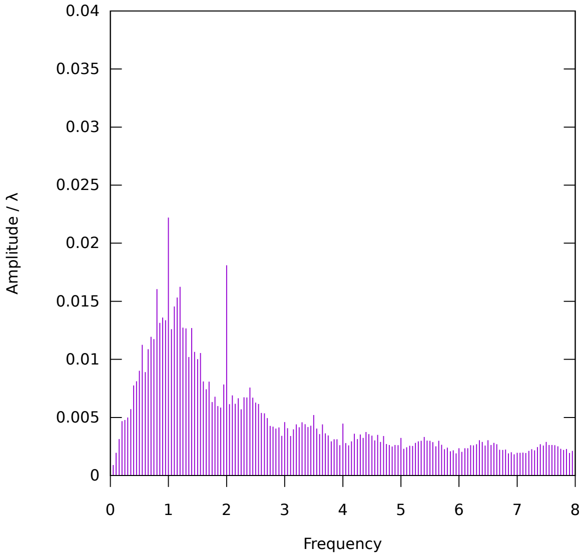

Figure 1: Mean spectrum [A1]

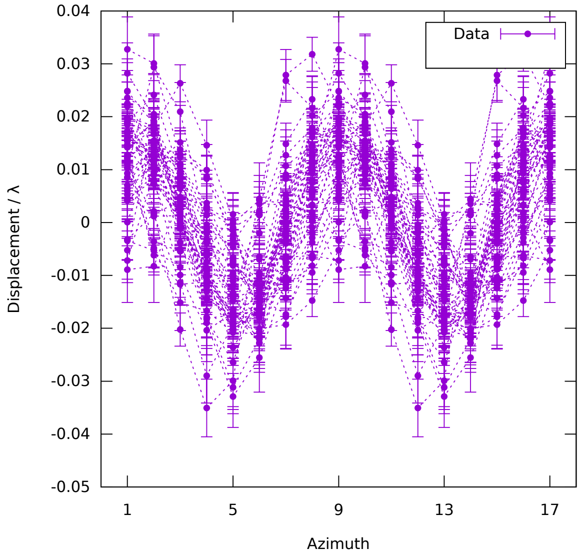

Figure 2: Overlayed signals [A3]

2.2. Normality test

A normality test gives a maximum proportion of $(5 \pm 3)\,\%$ measurements not normally distributed.[A2] The uncertainty gives a confidence interval for 95 %. This result is similar to the test result of the Mount Wilson data.

2.3. Fourier analysis

A discrete Fourier transform of all the data sheets yields a similar mean spectrum as the data from Mount Wilson. In Figure 1 a weak signal with frequency 4 is noticeable, which was not present in the Mount Wilson data. This signal is only present in the April and September epochs, not in August.

2.4. Groups

In April, according to the criteria in [2], only the Apr-13 group is usable. We will nevertheless take a closer look at the Apr-1 group later, although the uncertainty is a little too great. In August, all groups except Aug-1 are usable. In September, all groups are usable. An overview of the groups and data sheets can be found in the Aetherise project.[7]

In August and September there are interruptions of more than a week between individual groups. It is not clear whether the interferometer was dismantled during these interruptions.

[7] `dcm/data_sheets_27.pdf`

2.5. Anomalies

The anomaly also mentioned by Shankland *et al.* [5] is the Aug-31 group. Within 5 h the measured signal hardly changes. The expected theoretical signal is weak, but the phase shifts. Another peculiarity is the missing signal with frequency 1.[8] The noise around frequency 1 is increased, as also seen in Figure 1, but the amplitude of frequency 1 is of similar magnitude to the background noise from frequency 5 onwards.

Overall, almost all signals seem to behave similarly constant as the Aug-31 group. It seems that the same signal was measured at all sidereal times. However, with some variance.

In Figure 2 the signals of the usable data sheets are shown.[9]. The data were reduced using Miller's algorithm. The uncertainty of the individual values is $\sim 0.01\,\lambda$.

This approximately constant signal agrees well with the theoretical signal, which is expected near the sidereal times 5^{h} and 17^{h}. Because several groups were measured at these sidereal times, there are several good direct matches with theory. At these sidereal times, the theoretical signal has the largest amplitude. A plot can be found in Figure 3.

Other anomalies are groups that were measured in the same periods, but whose signals are different. The group Apr-1 differs from Apr-13, and Sep-6 from Sep-9.

[8] Only in the first Aug-31 data sheet is the signal present.

[9] Only the 3 data sheets of the Sep-9 group are missing because the signal deviates and they can be considered as an anomaly.

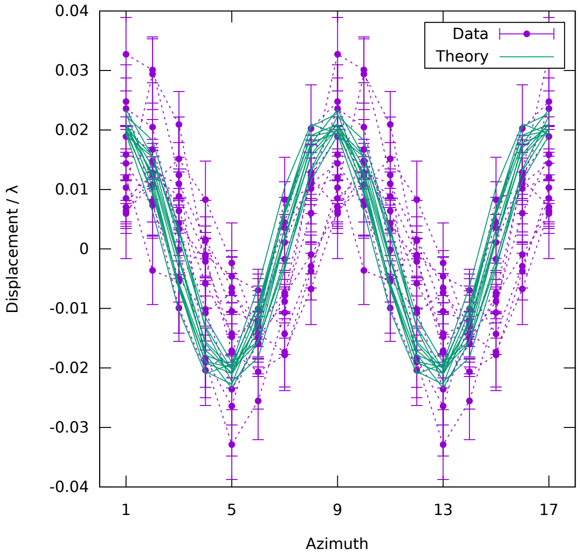

Figure 3: Signals in sidereal time interval $[16, 18]$ [A4]

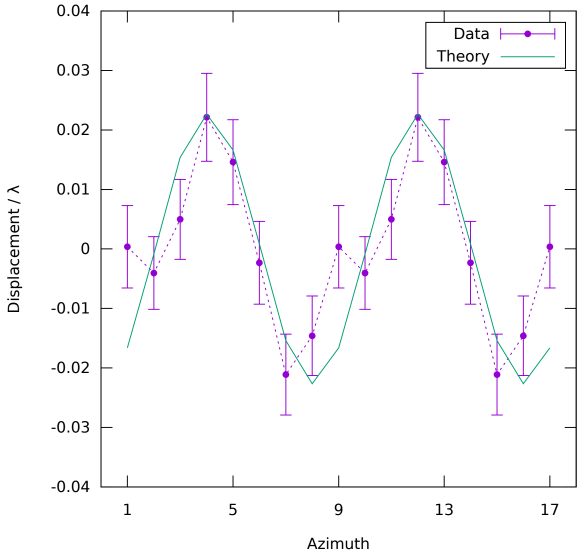

Figure 4: apr $[1, 4]$ - $[5, 8]$ [A5]

2.6. Difference signals

If one tries to extract difference signals with the same method as in [2], one fails. The difference signals found do not match the expected theoretical signals. The only exception is the difference signal in the group Apr-13. Using curve fitting, one obtains different parameter values than from the Mount Wilson data. After removing the largest outliers, the χ^2 statistic yields a reduced chi-squared $\chi^2/f \sim 3$. A cross-validation yields $\chi^2/f \sim 8$ and indicates a clear overfitting. Thus the result of the curve fitting is worthless.

Because the Apr-13 group is the only one that contains a suitable difference signal, let us take a closer look at the Apr-1 group, although it has been classified as unusable due to an increased uncertainty. In group Apr-1, too, one finds matching difference signals. For example, *apr [1, 2] - [4, 5]* or *apr [1, 4] - [5, 8]*.

In Figure 4 a difference signal of the group Apr-1 is shown. In Figure 5 a difference signal of the group Apr-13 is shown. The titles correspond to the expression for signal extraction. In both figures the data were reduced with Miller's algorithm.

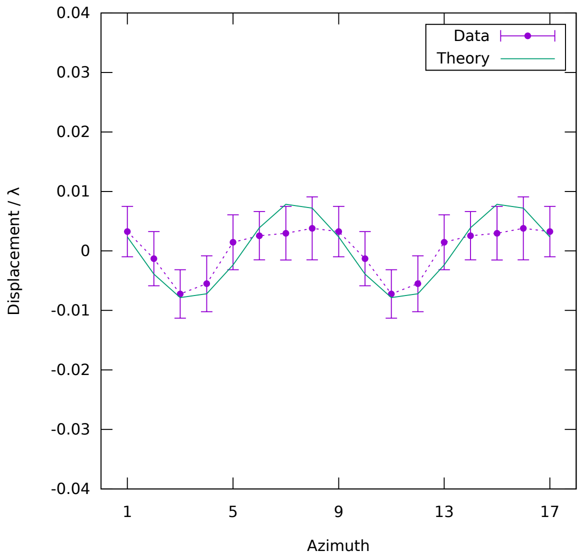

Figure 5: apr $[17, 18]$ - $[19, 20]$ [A6]

A test for signal content gives a positive result for both groups.

Table 2: Test for signal content

Data Sheets	R^2	R^2_-	R^2_+	Δ
Apr [1, 8]	12.83	13.45	14.99	1.54
Apr [17, 20] [A7]	14.45	13.62	21.86	8.24

3. Discussion

We have found in the data analysis that the data is basically similar to the Mount Wilson data.

There is also often good direct agreement with the theory without calculating difference signals. Because this correspondence only exists at certain times and the signal otherwise does not fit, I think it is more of a coincidence. It almost looks as if a periodic systematic error was measured.

With difference signals, one does not find any confirmation of the results in [2]. In the April epoch, however, difference signals are found that fit the theory well. It is possible that only in April were the conditions available to measure the theoretical signal. So it is not impossible that one can also measure a signal on the ground, and that measurements do not necessarily have to be taken on the summit of a mountain.

There are arguments for and against confirming the theory. The data do not allow any clear conclusions.

References

[1] Sebastian Pliet. *Analyse der Messungen von D. C. Miller in Cleveland 1927–1929*. 2021. DOI: 10.5281/zenodo.5802008.

[2] Sebastian Pliet. *Hypothese einer Verletzung der Lorentz-Invarianz in der Äthertheorie und Bestätigung durch die Experimente von D. C. Miller*. 2021. DOI: 10.5281/zenodo.5516950.

[3] Dayton C. Miller. 'The Ether-Drift Experiment and the Determination of the Absolute Motion of the Earth'. In: *Reviews of Modern Physics* 5 (1933), pp. 203–242.

[4] 19IM2 Dayton C. Miller Papers, 1878-1939, Case Western Reserve University Archives.
19IM2 7:10 Research. Interferometer. Cleveland, April 1927
19IM2 7:11 Research. Interferometer. Cleveland, August 1927
19IM2 7:9 Research. Interferometer. Cleveland, Sept.-October 1929.

[5] R. S. Shankland et al. 'New Analysis of the Interferometer Observations of Dayton C. Miller'. In: *Reviews of Modern Physics* 27 (1955), pp. 167–178.

A. Commands

List of commands used to generate data for tables and diagrams. The operating system is a Linux-like one. The Aetherise project 1.2.0 was used.

A1. `aetherise -ignore all dcm/csv27/*.csv dcm/csv27/bad/*.csv -spectrum -aggregate mean > s.dat`

   a) `plot_spectrum.sh s.dat "" image.svg`

A2. `aetherise -ignore all dcm/csv27/*.csv dcm/csv27/*/*.csv -aggregate test`

A3. `aetherise -single -ignore all dcm/csv27/*.csv -reduce -no_theory > s.dat`

   a) `plot_signal.sh s.dat "" image.svg`

A4. `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -reduce -month [1,9] -sidereal [4,6] -sidereal [16,18] > s.dat`

   a) `plot_signal.sh s.dat "" image.svg`

A5.
   a) `aetherise -single -ignore all dcm/csv27/bad/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -reduce -aggregate mean -month [4,4] -no [5,8] -csv > data.csv`

   b) `aetherise -single -ignore all dcm/csv27/bad/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -reduce -aggregate mean -month [4,4] -no [1,4] -data data.csv -subtract_data > s.dat`

   c) `plot_signal.sh s.dat "" image.svg`

A6.
   a) `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -reduce -aggregate mean -month [4,4] -no [19,20] -csv > data.csv`

   b) `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -reduce -aggregate mean -month [4,4] -no [17,18] -data data.csv -subtract_data > s.dat`

   c) `plot_signal.sh s.dat "" image.svg`

A7. Examples of how the values of the columns R^2, R^2_-, R^2_+ of Table 2 were determined

   a) `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -aggregate diff -month [4,4] -no [17,20]`

   b) `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -aggregate diff -month [4,4] -no [17,20] -subtract_theory`

   c) `aetherise -single -ignore all dcm/csv27/*.csv -latitude 41.504 -longitude -81.608 -altitude 210 -aggregate diff -month [4,4] -no [17,20] -add_theory`