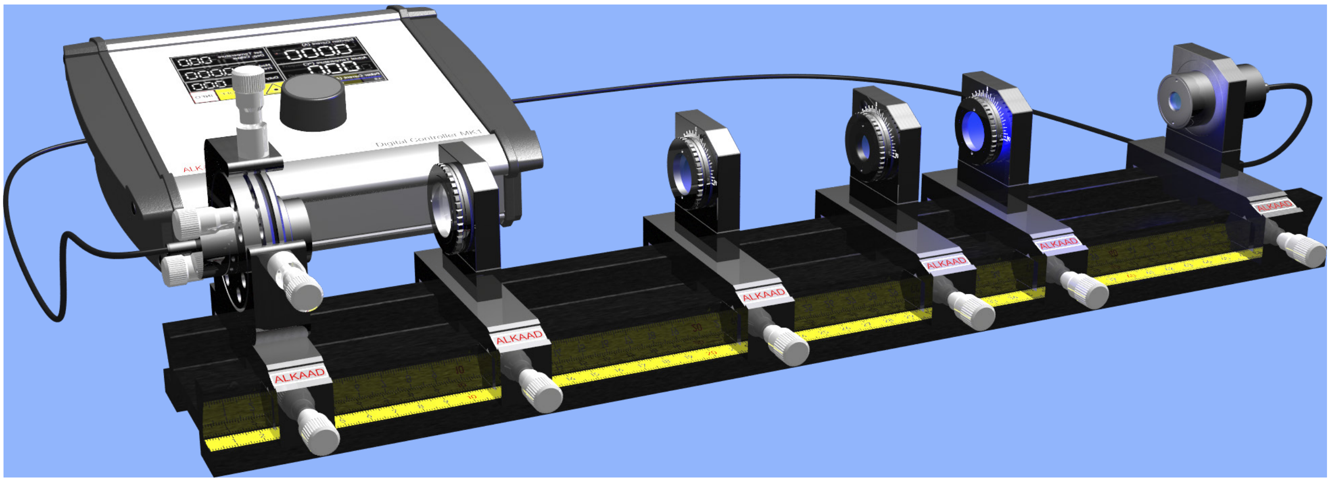
PE-0200 Polarisation of Light



Keywords

Optical Activity	**Double Refraction**	**Polarization of Light Sources**
Linear Polarized Light	**Elliptical, Circular Polarized Light**	**LED Light Source**
Green Laser	**Quartz Retarder Plate**	**Mica Retarder Plate**
Photodetector	**Light Power Control**	**Malus' Law**

Introduction

In the year 1809, Etienne Malus discovered the polarization of light by reflection and stated a law which describes the intensity distribution of polarized light as a function of the relative orientation of a polarization analyser. At that time his findings were in contradiction to the presumption of light waves being longitudinal rather than transversal. His discovery had far reaching consequences for the wave theory of light, and his unambiguous experimental results launched a big debate, among the leading scientists about the wave properties of light. Finally, as a compromise light was conceded to have transversal as well as longitudinal character. Two years later Dominique Arago investigated a sample of quartz and discovered its optical activity, a property of many natural and also synthetic materials. Later on, Augustine Fresnel could explain the effect of optical active materials on light by introducing the phenomenon of circular birefringence. In this series of experiments the polarization state of the light sources in use is determined. Furthermore, polarized light is used to prove the Malus' and Fresnel's Laws with respect to their states on polarization. The influence of crystal wave plates and optically active materials on polarization is studied.

How it works

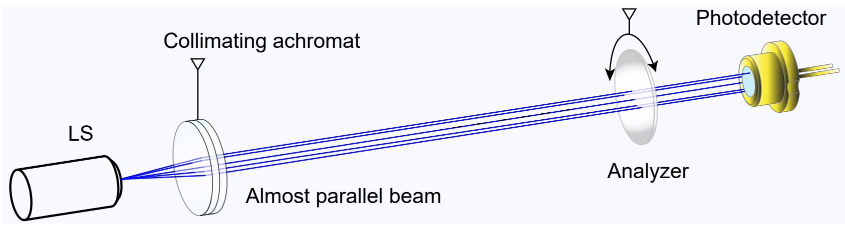


Fig. 4.7: Basic setup to measure the polarisation of a light source LS

As light source either as coherent "green" laser or a blue or white light emitting LED is used. In case of using a LED an achromat is used to form an almost parallel beam. By means of a polarisation analyser and the photodetector the intensity of the light source as function of the analyser angle is measured. As a result, three plots are created representing the polarisation of the green laser and the blue and white LED.

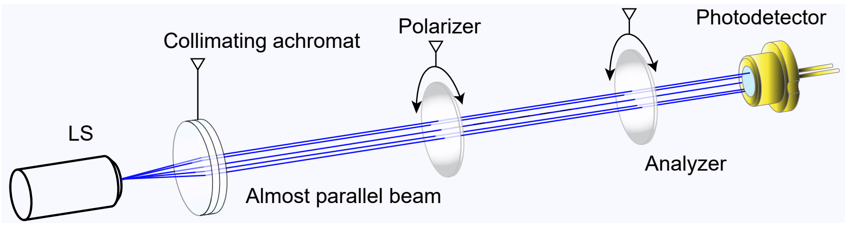


Fig. 4.8: Setup to measure the Malus's law

By using an additional polarizer the emitted light is polarised. If the analyser angle is set to 90 degrees with respect to the polarizer the passed intensity is a minimum and for 0 degree a maximum. Between these values the transmitted intensity behind the analyser is according to the Malus' law. This setup allows the verification of Malus's law and demonstrates furthermore an arrangement to change the intensity of a light source without changing the operating current.

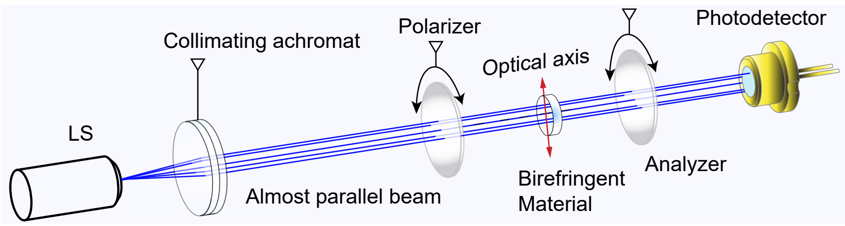


Fig. 4.9: Placing birefringent material between two crossed polarizer

Materials which change the polarisation of transmitted light are termed as optical active. Such natural materials are for instance crystalline quartz, calcite or mica. Within the frame of this experiment three crystalline plates made of quartz and mica are used. The plates are mounted in a click mount with an index mark. The plate is placed behind the polarizer and the transmitted intensity is measured as function of the analyser angle. The resulting angular intensity plot informs about the particular optical activity.

Optics Experiments

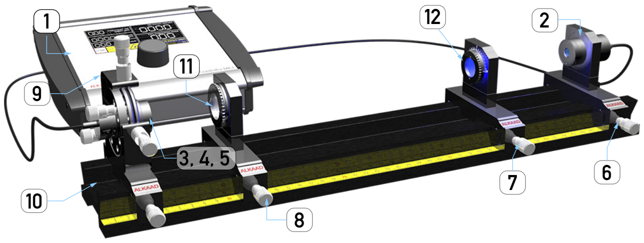


Fig. 4.10: Setup to measure the polarisation of the light source

Measurement of the Light Source

As light source either the blue (5) or white (4) or the "green" laser (3) is used. The light source is clicked into the four axes kinematic mount (9) and connected to the LED and photodiode controller (1). Each light source has an embedded non-volatile memory into which the property of the light source is stored. The information is processed and displayed by the controller (1) to ensure the operation of the attached light source within its allowed parameter. In addition, the controller contains a pre-amplifier and processing stage for the attached photodiode. The settings are selected by means of the touch screen and set by the precision digital settings knob. The measurements starts with the characterization of the light source as intensity versus injection current and versus the analyser (12) angle.

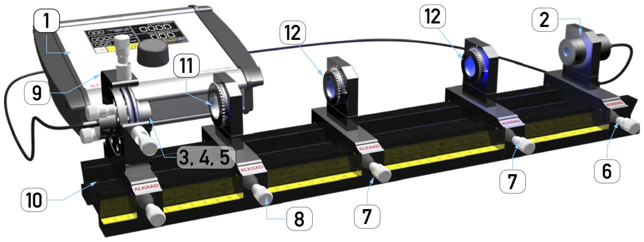


Fig. 4.11: Malus' Law and optical power control

Malus' Law and Optical Power Control

The achromat (11) is used to collimate the radiation of the LED to obtain an almost parallel light beam. To make sure that the light is linearly polarized, the first polarizer (12) is placed behind the collimator (11) and turned to maximum intensity. The second polarizer (12) is used as analyser. The transmitted intensity is measured by means of the photodetector (2) and the controller (1). A angular plot of the intensity yields the verification of the Malus' law. Such an arrangement is often used to control the intensity of a light source when the change of the emission wavelength by the control of the injection current is not desired.

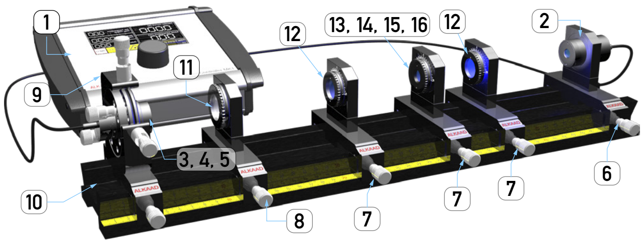
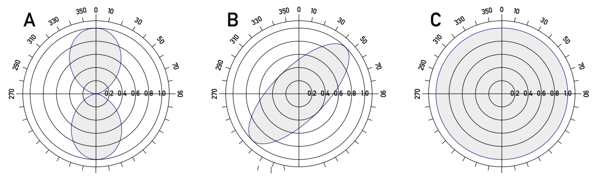


Fig. 4.12: Demonstration and measurement of optical activity



Polarisation by Optical Activity

To demonstrate the effect of double refraction or birefringence on the polarisation of the transmitted light beam 4 different optical active materials are used.

(14) Plate of crystalline quartz
(15) Quarter-wave plate made from quartz
(16) Have-wave plate made from quartz
(13) Plate of natural mica

The plates are mounted into a click 25 mount with an index mark and the mounting plate (7) provides the corresponding angle scale. The first polarizer is set to maximum intensity. The resulting linear polarised light of the light source (3, 4, 5) passes the inserted plate and undergoes a phase retardation depending on the kind and orientation of the birefringent material.

The measured results can be plotted either in Cartesian or polar coordinates. Below the Fig. 4.12 such an example in polar coordinates is shown for:

A. Linear polarized
B. Elliptical polarized
C. Circular polarized light

PE-0200 Polarisation of light consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	DC-0020	1	LED and Photodiode Controller	121 (2)
2	DC-0120	1	Si-PIN Photodetector, BPX61 with connection leads	123 (14)
3	LQ-0020	1	Green (532 nm) DPSSL in ø25 housing	118 (1)
4	LQ-0200	1	White LED in ø 25 Housing	119 (6)
5	LQ-0230	1	Blue LED in ø 25 housing	120 (12)
6	MM-0020	1	Mounting plate C25 on carrier MG20	93 (1)
7	MM-0024	3	Mounting plate C25-S on carrier MG20	93 (2)
8	MM-0030	1	Mounting plate C30 on carrier MG20	93 (4)
9	MM-0420	1	Four axes kinematic mount on carrier MG20	96 (24)
10	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
11	OC-0140	1	Achromat f=40 mm in C30 mount	99 (9)
12	OC-0710	2	Polarizer in C25 mount	102 (34)
13	OC-0810	1	Mica plate in C25 mount	103 (43)
14	OC-0830	1	Optical quartz plate in C25 mount	103 (45)
15	OC-0840	1	Quarter-wave plate in C25 mount	103 (46)
16	OC-0850	1	Half-wave plate in C25 mount	103 (47)
17	UM-PE02	1	Manual Polarisation of Light	

Highlights

Basic experiment

Intended institutions and users:
- Physics Laboratory
- Engineering department
- Electronic department
- Biophotonics department
- Physics education in Medicine