Lab Report
Experiment 7 Measurement of Fundamental Constants: The Speed of Light

Callum Massey
644475

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1 Abstract

By inducing a phase shift in a beam of light and using two signal generators to scale down the input to an oscilloscope by a factor of 601.506 ± 0.025 at regular distances allowed for a calculation to find c_{air} the speed of light in air which was calculated to be $c_{air} = (2.955 \pm 0.042)$ x 10^8ms^{-1}

2 Introduction

This experiment aims to confirm the established value for the speed of light $c = 299792458\text{ms}^{-1}$ through the phase shift method by measuring the time delay between two waves from the same source.

3 Theory

This experiment arose from the difficulty found in directly measuring the speed of light from the first known attempt when Galileo attempted the measurement in 1667 when he and his assistant stood on top of a hill a known distance apart, each with a lantern, he was unable to determine if at a distance of less than a mile if light travelled instantaneously or not[1]. To when Hippolyte Fizeau's method using a far more complex methods of direct measurement using the Fizeau-Foucault apparatus was improved upon by Leon Foucault who obtained a value of 2.98 $\text{x}10^8\text{ms}^{-1}$. The difficulty of such gave rise to this experiment which uses the technique of time-dilation to "slow down" the the response signals from transmitter and receiver allowing for a measurement of the phase difference between the signals on an oscilloscope.

4 Experimental setup and procedures

In this experiment the laser was set up to emit light through a focussing lens before entering the receiver, as shown in Figure 1. After measuring the phase shift between the the signal from the sine generator and the signal from the receiver multiplied by the signal from the second signal generator at increasing distances and finding the exact value for the time-dilation it is possible to plot a graph of the scaled phase difference against displacement between transmitter and receiver, the reciprocal of the gradient of which is our value for the speed of light.

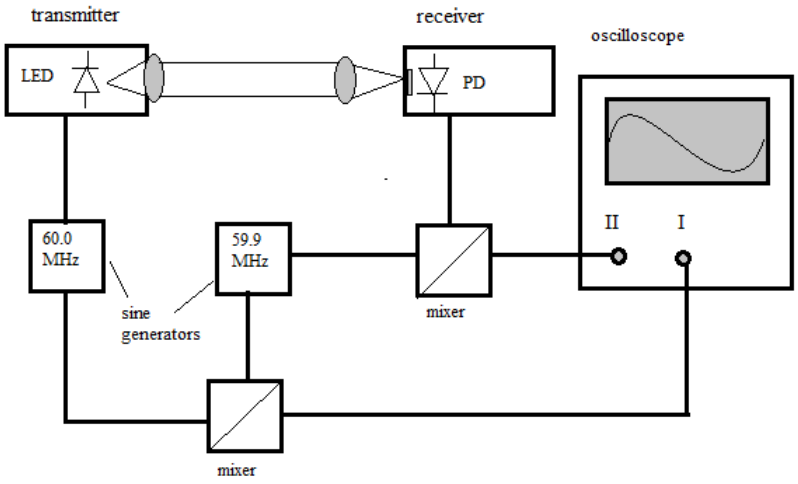
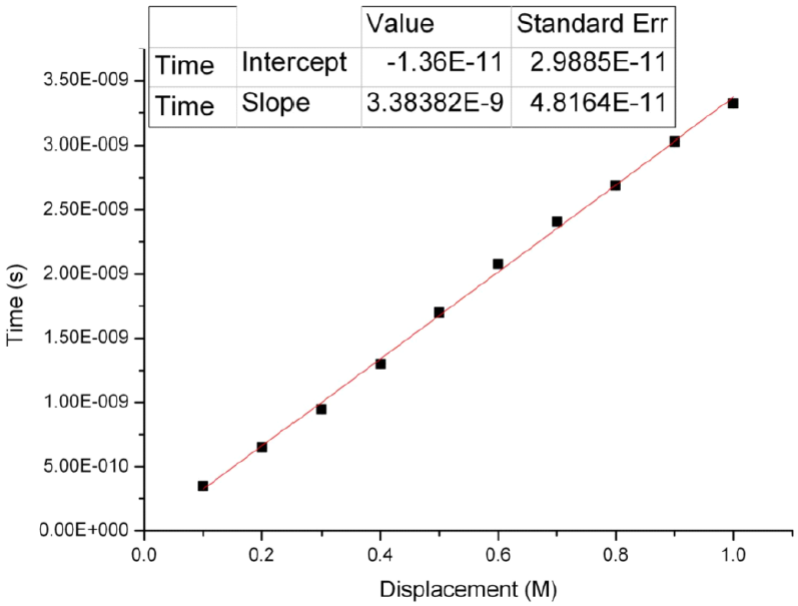


Figure 1

5 Results and analysis

The data we gathered from the oscilloscope is represented in the table in Appendix 1 after acquiring which we attached the laser to a digital counter to give us the value of f_1 and to the receiver for f_2 and using $\omega_1 = 2\pi f_1$and $\omega_2 = 2\pi f_2$, to calculate the angular frequencies of those waves which can then be used in the calculation of the time dilation factor $\Delta t' = \frac{\omega_1}{\omega_1 - \omega_2}\Delta t$ and then use this to multiply each of the average values in the table in appendix 1 to give actual values for the time the light takes to travel between the transmitter and receiver as shown in the table in appendix 2

Which was then used, as below,to produce a graph giving us the reciprocal of the speed of light as the gradient of the line, a value of
(3.3838 ± 0.0482) x10^{-9} giving our value for the speed of light to be
$c_{air} = (2.955 \pm 0.042)$ x10^8 ms^{-1} which is consistent with the established value $c = 299792458$ms^{-1}.



6 Conclusions

The aim of this experiment is to determine the speed of light, however this in itself is a flawed concept as any more accurate calculation for the speed of light will result in a change in the length of a metre which is defined as the distance light travels in $\frac{1}{299792458ms^{-1}}$ seconds.[2] By this, if the determined value were to be taken as absolutely accurate then the length of a metre would be redefined as 0.9856 ± 0.0147 times its current length.

7 References

[1] Galileo Galilei, Two New Sciences,
(Madison: Univ. of Wisconsin Pr., 1974) p. 50.
[2] Comptes Rendus de la 17e CGPM (1983), 1984, 97
Metrologia, 1984, 20(1), 25

8 Appendix

Appendix 1

Time Difference				
ΔS	1	2	3	average
10	2.2	2.0	2.2	2.1
20	4.0	4.0	3.8	3.9
30	6.0	2.0	2.2	5.7
40	7.8	7.8	7.9	7.8
50	10.0	10.0	10.5	10.2
60	12.5	12.5	12.5	12.5
70	14.5	15.0	14.5	14.5
80	16.5	16.0	16.2	16.2
90	17.5	18.5	18.5	18.2
100	20	20	20	20

Appendix 2

ΔS	Time
10	0.0035
20	0.0065
30	0.0095
40	0.0130
50	0.0170
60	0.0208
70	0.0241
80	0.0269
90	0.0303
100	0.0332