Investigating Polarization of Light through Jones Calculus*

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Polarization is a fundamental property of light. The purpose of this experiment is to get familiarized with the polarization of light as well as effects of different optical components on it. Polarization is best described through a matrix treatment called Jones calculus which you will also learn through this exercise.

Essential pre-lab reading:
"*Introduction to Optics*" by F. L. Pedrotti, L. S. Pedrotti and L. M. Pedrotti, Pearson Education, 2008; (Chapter 14: Matrix Treatment of Polarization).

1 Test Your Understanding

1. Understand the working of half wave plate (HWP) and polarized beam splitter (PBS). What is the fast axis of a wave plate?
2. Derive Jones matrices for a linear polarizer and half wave plate placed at some arbitrary angle θ.
3. Using your understanding of the aforementioned optical elements and Jones calculus, devise methods to generate linear polarization at arbitrary angles.
4. Derive and plot the intensity profile generated by the setup shown in Figure 1.

2 The Experiment

A HeNe laser beam is incident on a neutral density filter (NDF) and then polarizer. The polarized light further passes through a HWP and a PBS which divides the incident beam into two components. Each of the two beams emerging from the PBS passes through an iris and falls at photodiode A or B, as shown in Figure 1. Each photodiode outputs a current proportional to the intensity of the detected light beam. The current is measured as a voltage level through a current-to-voltage (I-V) converter and a digital multimeter (DMM).

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2.1 Rotating HWP keeping polarizer at a fixed angle

Orient the polarizer such that it produces a horizontal polarization. All angles will then be measured with respect to this polarizer. Generate a complete set of linear polarizations with angles 0° to 360° with a step of your choice by rotating the HWP. Record the photodiode outputs at position A and B.

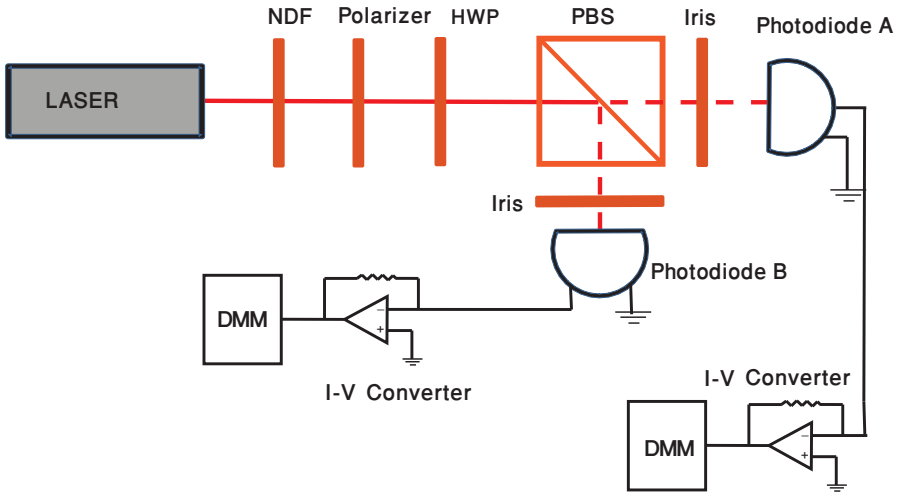

Figure 1: Setup for the experiment. The red line shows the perceived light path.

Q 1. Plot a graph between HWP angle and power measured at the two photodiodes. Does it corroborate with your intensity calculations based on Jones formalism?

Q 2. Why do we need a neutral density filter (NDF) in this setup?

Q 3. Why are we using an HWP for producing different linear polarizations? Describe the effect of HWP mathematically.

2.2 Rotating polarizer keeping HWP at a fixed angle

Now, keeping HWP fixed at an arbitrary angle of your choice, vary the angle of the polarizer from 0° to 360° with a step of your choice.

Q 4. Plot a graph between polarizer angle and power measured at the two photodiodes. Does it agree with your intensity calculations based on Jones formalism?