REPORT:
Optics Lab – Michelson Interferometer
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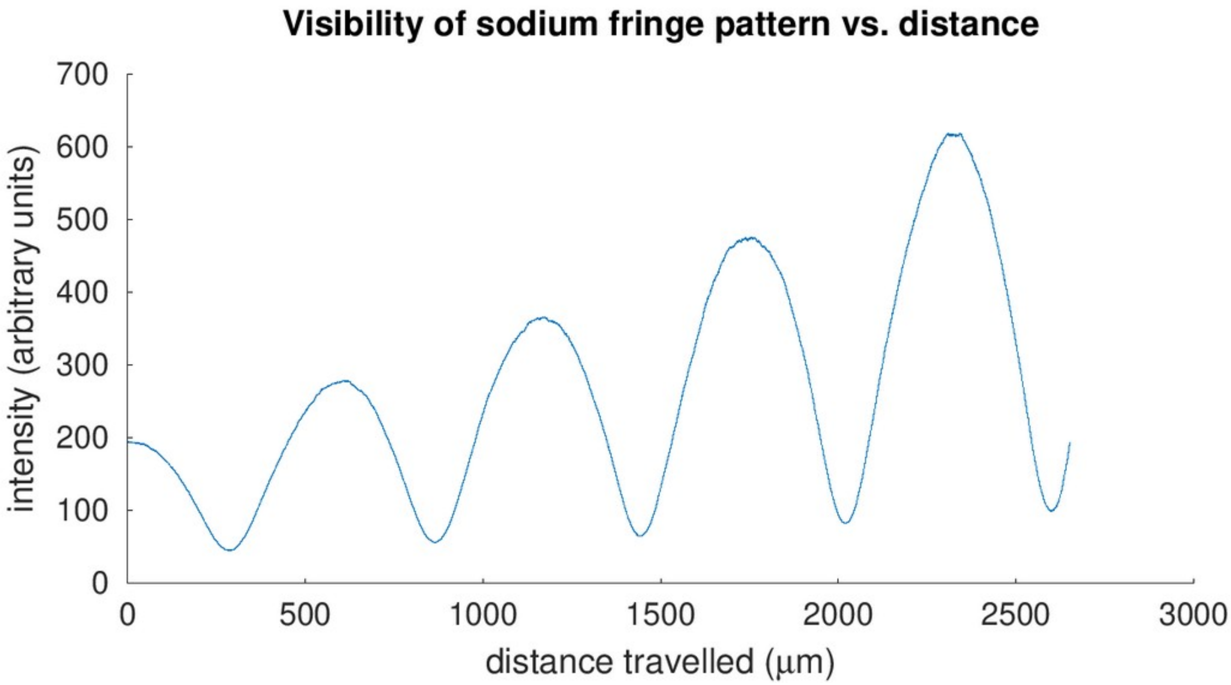

This graph was generated using a Michelson interferometer. One of the mirrors of the interferometer was mounted on a stage moving at 2.014 μm/s. A sodium lamp was used as the light source, and a CCD was used to gather the intensity data.

This is not the raw data; the data was first normalized to oscillate around 0, then the absolute value was taken of the data, and finally a moving average filter was applied to smooth it. The peaks show where the visibility of the sodium intensity pattern is highest, and the troughs show where the visibility is lowest. The distance traveled is relative to some arbitrary starting location of the stage. A MATLAB program was used to control the stage as well as gather intensity data simultaneously.

This graph, was used to help compute the difference in wavelength of the sodium D1 and D2 lines through the following equation:

$$\Delta\lambda = \frac{\lambda^2}{L}$$

Here, *L* is the distance between two peaks in the graph, Δλ is the difference between D1 and D2, and λ is the average wavelength. The average wavelength λ was found using a separate piece of data.

A part of the Michelson Interferometer laboratory consisted of finding the coherence length of various light sources, one of them being a Sodium lamp. The coherence length represents the average propagation distance in which two waves have the same phase, frequency, and waveform. It is a measure of the space over which the phase of a wave can be predicted.

To compute this length for the Sodium lamp, data for its spectrum was collected in the lab with a travel distance of 1.44 mm and a 0.001 mm speed, for the settings provided to MATLAB. This data was then truncated to dispose of noise at the beginning and end of the data recording from when the stage was moving to its initial position and resetting at the end. The mean value was subtracted from every value in the spectrum to center the oscillations around 0. The absolute value was taken for every data point, since we only care about the visibility, so any variation from 0 is important. Finally, a moving average allowed for the data to be smoothed out so that we could process it to find the minima and maxima properly.

The settings provided to MATLAB for the capture do not represent reality, so we had to gather separate data to find out what the actual velocity of the stage was: 2.014 ± 0.161 $\mu m/sec$. The intensity readings from the CCD are noisy and the Michelson interferometer was not isolated well enough from perturbations in the environment, resulting in a large uncertainty.

This allowed for the positions of local minima and maxima to be found at the different intervals. The differences between successive maxima were computed, and then the differences between successive minima. These values were combined together to get a value for *L,* which we found to be $577 \pm 47 \mu m$. The uncertainty is large due to the large standard deviation in the velocity calibration of the stage.

There are conflicting sources saying what the coherence length should be. Online we found a document from SFU stating that the coherence length of sodium is 590 μm, which is in the same order of magnitude as our value for *L*. However, we were told that the coherence length is equal to the distance from the highest peak in the graph to when the peaks fall below 1/e of the highest peak. In the latter case, the value should be much larger than *L,* about 2000 μm based on the graph.

We used our value for *L* as well as the average wavelength of the sodium D1 and D2 lines, which was gathered separately, in order to compute the difference between the two lines. This used the following formula:

$$\Delta\lambda = \frac{\lambda^2}{L}$$

The resulting value for $\Delta\lambda$ was 0.58 ± 0.16 nm, using the value 578 ± 106 nm for λ.