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Abstract

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CONSTRUCTING a Mach-zender INTERFEROMETER WITH a Variable Beam Path Using a Translation Stage

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**Introduction**

The purpose of this experiment was to utilise wave interference phenomena to identify possible impacts on an interference pattern using a Michelson interferometer with an adjustable beam length and a Helium Neon (HeNe) laser.

Interferometry is a measurement method of wave interference utilising the principle of superposition. This principle states that when two (or more) waves cross at a point, the displacement of the point is the sum of the two waves displacement (Bryan & Hellemans, 2004, p. 695). Interferometers work with electromagnetic waves to measure the inference pattern, when the waves are at peak construction or deconstruction.

The design relies on the superposition principal and nature of light waves to produce interference fringes visualised as dark spaces in projected light. The experiment relies on the symmetry of all elements; if the two beams intensity are unequal, the conclusion you draw from changing variables would be unreliable due to the absence of a base measurement. In this experiment the ‘base measurement’ would be when the beams align at all peaks, showing equal fringes. This cannot happen if the beams are different intensities as the beams do not equally contribute to the peaks.

In this experiment we explored the impact of beam length and horizontal shift on the interference pattern.

After constructing the interferometer, the power measured of the final interference beam had major fluctuations between 0.3 and 0.7 micro watts. To determine the major contributing factors to the fluctuation a Fast Fourier Transform (FFT) was applied to the recorded data.

**Materials and Methods**

**Materials**

List the components used, including:

* Laser source
* Beam splitter
* Mirrors
* Adjustable translation stage
* Power meter
* Mounts, screws

**Setup Construction**

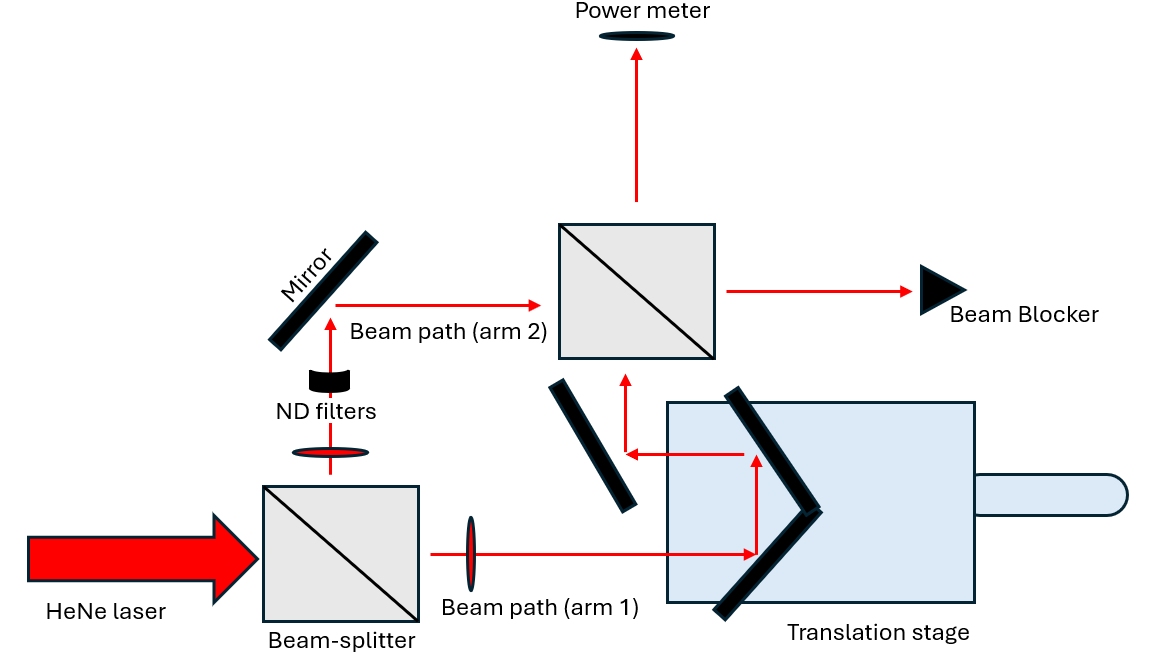


Figure . Mach-Zender Beam splitter diagram slightly modified from: (ChaosFlaws, 2016)

The approximate location of the first mirror of arm one was identified. This was marked and the translation stage was screwed into the table. The first mirror was screwed into the right of the translation stage, and it was rotated slightly left. To track the beams movement a white card was held up and moved alongside the mirror. After reaching an approximate right angle the second mirror was placed in the beams path. This was a challenge due to the translation stage not being wide enough to accommodate both the mirrors’ bases. This was fixed by increasing the angle that the first mirror faced at to take up less horizontal space. To ensure simplicity in construction, an initial position was chosen for the second beamsplitter. The third mirror of arm two was positioned along the same row as the second beamsplitter

**Incorporation of Translation Stage**: Explain how the adjustable translation stage was integrated into one path.

1. **Combining the Beams**: Discuss alignment to ensure the beams recombine at the detector.
2. **Detector Setup**: Describe setting up the power meter or other measurement tools.

**Challenges and Adjustments**

To confirm that the beam-splitter is 50%-50%, the power meter was placed the indicated point on each arm (figure *1. Red power meters)* and it was determined that they had a percentage difference of 35% (*Appendix 1)* favouring arm two*.* This difference has an adverse effect on the interference pattern of the two beams as mentioned in the introduction. To combat this limitation two 0.1 ND filters was placed intercepting arm two, reducing the beams intensity to 0.331 microwatts, a 0.004 difference to arm ones 0.327 microwatts. Decreasing the percentage difference to 0.2% (*appendix 1)*. This was decided to be reasonable enough to conduct the experiment.

Provide space to document:

* Misalignments and how they were corrected.
* Steps that had to be redone due to unforeseen issues.
* Difficulties in achieving precise alignment of the optical components.

**Results and Observations**

**Interference Patterns**

* Detail the observed interference patterns as the stage is moved.
* Present measurements of power fluctuations between the two beams (graphs or tables).

**Sources of Fluctuation**

* Discuss factors contributing to measurement fluctuations, such as:
  + Environmental vibrations
  + Thermal effects
  + Imperfect alignment

**Discussion**

* Reflect on how changes in the path length (via the translation stage) influenced the interference pattern.
* Evaluate the sources of error and how they impacted the results.
* Suggest improvements to the setup or experimental method to minimize issues.

**Conclusion**

Summarize key takeaways, focusing on:

* How movement of the translation stage affected the construction and deconstruction of the interference pattern.
* Practical insights into maintaining stability and alignment in optical systems.
* The broader implications for using interferometers in precise measurements.

**References**

List any textbooks, research papers, or manuals consulted during the experiment.

**Bryan, B., & Hellemans, A. (2004).*The history of science and technology.* New York: Scientific Publishing Inc.**

**ChaosFlaws. (2016). Outcome of Mach-Zehnder interferometer experiment. Retrieved from** [**https://physics.stackexchange.com/questions/274379/outcome-of-mach-zehnder-interferometer-experiment**](https://physics.stackexchange.com/questions/274379/outcome-of-mach-zehnder-interferometer-experiment)

**CUEMATH. (2023). Percent Difference. Retrieved from** [**https://www.cuemath.com/commercial-math/percent-difference/**](https://www.cuemath.com/commercial-math/percent-difference/)

**Appendices (if applicable)**

* Include any raw data, detailed diagrams of the setup, or additional notes that support the main report.

Appendix 1: (CUEMATH, 2023)