Investigating Polarization of Light through Jones Calculus

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Version 1; May 20, 2014

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 would 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).

1 Test Your Understanding

1. Understand the working of quarter wave plate (QWP), 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, quarter wave plate 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 elliptical, circular and linear polarizations.
4. Derive and plot the intensity profile generated by the setup shown in Figure 1.
5. Derive and plot the intensity profile for experiment devised in Figure 2. Make a polar plot with intensity treated as radius shown against the variation of the analyzer angle.

2 The Experiment

A HeNe laser beam is incident on a polarizer. The polarized light then passes through a half wave plate, neutral density filter and a polarized beam splitter which divides the incident beam into two. The two beams emerging from the polarizing beam splitter, at position A and B in Figure 1, are then measured by a photodiode.

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 polarizations from 0° to 360° with a step of your choice by rotating the half wave plate. Record the photodiode output with photodiode first placed at position A and then at B.

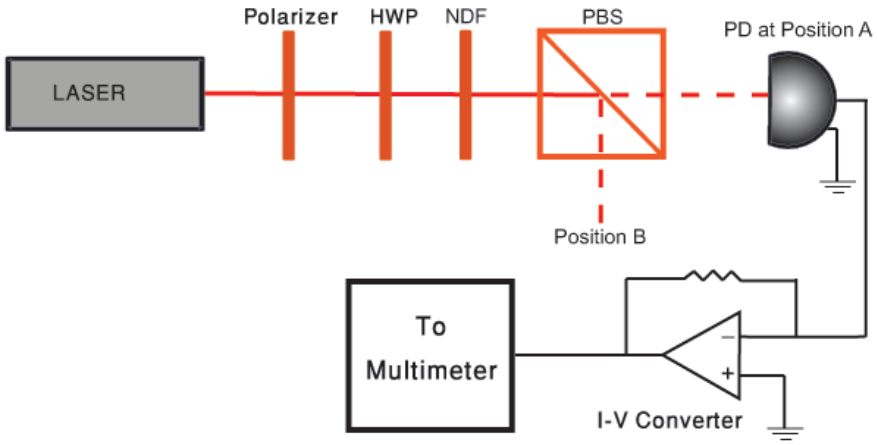

Figure 1: Setup for the polarizing beam splitter (PBS) experiment. The red line shows the perceived light path.

Q 1. For obtaining the intensity profile, what should be the normalization factor for the photodiode output?

Q 2. Plot the intensity with respect to polarization angle for the two sets of measurements. Does it match with your calculations based on Jones formalism?

Q 3. Why do we need a neutral density filter (NDF) in this setup?

Q 4. Why are we using half wave plate for producing different linear polarizations? Describe the effect of HWP mathematically.

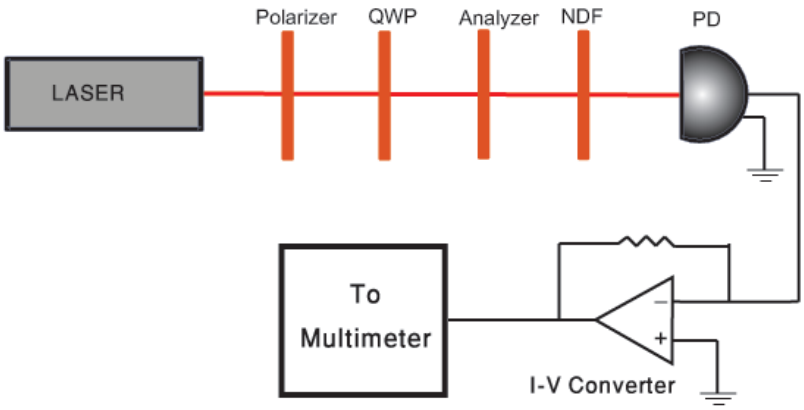

Figure 2: Setup for producing and analyzing circular and elliptical polarizations.

Elliptical and circular polarizations can be produced using a quarter wave plate. The schematic is shown in figure 2. The laser beam is first polarized and then incident upon a quarter wave plate placed at some angle α with respect to the initial polarization. Finally it passes through an analyser and falls on a photodiode.

Rotate the analyser and record the intensity profile for particular choice of α.

Q 5. Make a polar plot of the intensity and the angle of analyser. Does it match the theoretical calculations from the previous section?