Measuring the Wavelength of Red Light Using the Michelson Interferometer Lab 1: Michelson Interferometer

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Lab Partners:
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1 Introduction

The introduction provides any background knowledge a student coming into Modern Physics may need in order to understand what you did in the lab. This includes relevant physics concepts, derivations of equations you used, and your experimental set-up. An example for the Michelson Interferometer lab is given below. **This is the portion of your lab which will be collected at the beginning of the lab to demonstrate you have read through the lab manual and understand the relevant background.** You may make modifications to the Introduction for the final lab write up based on what you learned during the lab and any feedback received.

1. Does the student explain the physical concepts which are explored in the lab? (ex. for Michelson Interferometer: interference (constructive & destructive), in-phase & out-of-phase)

2. Does the student explain relevant equations which are used throughout the lab (and in the context of the lab set up)? (ex. for Michelson Interferometer: $\lambda = \frac{2d}{m}$)

3. Does the student explain how the lab set up is related to the concepts being investigated? (ex. for Michelson Interferometer: explain the parameters given in the equation in the context of measurable values in the lab)

4. Does the student identify what it is they are attempting to determine from the lab? (ex. for Michelson Interferometer: trying to calculate the wavelength of a red laser)

Example Introduction for Michelson Interferometer:

You may use any/all of this for your lab report this week as long as you properly cite me and the sources I've used. I did not entirely explain the equation which gives you the wavelength, so it may be worth elaborating on that. You may also decide that I gave extraneous information. An Introduction section with this amount of detail would likely get close to full points despite leaving out some of the important details.

The Michelson interferometer uses the wave-like properties of light to cause interference patterns. In this experiment, we use a monochromatic coherent light source, a red laser, with the Michelson interferometer to observe interference patterns in order to determine the wavelength of the light source.

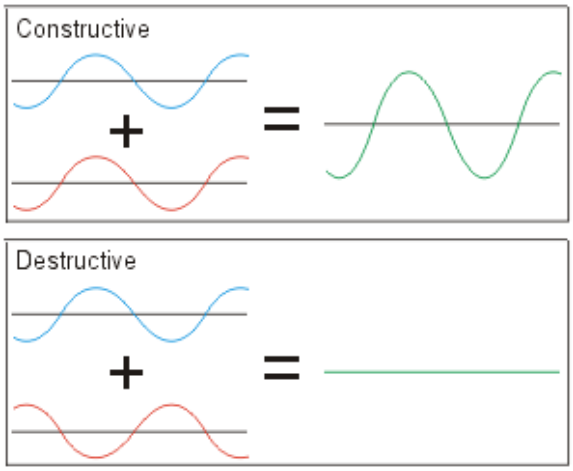

Figure 1: Total constructive interference occurs when crests of waves align and the resultant wave has a larger amplitude. Total destructive interference occurs when the crest of a wave aligns with the trough of another and resultant wave has no amplitude. Figure from Ref. [4].

Light which acts as a wave can be subjected to constructive and destructive interference. Total constructive interference occurs when light is in-phase (coherent), and total destructive interference occurs when light is out-of-phase by 180° (a half wavelength). In order to further illustrate what this means, consider two light waves as shown in Figure 1. When crests align, the superposition of the waves causes a resultant wave with larger amplitude–which will appear brighter. When the crest aligns with a trough,

the superposition of those waves cause a resultant wave with no amplitude– canceling out each other.

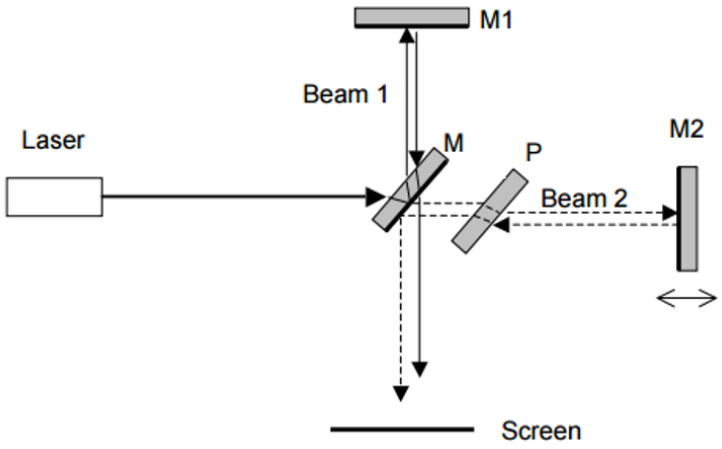

Figure 2: The set up of the Michelson interferometer [2]. Light travels from the laser to the first lens, M, where it continues to travel to the mirror, M1, or to the second lens, P. The first beam reflects off of M1 and then travels back to lens M and can pass through to the screen. The second beam passes through lens P, reflects off M2, reflects off the surface of M, and travels to the screen. Each beam passes through lenses three times.

The Michelson interferometer, the set up shown in Figure 2, uses lenses and mirrors to cause light emitted from a coherent source to travel two different paths before recombining. Both beams pass through lenses the same number of times: beam 1 passes through lens M three times, and beam 2 passes through lens M once and lens P twice. However, the position of the mirror M2 is allowed to vary, so the distance that beam 2 travels can be different from the distance beam 1 travels.

As beams 1 and 2 recombine at the screen, they interfere with each other causing interference fringes which are "circular patterns of bright and dark rings" [2]. The bright regions correspond to constructive interference while the dark rings are those of destructive interference. Because we can change the position of mirror M2, the beams travel different distances. If the mirror M2 is changed by a whole number, m, of wavelengths, "each bright region on the screen will go dark and then bright again m times" [2]. We can then determine the wavelength from Equation 1 where d is the distance M2 is

moved, and m is the number of cycles iterated.

$$\lambda = \frac{2d}{m} \tag{1}$$

2 Procedure

Briefly summarize the procedure you followed with any modifications made from the lab manual. This can (and should) be written using descriptions such as "we did this". **Write as a paragraph, not as an enumerated list.**

1. Is there a paragraph format used to describe the procedure? *Please do not use an enumerated list.*

2. Does the student describe the actual procedure (which might differ from the one described in the lab manual)?

3 Data

In this section, you should write a paragraph identifying what data you are including (with references to each table and/or figure). Then include all raw data.

If there is a lot of data, include one set here and include an appendix with the remaining set(s) of data but be sure to reference the appendix here.

1. Is there a short paragraph referencing tables or figures which include the data and what that data is?

2. Are the data presented in a clear manner to the reader?

3. Are there units clearly provided on all quantities?

4 Analyses & Results

In this section, follow the instructions in the lab manual in order to obtain the results. **Explain all of your steps and provide sample calculations.** All sources of uncertainty should be thoroughly identified and explanations

of how the uncertainty is propagated through calculations must be provided. This section will be the most difficult, but it will be easier if you finish your preliminary analyses during the lab session with your group.

1. Are all calculations explained?
2. Are sample calculations provided?
3. Are there explanations of sources of uncertainty from the experiment?
4. Are there explanations on the methods of error propagation throughout the analyses?
5. Are any modifications to the manual's analysis procedures thoroughly explained and defended?
6. Are there units on all measurable and calculated values?
7. Are the tables or figures used clear and effective in communicating information?

5 Discussion

A discussion of your own results should go here. If things agree with the theory, state why they do, consider how to improve or confirm your results, and discuss the implications of your results. If your results do not agree with the theory (and this is okay), identify what issues you encountered which reduce the accuracy of your results, how you would improve your results, and what your results mean.

Following this, answer the questions listed in the lab packet. Rewrite the question then provide a thorough answer following the question. If you answer the question in a different section of the lab, identify the location of your answer clearly.

1. Does the student provide a thoughtful and interesting discussion about the meaning and implication of their results obtained from the analyses?
2. Are the questions posed in the lab manual thoughtfully and thoroughly answered?

6 Bibliography

I am including a bibliography at the end of this document with examples of ways to cite people and resources. You may choose any sort of citation style (I made one up that allows the reader to know how to gain access to the resource and gives credit to developers of the resource) as long as you give proper credit.

Other

I will be harsh in this category as it is about spelling, grammar, formatting, and proper citations–all are relatively straightforward unlike some of the analyses and questions. A poorly written lab (or one neglecting citations, or one which doesn't use expected formatting) will be evaluated for content in the preceding sections but will receive few (or possibly no) points in this category. For repetitive cases with severe citation issues, more points will be deducted from other sections of the lab as well.

1. Is the lab well-written? Are there extensive spelling or grammatical errors?
2. Do all tables and figures have captions which fully explain them?
3. Are all tables and figures referenced in the body of the text?
4. Is everything properly cited? Does the student give proper credit to collaborators and resources used?
5. Is the tone professional?

What does she mean by this "Other" category?

1. All tables and figures must be referenced within the body of the text. I am using Table 1 as an example. I just referenced it within the body of my text in the previous sentence.
2. All tables and figures must be given a caption which explains what is contained within the table or figure. This should give a reader sufficient detail to understand what is contained within a table or figure.

This	is	an	example	of	a	table	!!!!
This	is	an	example	of	a	table	!!!!
This	is	an	example	of	a	table	!!!!

Table 1: All tables (and figures) should be labeled with an explanation of what is contained within the table (or figure). These captions can be lengthy if much explanation is required. Someone reading the report should understand what is in the table (or figure) without looking in depth at the rest of your report.

3. All statements which require a reference must be cited. If you work with other students, cite them [1]. If you ask an instructor for help, cite them. If you use the lab manual for information, cite it [2]. If you use outside resources, cite them [3]. Plagiarism is avoided by proper citations. Direct quotes from literature, figures found online, and discussions with other students are all okay provided proper credit is given.

4. Proper spelling and grammar must be used throughout the writing.

5. Maintain a professional tone. If you have questions on what is considered professional, please ask.

References

[1] Private communications with Emily M. Smith

[2] Lab 1: Michelson Interferometer. Developed by K. Krane & K.C. Walsh. Accessed at `http://physics.oregonstate.edu/ph314`.

[3] Oregon State Modern Physics Website. `http://physics.oregonstate.edu/ph314`

[4] Physics of Sound, The Method Behind the Music. Developed by B. Hollis. 1999-2015. `http://method-behind-the-music.com/mechanics/physics/`