Related topics

Electric theory of light, polarization, polarizer, analyzer, Brewster's law, Malus' law.

Principle and task

Linear, polarized light passes through a polarization filter.
Transmitted light intensity is determined as a function of the angular position of the polarization filter.

Equipment

Laser, He-Ne 1.0 mW, 220 V AC	08181.93	1
Optical profile bench, l = 60 cm	08283.00	1
Base for optical profile bench, adjustable	08284.00	2
Slide mount f. opt. pr.-bench, h = 30 mm	08286.01	3
Polarising filter on stem	08610.00	1
Photocell, silicon on stem	08734.00	1
Digital multimeter	07134.00	1

Problems

1. The plane of polarization of a linear, polarized laser beam is to be determined.
2. The intensity of the light transmitted by the polarization filter is to be determined as a function of the angular position of the filter.
3. Malus' law must be verified.

Set-up and procedure

The experiment is set up according to Fig. 1. It must be made sure that the photocell is totally illuminated when the polarization filter is set up.
If the experiment is carried out in a non darkened room, the disturbing background current i_0 must be determined with the laser switched off and this must be taken into account during evaluation.
The laser should be allowed to warm up for about 30 minutes to prevent disturbing intensity fluctuations.
The polarization filter is then rotated in steps of 5° between the filter positions +/- 90° and the corresponding photo cell current (most sensitive direct current range of the digital multimeter) is determined.

Theory and evaluation

Let AA' be the Polarization planes of the analyzer in Fig. 2. If linearly polarized light, the vibrating plane of which forms an angle φ with the polarization plane of the filter, impinges on the analyzer, only the part

$$E_A = E_0 \cdot \cos \varphi \quad (1)$$

will be transmitted.
As the intensity I of the light wave is proportional to the square of electric field intensity vector E, the following relation (Malus' law) is obtained

$$I_A = I_0 \cdot \cos^2 \varphi \quad (2)$$

Fig. 1: Experimental set-up: Malus' law.

Fig. 2: Geometry for the determination of transmitted light intensity.

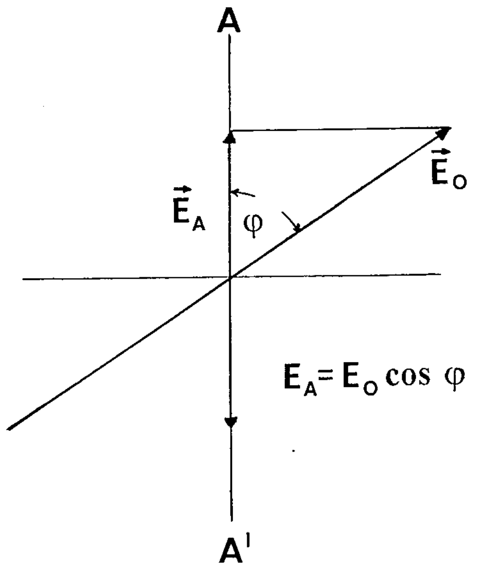

Fig .4: Normalized photo cell current as a function of $\cos^2 \varphi$.

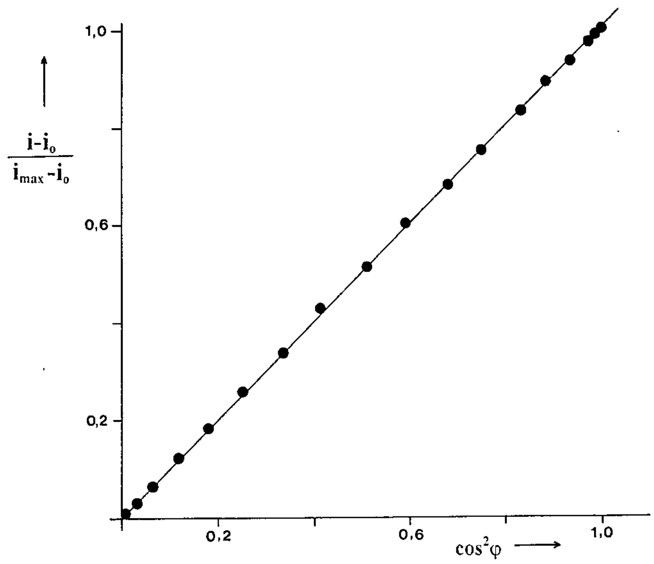

Fig.3 shows the photo cell current after background correction (this is a measure for the transmitted light intensity) as a function of the angular position of the polarization plane of the analyzer. The intensity peak for $\varphi = 50°$ shows that the polarization plane of the emitted laser beam has already been rotated by this angle against the vertical.

Fig.4 shows the normalized and corrected photo cell currents as a function of the angular position of the analyzer. Malus's law is verified by the initial line's 45° slope (Note: to determine Malus' line in Fig. 4, an angular setting of 50° of the analyzer must be considered for $\varphi = 0°$).

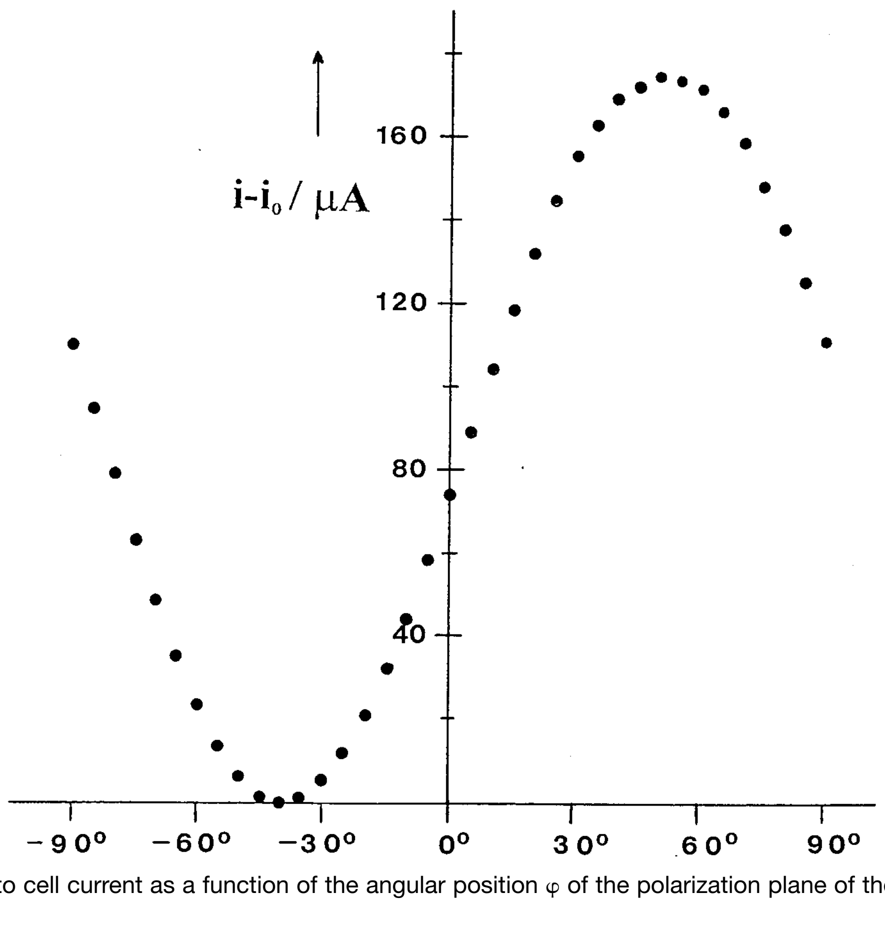

Fig.3: Corrected photo cell current as a function of the angular position φ of the polarization plane of the analyzer.