Quarter and Half Wave Plates

by Jamie Quinton and Adam Blanch

Experiment Overview

This experiment involves the use of plane-polarised laser light to investigate the properties of quarter wave and half wave plates. Students measure the angular dependence of the transmitted intensity in order to determine the positions of the transmission axes of a quarter wave plate and further use this information to produce circularly polarised light from the incident linearly polarised radiation. The phase shift of 180 degrees induced by a half wave plate is also investigated in a similar manner. The major learning outcome is expected to be an understanding of the way in which altering the transmission of an electromagnetic wave along one of the axes of wave plate devices can change the polarisation of the propagated light.

It is also notable that the students who undertake the experiments in our second year physics subject do so in a Round-Robin style, and so some students will do this experiment in the middle of semester, while others will do it at the end, and thus may have differing amounts of background knowledge prior to their experience with this experiment.

Learning Experience

This experiment is one of five experiments that support the second year Physics subject at Flinders on (geometrical and wave) Optics and Lasers. It has a good scientific foundation, with results that are repeatable, reliable, and easily attainable within the three hour time limit. Students must make links between what they measure in the laboratory and abstract equations for optical retarders (wave plates) in order to achieve the experimental aims of the experiment.

This experiment was chosen for the ASELL workshop because the notes for the experiment have not been changed at all for several years and could do with improvement; including making the experiment more exciting and engaging for the students involved.

Aims and Objectives

The aims of this experiment are to observe the phase shift undergone by linearly polarised light when passed through a quarter wave plate, and subsequently the effect of a half wave plate on the same incident light. The objective of the first part of the experiment is to ascertain the positions of the fast and slow axes of a quarter wave plate, align the plate such that circularly polarised light is produced and observe that such light is unaffected by a polariser. The second part of the experiment involves the observation of the change of linearly polarised light that is inclined at some angle θ to an inclination angle of $-\theta$ upon transmission through a half wave plate.

Level of Experiment

The experiment is designed as a 2nd year lab; however students are sourced from multiple degrees and therefore have differing levels of knowledge. Therefore the lab is pitched at a more diverse audience.

Keyword Descriptions of the Experiment

Domain
Polarisation, Wave properties of light

Specific Descriptors
Laser, Optics, Polarisation, Wave Plate, Retarder

Course Context and Prerequisite Knowledge and Skills

The lab is designed for students from BSc Physics, Nanotechnology and Vision Science (B. Med. Sci.) courses. Students should have prior knowledge of laser light, polarisation, and skills in graphing and interpretation of data. Some basic mathematics is also required.

Educational Aims

The aims of this topic are focussed on building a sound understanding of the fundamentals of optics. In addition to building an experimental understanding of the basic theories in these areas of physics, students will also critically examine theoretical concepts and continue to develop their computational and visualisation skills using Mathematica; and build experimental competence and confidence through directed laboratory exercises.

Expected Learning Outcomes

At the successful completion of this topic, students will have developed a sound knowledge of fundamental optical phenomena, namely Optics and Lasers. Students will:

- understand lenses, mirrors and the background science of optical systems;
- understand the wave properties of light, such as polarisation, interference and diffraction; and
- understand the basic principles of laser devices.

Furthermore students will be empowered to solve many basic scientific problems, and will begin to develop their professional skills in critical scientific thinking and problem solving, both theoretically and experimentally.

Syllabus

Material to be taught in this topic will be selected from Optics and Lasers: Geometrical optics; Wave nature of Light; Polarisation; Interference and diffraction; Coherence; Laser Theory; Laser types; and Laser applications.

Time Required to Complete

Prior to Lab: 10 mins (prior reading)
In Laboratory: 3 hours including write-up
After Laboratory: None

Experiment History

This experiment has been in use in the topic ‘Optics & Lasers’ for a minimum of ten years at Flinders University without alteration. The original authors are presently unknown