**Experiment 7: Michelson Interferometer**

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**Abstract**

The polarization of light is studied using combinations of linear polarizing films, reflective surfaces, and a quarter wave plate. To get quantitative data, a power meter is used to measure the amount of light being transmitted through a system. It’s found that reflected light is polarized in a plane along the traveling ray of light but perpendicular to the plane made by the incoming, refracted and reflected rays. When the orientation of incoming light is perpendicular to that of the polarized filter, light does not pass but using another filter in between can negate that effect. Quarter wave plates can be used to take polarized light and make it circularly rotate.

**Introduction**

Light is described as a traveling and oscillatory electromagnetic field whose field vectors at any given point are always perpendicular to its direction of motion. The oscillating amplitude of a field component will reach some maximum, decrease through zero as it reaches a maximum in the opposite direction, and then return through zero once more before reaching its initial orientation and amplitude. The distance light travels in the time required to perform one full oscillation as described is its wavelength, and the time it takes is its period. When two rays of light cross paths, the amplitude and direction of field components at that point of crossing is simply the addition of their respective field vectors. If you take two waves of equal wavelength—the same color—and send them along the same optical path, the addition of their fields will cancel each other out completely (destructively) if the maximum of one is seen at the same time and location as when the other is exactly opposite: when the relative phase of each wave is off by half an oscillation or 180 degrees in phase. Conversely, constructive interference is seen when the maximum field amplitude of one is seen at the same time and location as the others maximum: in other words when the phase difference between them is 0.

A Michaelson Interferometer is an optical set up that allows for the measurement of a light’s wavelength. It does this by splitting a beam of light from a single source in two, and directing each along separate optical arms of adjustable length before re-aligning them and sending them together to some diagnostic—where the wavelength is calculated based on characteristics of the observed interference pattern. Once split, the waves must continue to oscillate in the same way as they were when together, they continue to perform full oscillations at the same wavelength. But by adjusting the length of one arm and not the other, one can force one beamlet to traverse an extra distance before being re-aligned with the other. This optical path difference creates a relative phase difference between the two such that an interference between the two can be observed. In this lab, we simply used our eyes as a diagnostic to identify and measure the resulting interference pattern and its characteristics. A micrometer was used to make measurable adjustments in the movement of a rod that then moved a lever which in turn shortened or lengthened one arm of the interferometer. Note that due to the lever, movement measured on the micrometer needs to be divided by a factor of 5 to define the effective change in distance for the arm. The other arm had adjustments for ensuring proper re-alignment of the two beams.

Once re-aligned, the two split beams can be thought of as point sources radiating spherically. The result is that the interference pattern will change radially outward from the point of perception, as described by the following equation:

A Mercury [Hg] lamp was used as a light source with a known wavelength of 5461 Angstrom or 5.461\*10^-7 meters.

**Analysis & Discussion**

With the Mercury lamp as a source, an eye was placed at the exit of the interferometer and a diffraction pattern was seen though difficult to make out due to the fine spacing of the fringes. Adjusting the angle of one mirror allowed for centering of the zero-th order fringe.

The It was observed that as the mirror was moved in, shortening the optical length of that arm, the fringes moved toward the center: the opposite is true for moving the mirror in the other direction. At the value where the fringes appeared to neither move outward or inward is where we took the optical path length to be as close to zero as possible. This length was read out from the micrometer: 11.75 +- 0.5 um. It needs to be noted that—due to the mechanics of the lever which the micrometer moves to adjust the longitudinally mobile mirror—units read out from the micrometer need to be divided by 5 to get the true value: meaning that the true value is in fact 2.35 +- .1 um.

**Conclusion**

Reflected light off a surface has an angle at which it gets perfectly polarized. This effect was observed when viewing the reflection through a polarizing film and rotating it. Full cancellation of the light could be observed to happen 90 degrees from the angle of maximum transmission.

Light emitted from a laser in the lab was found to be polarized by using the same method as with the reflected light but using a meter which detected the lights power at the exit of the system. A plot of the data matched as well as could be expected to the theoretical equation with an R Squared value of 0.9972.

Just as orienting a polarizer perpendicular with an incoming wave will block all the light, this is assured with two polarizing films oriented at angles orthogonal to each other. Though some light can be expected to pass through when placing a third polarizer in-between, all light can be passed through the second when using a quarter wave plate as it’s effect is to circularly polarize the light. The maximum field amplitude of such light will reoccur at locations separated distances of integer wavelength.