Method for Studying Speed of Light (Foucault Theory)

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Introduction

The basis of the project was to recreate the study that Léon Foucault used to study the speed of light. Foucault used mirrors to observe the speed of light by using a candle, whereas in modern times, we use lasers, as shown in this experiment. Using the angle of the mirror, the speed of light is able to be determined based off the reflection from the mirrors.

Methods

1. Place the Laser and Rotating Mirror Assembly on either side of the bench and align them so that the laser hits the center ot the mirror.
2. Set up the front and rear of the laser so that it can go through the holes and adjust the mirror so that it reflects back through the hole of the first alignment jig.
3. Place the lenses down into the appropriate positions and adjust them to realign the laser with the center of M_R(rotating mirror).
4. Place the measuring microscope in between both lenses in the appropriate position (making sure beam splitter is facing the correct direction).
5. Position M_F(fixed mirror) 2-15 meters away, at an angle no greater than 20 degrees. ***Optimal Distance is 13.5 meters away, with an angle of 12 degrees
6. Adjust the angle of M_R and the position of M_F so that the laser beam hits the center of M_F and is reflected back towards M_R. Make sure the reflected beam from goes through the beam splitter.
7. Place Polarizer down and adjust microscope to view the reflected image.
8. Adjust for interference patterns (angle the lenses appropriately).
9. Rotate mirror clockwise and counterclockwise, record micrometer reading.

Data

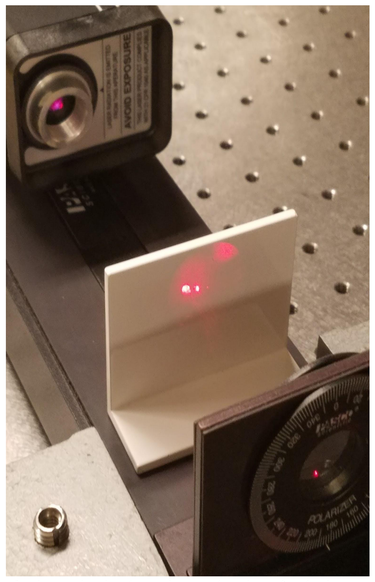
$L1_3 := 93.2cm$ $B_3 := L2_3 - M_R = 0.456\,m$

$L2_3 := 62.6cm$ $D_3 := 917.8cm$

$A_3 := L1_3 - L2_3 - f_{L1} = 0.258\,m$ $c_{3avg} := mean(c_3) = 3.036 \times 10^8\,m$

$M_R := 17cm$ $f_{L1} := 48mm$

$$S_{cw3} := \begin{pmatrix}1527\\1527\\1527\\1528\\1527\\1528\\1528\\1529\end{pmatrix} \quad S_{ccw3} := \begin{pmatrix}1526\\1528\\1527\\1528\\1527\\1533\\1529\\1531\end{pmatrix} \quad m_{cw3} := \begin{pmatrix}12.98\\12.97\\13.00\\13.00\\13.00\\13.01\\13.00\\13.00\end{pmatrix} mm \quad m_{ccw3} := \begin{pmatrix}12.39\\12.43\\12.43\\12.43\\12.40\\12.43\\12.44\\12.44\end{pmatrix} mm \quad c_3 := \frac{\left[8\pi \cdot A_3 \cdot D_3^{\,2} \cdot (S_{cw3} + S_{ccw3})\right]}{(D_3 + B_3) \cdot (\Delta m_3)} = \begin{pmatrix}2.934 \times 10^8\\3.207 \times 10^8\\3.038 \times 10^8\\3.04 \times 10^8\\2.886 \times 10^8\\2.992 \times 10^8\\3.095 \times 10^8\\3.098 \times 10^8\end{pmatrix} m$$



A closer look at equipment setup, featuring the Helium Neon laser and the calibrated polarizers

Helium Neon laser from Cleveland State University's Optics Lab

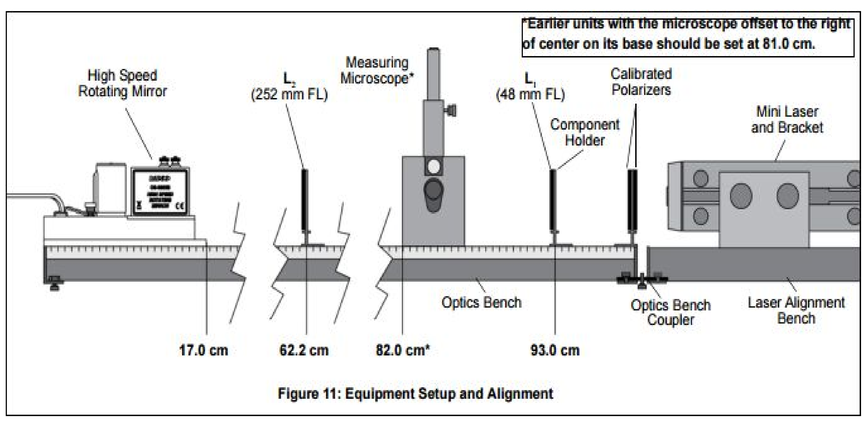


Figure 11: Equipment Setup and Alignment

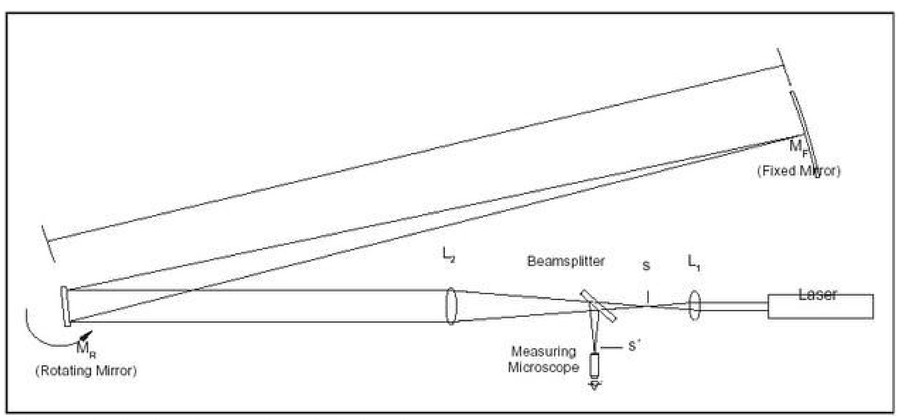
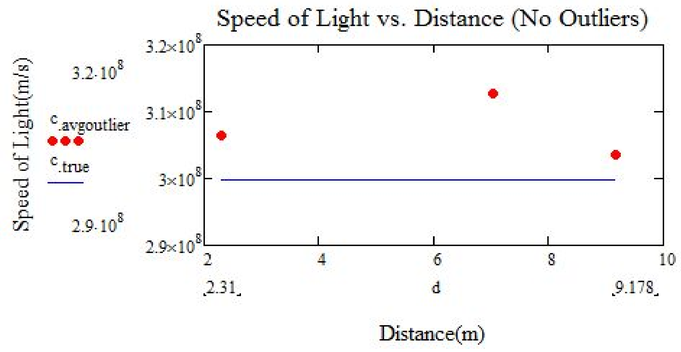
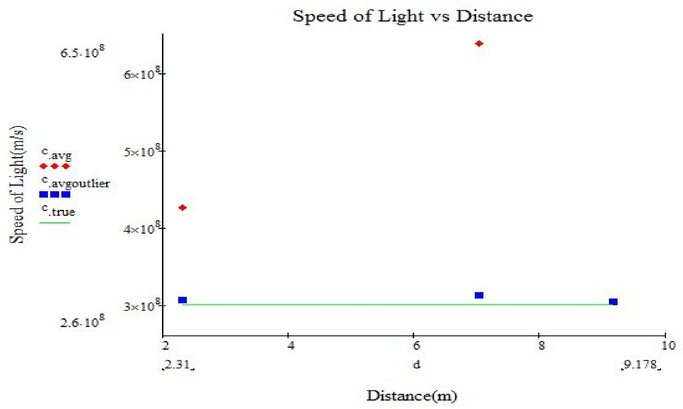


Diagram showing how the experiment is designed

Graphs and Charts





Conclusion

With Outliers Without Outliers

$$\left[\frac{(c_{avg} - c_{true})}{c_{true}}\right] \cdot 100 = \begin{pmatrix}42.184\\112.6\\1.277\end{pmatrix} \quad \left[\frac{(c_{avgoutlier} - c_{true})}{c_{true}}\right] \cdot 100 = \begin{pmatrix}2.229\\4.283\\1.277\end{pmatrix}$$

The farthest distance resulted in the most accurate measurements by far. This reiterates what is expected for the result of this test, which is that the optimal distance is between 10 and 15 meters, or more precise 13.5 meters. The most obvious source of error originates from the distance between M_F and M_R, although the micrometer readings also had a significant effect on the data points. Given more space to allow a longer distance, the measurements would most likely be even more accurate than the trial at 9 meters.

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