Rotation of the plane of polarization with quartz

Objects of the experiments

- Observing the rotation of the plane of polarization by quartz in an arrangement of two crossed polarizers.
- Distinguishing between right-handed, left-handed and non-rotating (i.e. cut parallel to the crystal optic axis) quartz.

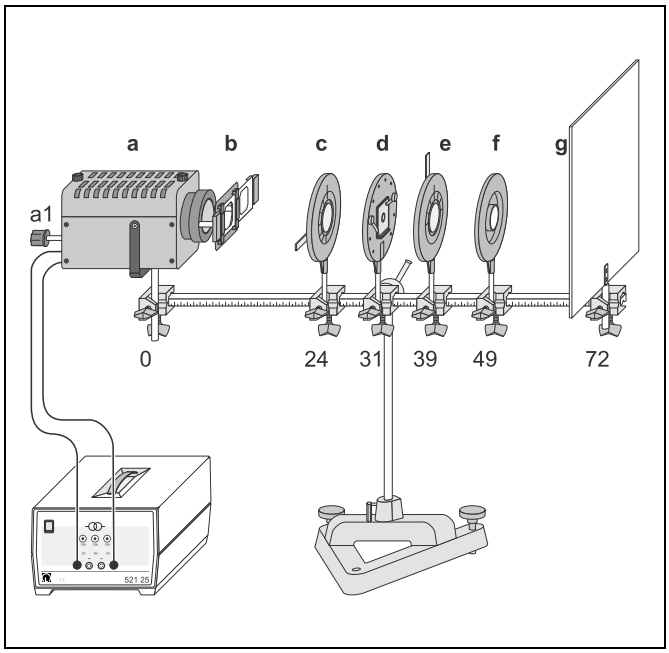

Fig. 1 Experimental setup for observing the rotation of the plane of polarization by quartz.
a Halogen lamp housing
b Light filter (in picture slider)
c Polarizer
d Quartz crystal (in holder with spring clips)
e Analyzer
f Lens
g Observing screen

Principles

If a plane-parallel quartz plate which is cut perpendicularly to a crystal direction called the optic axis is put into the ray path between two crossed polarizers, the field of view is lit up (*F. Arago*, 1811). For monochromatic light darkness is re-established if the analyzer is rotated by a certain angle α. That means the quartz plate has rotated the plane of polarization of the light by the angle α.

The rotatory power of the quartz crystal is due to its helical crystal structure, which leads to different phase velocities for the propagation of right-circularly and left-circularly polarized light in the crystal. Linearly polarized light which enters the crystal can be decomposed into a right-circularly and a left-circularly polarized partial wave. The two partial waves propagate at different phase velocities so that a phase difference arises, which is proportional to the distance covered in the crystal. After the two partial waves have covered this distance, their superposition results in a linearly polarized wave whose direction of polarization is rotated relative to the original wave. The angle of rotation α thus is proportional to the distance covered in the crystal, i.e. to the thickness *d* of the crystal.

There are right-handed and left-handed quartzes. In a right rotation the plane of polarization is rotated clockwise as seen by an observer looking in the direction opposite to the light ray propagation, in a left rotation the plane of polarization is rotated anticlockwise. As the angle of rotation strongly depends on the wavelength of the light, single-coloured light is used in the experiment.

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Apparatus

1 quartz, parallel	472 62
1 quartz, right-handed	472 64
1 quartz, left-handed	472 65
1 halogen lamp, 12 V/100 W	450 63
1 halogen lamp housing 12 V, 50/100 W	450 64
1 picture slider for halogen lamp housing	450 66
1 mercury light filter, yellow	468 30
1 transformer 2 ... 12 V	521 25
2 polarization filters	472 401
1 lens, f = + 100 mm	460 03
1 holder with spring clips	460 22
1 translucent screen	441 53
1 small optical bench	460 43
1 stand base, V-shape, 28 cm	30001
6 Leybold multiclamps	301 01

Connecting leads with 2.5 mm^2 cross section

Setup

The experimental setup is illustrated in Fig. 1.

– Mount the components on the small optical bench according to Fig. 1, where the position of the left edge of the Leybold multiclamps is given.
– Align the polarization filters so that their scales point towards the observing screen, and set them both to 90°.
– Set up the halogen lamp housing for 100 W operation (use the reflector, see instruction sheet for halogen lamp housing), and insert the mercury light filter in the picture slider in front of the exit aperture.
– Align the halogen lamp with the adjusting rod **(a1)** of the lamp housing and shift the lens on the optical bench so that the field of view on the observing screen is uniformly illuminated.
– Set the analyzer to 0° (maximum darkness of the field of view).

Carrying out the experiment

– Insert the parallel quartz in the holder with spring clips so that it is centred, and adjust maximum darkness with the analyzer.
– Insert the right-handed quartz in the holder with spring clips so that it is centred, and adjust maximum darkness with the analyzer.
– Insert the left-handed quartz in the holder with spring clips so that it is centred, and adjust maximum darkness with the analyzer.

Measuring example

Table 1: Angular position of the analyzer for maximum darkness of the field of view (polarizer: 90°)

object	thickness	angular postion
without quartz		0°
quartz, parallel		0°
quartz, right-handed	1,5 mm	+32,5°
	4 mm	+87°
quartz, left-handed	1,5 mm	-32,5°
	4 mm	-87°

Evaluation and results

Viewed opposite to the direction of the light ray, the right-handed quartz crystal rotates the plane of polarization by 32.5° to the right whereas the left-handed quartz crystal rotates it to the left.

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