

# Using Microwave Michelson Interferometer To Measure the Speed of Light

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# Outline

- ▶ Importance
- ▶ Michelson Interferometer Overview
- ▶ Experimental Setup
- ▶ Procedure
- ▶ Data Collection
- ▶ Results

# The Cosmic Speed Limit

- ▶ How fast electromagnetic waves travel in vacuum
- ▶ Maximum speed at which any information may travel
- ▶ Many of the greatest scientific discoveries could not have arisen without knowledge of the speed of light
- ▶ Speed of light in vacuum is different than in air
  - ▶ index of refraction of air,  $n = 1.0003$



# Michelson Interferometer

Microwaves, just like any other waves, can be Doppler shifted. The microwave detector received waves that were shifted to lower frequencies along with unshifted waves

- ▶ we used the resulting phenomena to calculate the value of  $c$

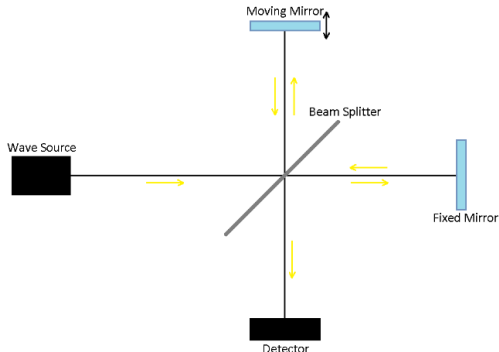


Figure 1: Schematic Diagram of microwave Michelson Interferometer

# Equipment

- ▶ Microwave Source
- ▶ Fiberboard beam splitter
- ▶ Fixed mirror
- ▶ Movable mirror
- ▶ Air Track and glider
- ▶ Photogate
- ▶ Detector

# Experimental Setup

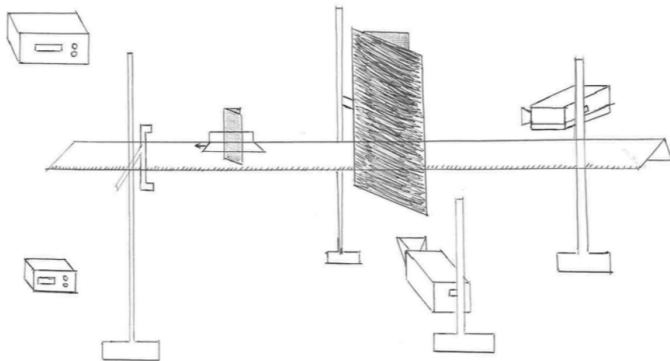


Figure 2: Schematic Diagram of experimental setup

# Data Collection

- ▶ Frequency at which the microwaves are emitted

$$f = 10.525GHz \quad (1)$$

- ▶ Average speed of glider

$$v = \frac{d}{t_{v1} - t_{v2}} \quad (2)$$

- ▶ Average beat frequency

$$B = \frac{N_B}{t_{B1} - t_{B2}} \quad (3)$$

# Data Collection

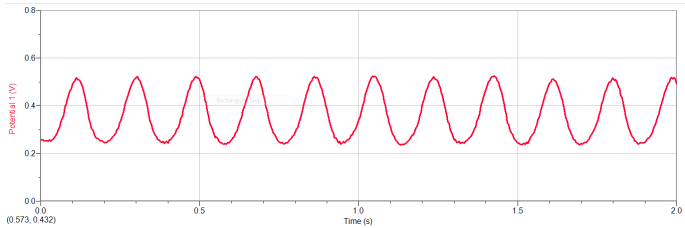


Figure 3: Potential vs Time graph for beat frequency

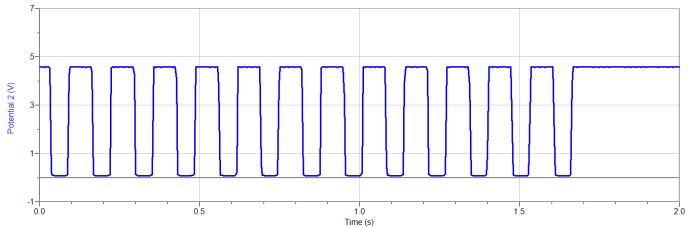


Figure 4: Potential vs Time graph for photogate



## Results

<b>Trial</b>	<b>Speed of light (<math>10^8 m/s</math>)</b>
1	2.988
2	3.007
3	3.023
4	3.002
5	3.000
6	3.002
7	3.003
8	3.008
9	3.011
10	2.995

Table 1: Value of  $c$  for each trial

- ▶ Average value of speed of light

$$c_{measured} = (3.004 \pm 0.003) * 10^8 m/s$$

## Results and Conclusion

- ▶ Average value of speed of light

$$c_{measured} = (3.004 \pm 0.003) * 10^8 m/s$$

- ▶ Accepted value of speed of light

$$c = 2.998 * 10^8 m/s$$

- ▶ Percentage error = 0.202%
- ▶ Measures the Doppler shift of the microwaves
  - ▶ results when one of the interferometer's mirrors is moving

# Acknowledgements

- ▶ Dr. Kevin Riggs
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