

Optics Laboratory Rules

- Be alert and safety conscious.
- Keep the laser beam parallel to the table top and avoid placing your head (eye) in that plane.
- No eating, drinking, or tobacco products in the lab.
- All components need to be laid down or fastened to the optical table in order to prevent accidental tipping and damage.
- Use extreme care to avoid finger prints on any optical component.
- Finger cots must be worn if you need to touch an optical component (lens, neutral density filter, prism, etc.)

Lab 1: Detection of Light

I. Objective

The purpose of this experiment is:

1. to introduce a method of quantitatively measuring light from a helium-neon (HeNe) laser.
2. to show how the light from a laser source can be directed by introducing various optical components into its path.

II. Introduction

Various types of light sources are used extensively in today's research environments. However, the most sophisticated light source is of little use to any researcher or scientist if it cannot be measured or manipulated to suit the users needs. In this experiment, a HeNe laser will be used as the light source. The student will become familiar with Neutral Density filters and how they can be used to alter the power of the light source. Finally, this lab will examine the method of quantitatively measuring the light from the He-Ne laser using a photo-diode.

III. Procedure

A. Calibrate the Neutral Density Filters

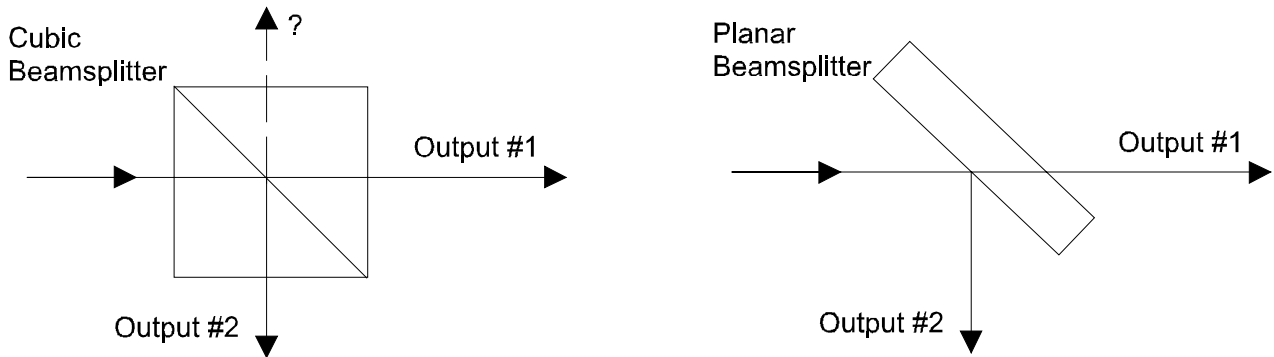
1. Measure the power of the laser beam with no filters in place using the Newport optical power meter. Be sure that the OD3 neutral density filter is attached to the detector before attempting this measurement.
2. Measure the transmitted beam power for the ten neutral density filters on your filter wheel and record them in the lab report table. Change the scale setting on your power meter to get the maximum number of significant digits. If the optical power incident on the power meter is too low, you will not get an accurate reading. If this is the case use the assigned value for future calculations.
3. Neutral density filters decrease the intensity of the light without altering the relative spectral distribution of the energy (i.e., the manufacturer tries to make them independent of wavelength over some range). The transmittance of a ND filter is specified by its Optical Density (OD). Optical density equals the log to the base 10 of the reciprocal of the transmittance, the ratio of the transmitted power to the incident power.

$$OD = -\log_{10} T; \quad T = \frac{I_{transmitted}}{I_{incident}}; \quad I_{transmitted} = I_{incident} 10^{-OD}$$

4. Calculate the OD for the filters on your filter wheel. You will need to use these values throughout the semester.

B. Calibrate the Beamsplitters

Figure 1: Propagation of light in a Beamsplitter



1. Measure the power of the laser beam directly with the power meter, then direct the beam into the cubic beamsplitter.
2. Measure the power of each of the output beams (see Figure 1).
3. Repeat the measurements for the planar beamsplitter.

C. Measuring photo-diode voltage using an oscilloscope. Does Background light affect the measurement?

1. Place the photo-diode on the table with the diode facing the lights on the ceiling and connect its output to the computer oscilloscope card using a BNC cable. Trigger the scope on auto with a line base of roughly 20 msec/division. Make sure to DC couple the input. You should observe a small signal. If you do not observe any detectable signal, please ask for help.
2. Cover the photo-diode with your hand (be careful not to touch the silicon photodiode element) and observe any changes. What is the observed change in the detected signal due to?
3. Mount the photo-diode on a post on the table. Increase the sensitivity of the oscilloscope if necessary (DC coupled). Can you still observe the signal observed above?

D. Determine the Linearity of the Diode

1. In order to filter out room light in the calibration of the diode, use the chopping wheel and lock-in amplifier. Ask for assistance in making the connections.
2. The diode should be mounted in an x-y-z translation mount. Before **EACH** measurement with the diode, you should adjust the mount to **maximize** the signal. This optimization of the

diode position is necessary because any small deviation of the laser beam will change the apparent reading from the photo-diode.

3. It is most likely that the direct light from the laser will saturate the diode (i.e. max out the diode). However, it may not. The result of saturating a diode is that it does not operate in a linear fashion, i.e., the voltage produced by the detector is not proportional to the power of incident light. Therefore it is necessary to determine what Neutral Density (ND) filter (if any) should be placed before the photo-diode so that the detector responds linearly to detected light. You can quickly determine if the detector is linear by placing a 0.3 ND filter between the beamsplitter and diode, the output signal from the diode should drop by 50% (not 10%, 20% etc.). With no ND filters in the laser path, determine using the 0.3 ND filter if the detector is linear. Is it linear? Why or Why not?
4. At this point, you can use your calibrations from IIIA and IIIB to determine the optical power on the photo-diode.
5. Develop a calibration curve for the output voltage of the photo-diode as a function of watts in the following manner:

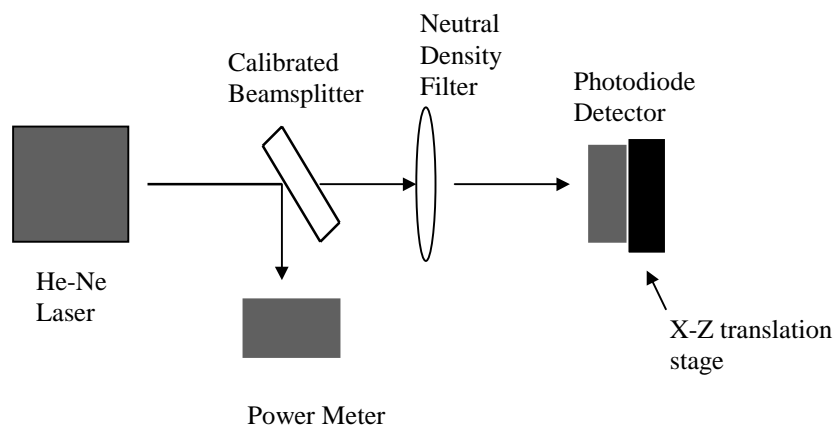
Place a ND filter wheel and the chopper between the beamsplitter and the diode.

Record the signal from the light that has passed through the ND filter using the photo-diode connected to the lock-in (volts). Monitor the lock-in amplifier output with the digital multimeter card on the computer.

Record the power (milliwatts) reflected to the power meter. Based on this measurement and your calibration of the beamsplitter and neutral density filter calculate the power incident on the photo-diode detector. Repeat this procedure for a variety of ND filters to develop the calibration curve for the photo-diode. Be sure to include the 3.0 ND filter. You should also make a measurement by blocking the laser light completely.

Make a plot of the photo-diode voltage versus power (mW) transmitted through the beamsplitter onto the photo-diode.

Figure 2- Linearity of Diode



Lab 1 Report

Name _____

A. Calibrate the Neutral Density Filters

ND Filter	Power Reading (mW)	ND Calculated Value
0		
0.2		
0.3		
0.4		
0.6		
4.0		
1.0		
2.0		
3.0		
4.0		
0.5		

B. Determine the ratio in which the beamsplitter splits the light from the laser. State explicitly the percentage of light in each direction.

Cubic beamsplitter

Output #1

Output #2

Planar beamsplitter

Output #1

Output #2

What is the laser beam corresponding to the dashed line of the cubic beamsplitter of Figure 1 due to?

C. Measuring photo-diode voltage using an oscilloscope.

2.

3.

D. Linearity of the photo-diode.

1. Determine if a ND filter is required to enable the photo-diode to operate linearly. If a filter is required, state which filter was used and why.

2. Develop and attach a calibration curve for the photo-diode (volts) as a function of power (milliwatts).
3. Below what power level is the photo-diode linear?
4. Without the chopper and lock-in amp, how does room light affect your measurement of the photo-diode calibration curve?
5. Why?
6. Does room light affect the calibration point for the 3.0 ND filter?
7. Why?
8. Assuming that a 1.0 ND filter is required to make the photo-diode linear, where, relative to the photo-diode, should the filter be optimally placed.
9. Why?