Chromatic polarization

Task and equipment

Information for teachers

Additional Information

Most conventional plastic films retain lasting inherent tensions from the stretching or rolling processes they undergo during manufacture. These tensions render them optically anisotropic. Hence, the light velocity in such foils is dependent on direction, i.e., a light beam striking the surface of such materials is split into two parts known as the ordinary and extraordinary ray.
If such foils are positioned between two polarization filters, coloured images appear in the visual field behind the analyzer, in which the colours and their intensity are dependent on the mutual angle of rotation of the polarization filters, on the stretch direction of the foils and on their layer thickness.
This is the learning objective of the experiment. The students should also realize - with the aid of the film specimen (comp. Fig. 14) - that the two components, into which the incident natural light is split, are polarized in a mutually perpendicular plane and have symmetrically arranged, complementary colours.

Suggestions for Set-up and Performance

The teacher should have **suitable** plastic films ready for the experiment; not every sort of film is optically anisotropic.
We recommend letting the students make the film strip specimens prior to the experiment so that no time is wasted once the experiment begins. Once made, a set of these specimens can be saved and used again.

Remark

The statements made under points 1. and 2. of the evaluation are of a general nature only.
Prior to cutting the film strips to size, i.e. before making the strip specimen, it is imperative to determine the stretch direction of the utilized film. In the normal way this will pose no problem, as rectangular film is generally supplied with one side running parallel to the stretch direction.
The anisotropic nature of the film strips causes the incident light emerging from the polarizer to be split into two components which are polarized in mutually perpendicular planes, and at angle $\delta = 45°$ (see Fig. 15) are of the same intensity. Since these two components pass through the films at differing velocities, they display a mutual path difference Δ.
If the components are brought to interference, then - given the same intensity, i.e. $\delta = 45°$ - that colour is blocked out to which $\Delta = (2k + 1) . \lambda/2$ applies; the film appears in its complementary colour.

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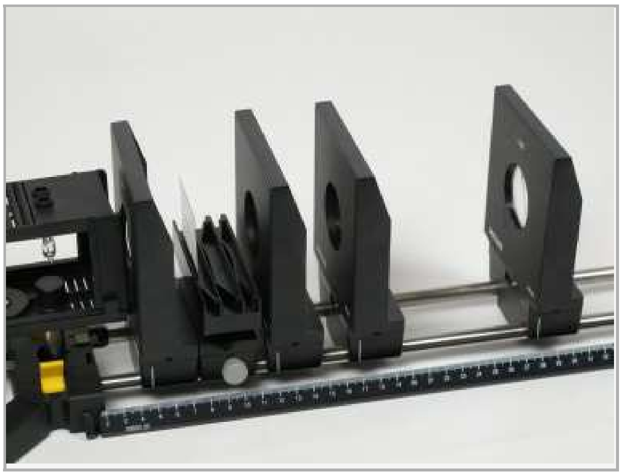
Task

How can we use transparent film to produce unusual colour effects?

Insert transparent film into the space between two crossed polarization filters and investigate the phenomena which occur when, either the foil, or one of the filters is rotated.



Equipment

Position No.	Material	Order No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Bottom with stem for light box	09802-10	1
3	Support base, variable	02001-00	1
4	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
5	Meter scale for optical bench	09800-00	1
6	Lens on slide mount, f=+100mm	09820-02	1
7	Lens on slide mount, f=+50mm	09820-01	1
8	Mount with scale on slide mount	09823-00	2
9	Screen, white, 150x150mm	09826-00	1
10	Slide mount for optical bench	09822-00	1
11	Plate mount f.3 objects	09830-00	1
12	Polarising filter, 50 mm x 50mm	08613-00	2
13	Diaphragm holder, attachable	11604-09	2
14	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
Additional material			
15	Adhesive tape		
16	Scissors		1
	Various kinds of transparent film		

Set-up and procedure

Set-up and procedure

- Set up the optic bench with the two support rods and the support base and place the scale in position (Fig. 1 and Fig. 2).

Fig. 1

Fig. 2

- Assemble the light box according to Figures 3 and 4 and clamp it into the left part of the support base with the lens end pointing away from the optic bench (Fig. 5). Insert a light-tight diaphragm into the well in front of the lens (Fig. 6).

Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Clamp the screen into the right part of the support base (Fig. 7).

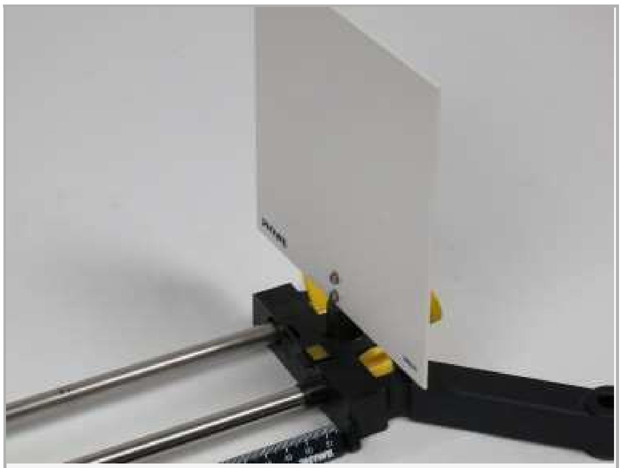


Fig. 7

- Position a lens with f = +50 mm directly next to the light on the optic bench (Fig. 8).

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Fig. 8

- Set up a plate mount with a polarization filter (polarizer) on a slide mount at approx. 8 cm (Fig. 9).

Fig. 9

- Insert a second polarization filter (analyzer) into a diaphragm holder, attach this to the scale mount so that the mark is positioned above the zero point on the scale; set up the mount at approx. 17 cm (Fig. 10).

Fig. 10

- Place a lens with f = +100 mm at approx. 28 cm (Fig. 11 and Fig. 12).

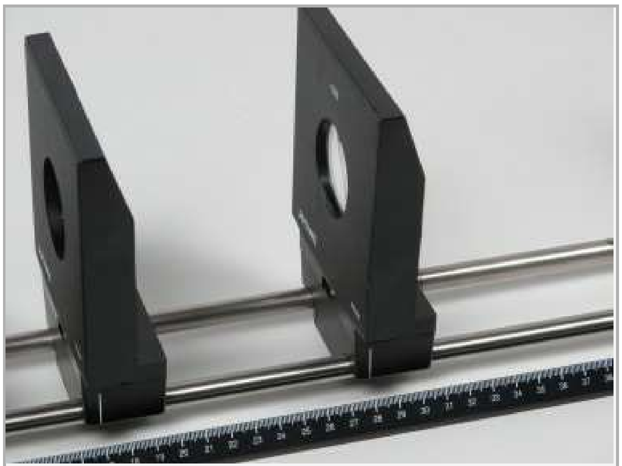

Fig. 11

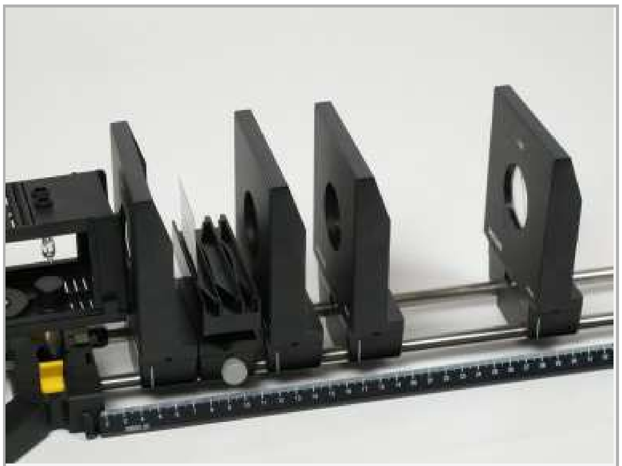

Fig. 12

- Connect the light to the power supply (12 V~) and swith on the power supply (Fig. 13).

Fig. 13

- If the polarization filters are not crossed, rotate the polarizer through 90° and then attach it again to the plate mount.
- Hold a rectangular strip of transparent film into the light path at approx. 11 cm and rotate it about the optical axis; finish up with the film at an angle of about 45° to the polarization directions of the filters. If the film is pliable enough, stretch it. Now hold a piece of crumpled packaging foil between the polarizer and the analyzer instead of the film strip. Turn the analyzer to the left and right.
- During these manipulations watch the screen and note your observations in the report (Result - Observations 1).
- For a more thorough invesigation of the observed phenomena, insert a specially prepared specimen of transparent film strips (see Fig. 14) into a second diaphragm holder, attach this to the scale mount, move the mark on the diaphragm holder to 45° and position mount at approx. 11 cm. Move either the strip specimen or the lens with f = +100 mm to focus the strips on the screen. Describe the image of the specimenin the Report (Result - Observations 2).

Remark: Figure 14 gives you an example of how to cut and overlap the foil strips for the strip specimen. In the end, the edges should be stuck together with adhesive tape to prevent slipping.

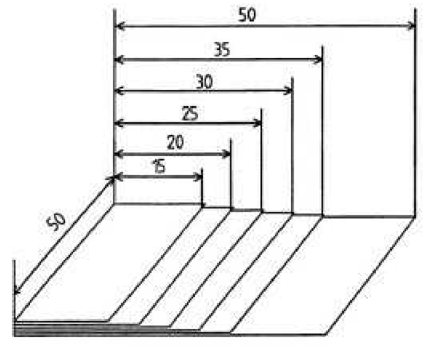

Fig. 14

- Turn the specimen through 45° to the left and right; at the same time watch the screen and note your observation in the report (Result - Observations 3). Note the colours, their position and intensity.
- Restore the specimen to its original position δ = 45° (see Fig. 15) and turn the analyzer to the left (α_l) and right (α_r); watch the screen, paying attention to the colours, their sequence and intensity, and also the rotation angle of the analyzer. Note your observation and results in the Reprt (Result - Observations 4).

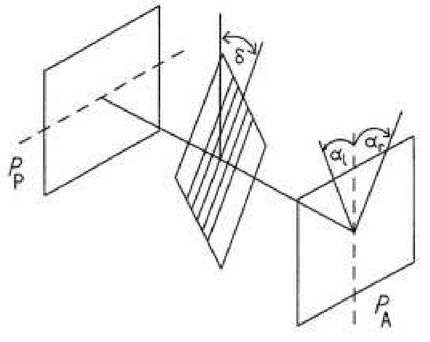

Fig. 15

- Switch off the power supply.

Report: Chromatic polarization

Result – Observations 1

Note down your observations during the turn of the analyzer:

Result – Observations 2

Describe the image of the specimen during the following part of this experiment:

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Result – Observations 3

Note down your observations during the turn of the specimen:

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Result – Observations 4

Note your observation and results during the last part of this experiment:

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Evaluation – Question 1

Try to answer the question posed at the beginning:

How can we use transparent film to produce unusual colour effects?

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Evaluation – Question 2

The observed phenomena occur because certain materials bring about chromatic polarization of the light passing through them. Natural light is split up into two components which are polarized at right angles to one another.
Summarize the results of this experiment in the light of this information.

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Evaluation – Question 3

Suggest possible practical applications for the colour phenomena observed in the experiment.

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