Building a Michelson Interferometer

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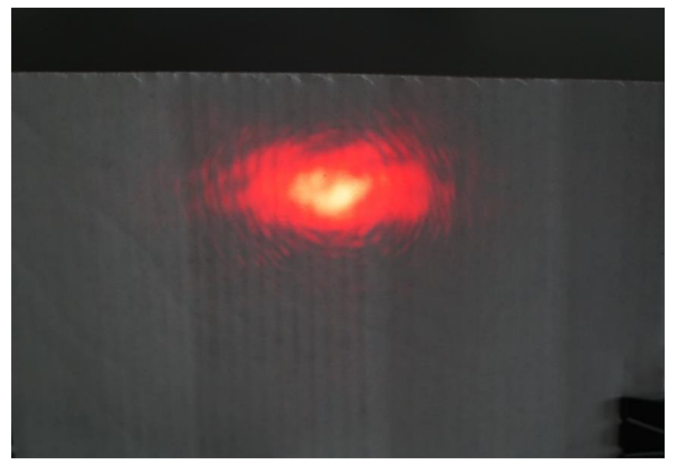
What is a Michelson interferometer?

The Michelson interferometer is a common setup for optical interferometry using a beam splitter to split a source of light into two arms. By reflecting the beams back into the splitter, they interfere with each other resulting in an interference pattern.



Why is this important?

This interferometer design is used for many applications in various fields.

Fourier Transform Spectroscopy:

- Essentially a Michelson interferometer with one movable mirror. Offers significant advantages over dispersive spectrometers (Grating and prism).

Gravitational Wave Detection:

- The Michelson interferometer is used in the Laser Interferometer Gravitational Observatory (LIGO) using 4km long arms to detect miniscule gravitational waves.
- Proved a prediction of Einstein's theory of general relativity 100 years later.

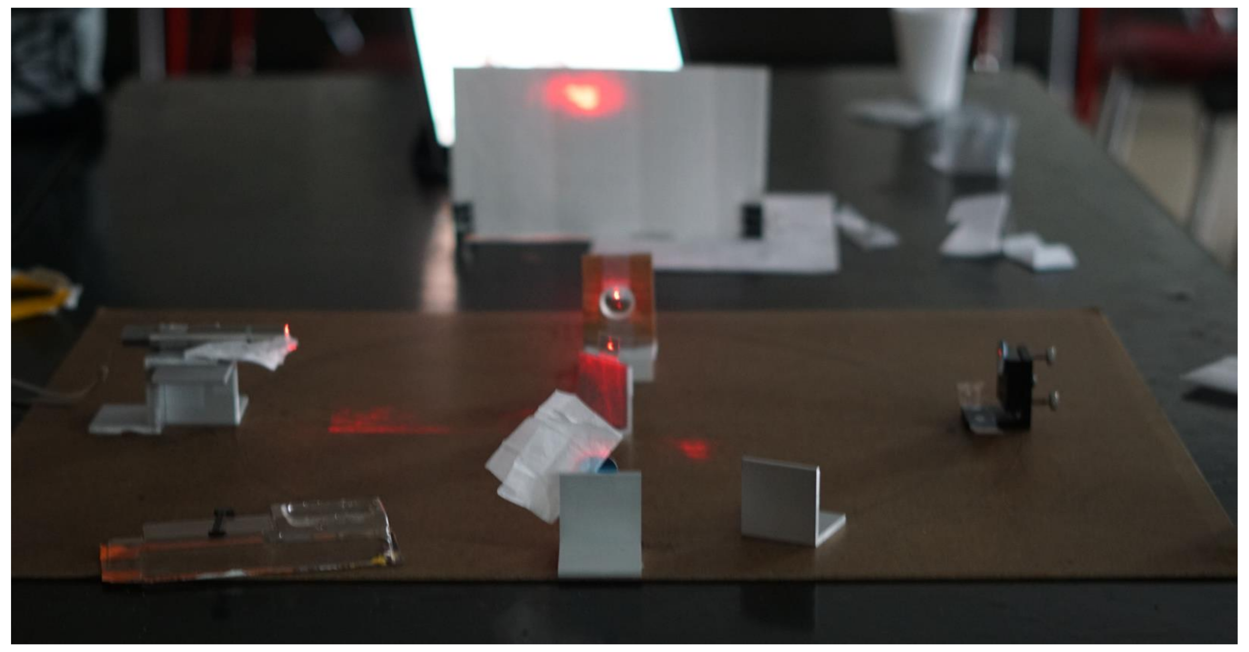
Atmospheric and Space Applications:

- Used for studies of Earth's upper atmosphere
- Used in the Helioseismic and Magnetic Imager on the Solar Dynamics Observatory to image the magnetic activity of the Sun
  - Integral to furthering our understanding of the Sun

How we built an interferometer

Building the interferometer itself is a process that required a significant amount of trial and error for us to ensure each component was in the correct location.

1. We marked locations on a large board to determine the locations of the optics
   - The two mirrors needed to be perpendicular to each other
   - The laser was placed directly in front of one of the mirrors
   - A beam splitter was placed such that the laser would directly strike both mirrors
2. Each component was tested in the determined location and then attached to the board using epoxy
3. A significant portion of the time spent building the interferometer was spent on calibration of the optics
   - The mirrors had to be angled precisely to combine the beams on the screen to achieve the interference pattern
   - A problem we encountered in our building process was that the tape attaching the mirrors would cause the mirrors to shift slightly.
   - We solved this by inserting a piece of thin paper to prevent the optics from moving significantly
4. Between the lens and screen, we placed a lens to increase size of the laser beam for visibility



What else can we do with this?

Using this tabletop interferometer, we can use this as a microphone by playing sound close to one of the mirrors and detecting the difference in the interference pattern using a camera.

This is very similar to how LIGO detects gravitational waves as both sound and gravitational waves would affect the length the laser travels, leading to a change in interference patterns.

Unfortunately, we could not attempt this within the timeframe of the program.