

Pockels effect

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Abstract

TODO Adjusting screw Scatter plate Analyzer Screen Laser
Oscilloscope EMF source Photodiode

$$r_0 \ r_1 \ r_2 \ \dots r_m$$

Birefringence

In materials refractive index can depend on the polarization and propagation direction of light.

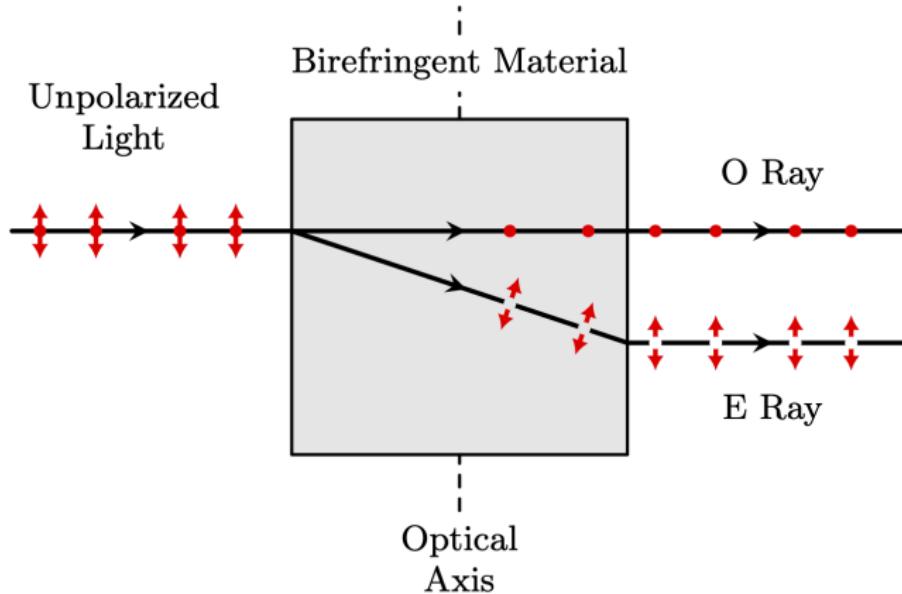


Figure: Ordinary (n_o) and extraordinary (n_e) waves scheme.

Analyzer

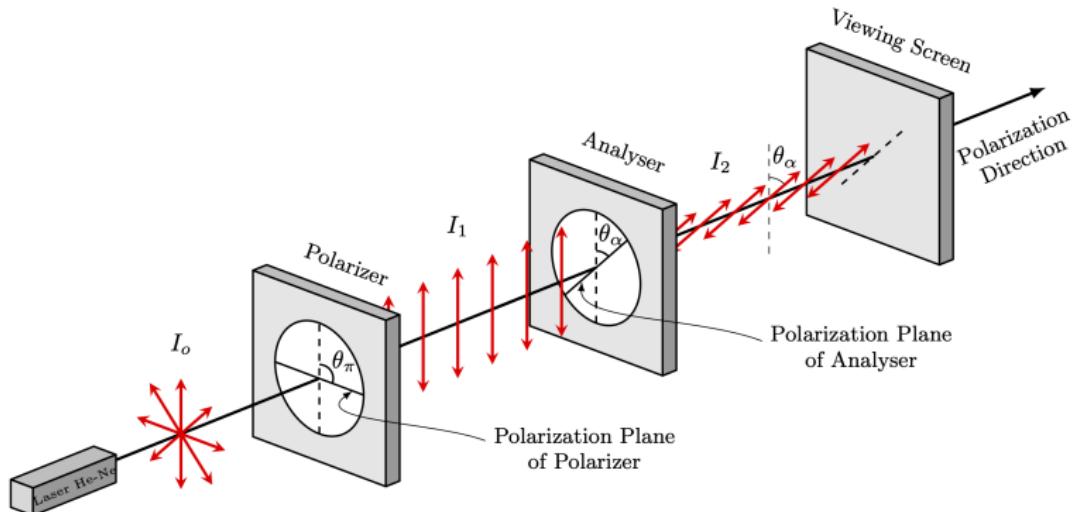


Figure: Usage of analyzer

To describe polarization, analyzer and Malus' law is used:

$$I(\theta_i) = I_0 \cos^2 \theta.$$

Scatter plate

Scattering plate

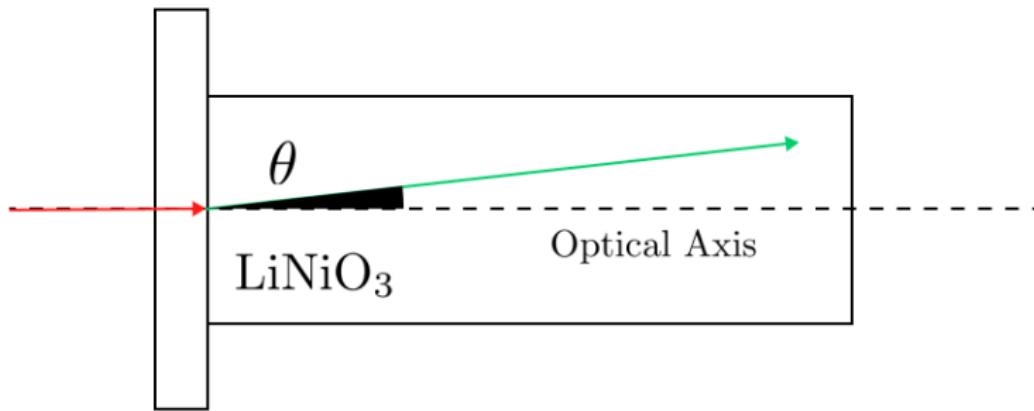


Figure: Ray propagation

Ordinary: Refractive index stays the same: $n_o(\theta) = n_o$

Extraordinary: Refractive index can be assumed from:

$$\frac{1}{n_e^2(\theta)} = \frac{\cos^2 \theta}{n_o^2} + \frac{\sin^2 \theta}{n_e^2} \implies n_e^2(\theta) \approx n_o - (n_o - n_e)\theta^2$$

Interference observation

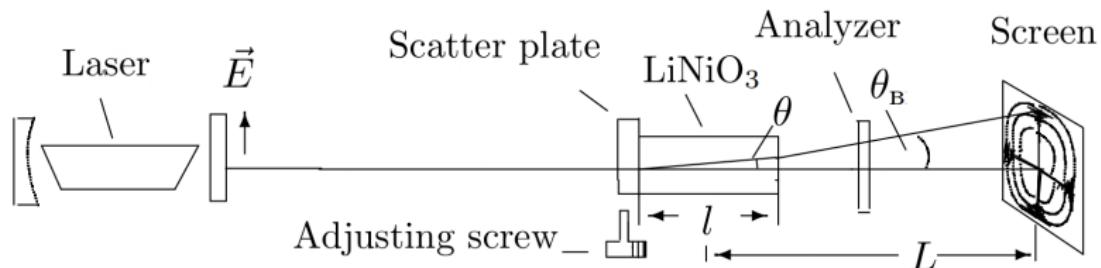


Figure: Experimental setup

Phase shift between ordinary and extraordinary waves can be estimated:

$$\Delta\varphi = \frac{2\pi}{\lambda} l(n_o - n_e)\theta^2,$$

where λ – wavelength, l – LiNiO₃ crystal length.

Conoscopic interference patterns

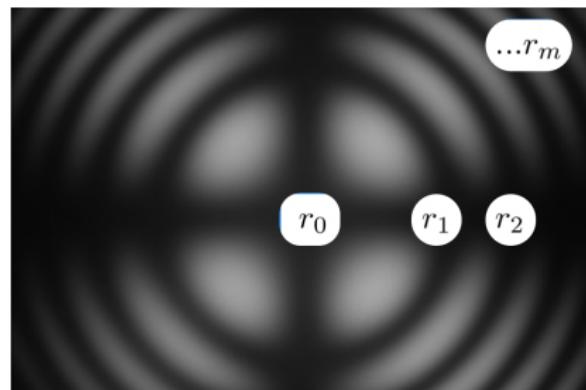


Figure: Conoscopic interference pattern with the dark "maltese cross"

The radius of the n th ring can be calculated by equating: $\Delta\varphi = 2\pi m$

$$r_m^2 = \frac{\lambda}{l} \frac{(n_o L)^2}{(n_o - n_e)} m, \quad m = 1, 2, \dots,$$

where L – distance from crystal to the screen.

Measurements and Results

Experimental setup

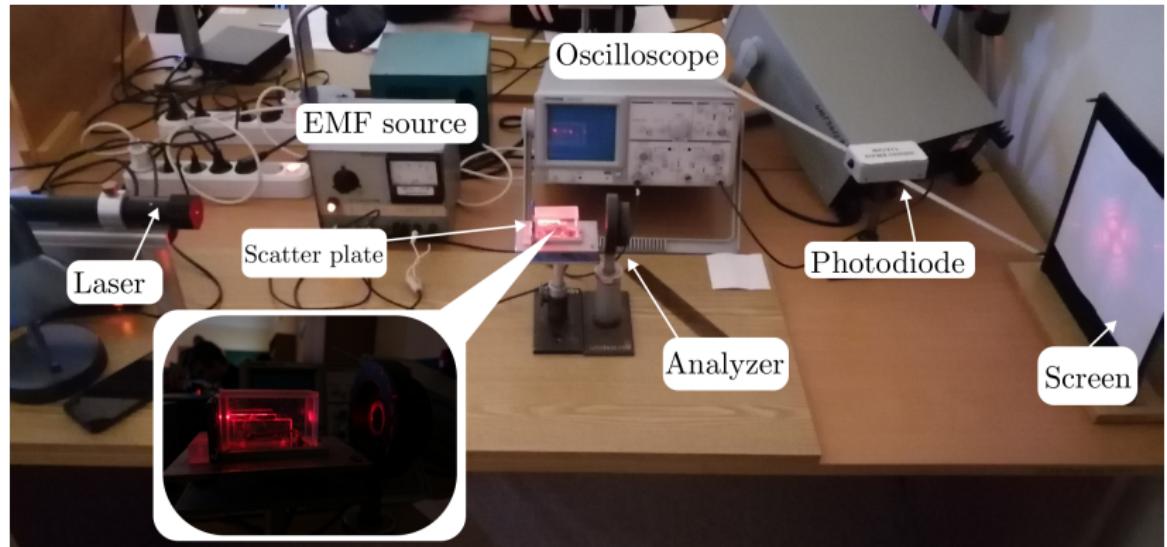


Figure: Photo of the experimental setup.

Conoscopic interference patterns

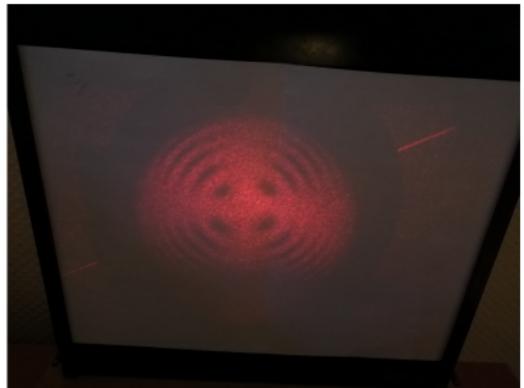


Figure: Dark (left) and light (right) "maltese cross" patterns. When the polarizer is rotated by 90 degrees, the cross pattern changes to a bright cross on a dark background.

Dark rings



Figure: Conoscopic interference patterns rings

From the series $r_m(m)$ we can calculate the birefringence difference using slope:

$$\Delta n = n_o - n_e = \frac{\lambda}{l} \frac{(n_o L)^2}{\frac{\partial r_m^2}{\partial m}} = (0.098 \pm 0.004)$$

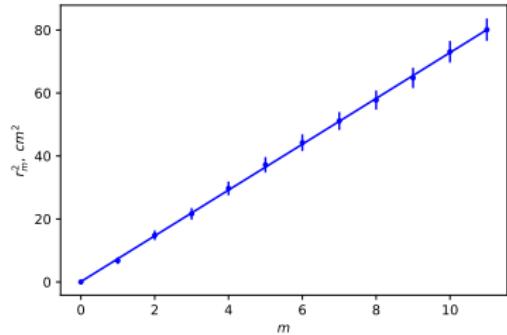


Figure: Linearization $r_m^2(m)$

Half-wave voltage

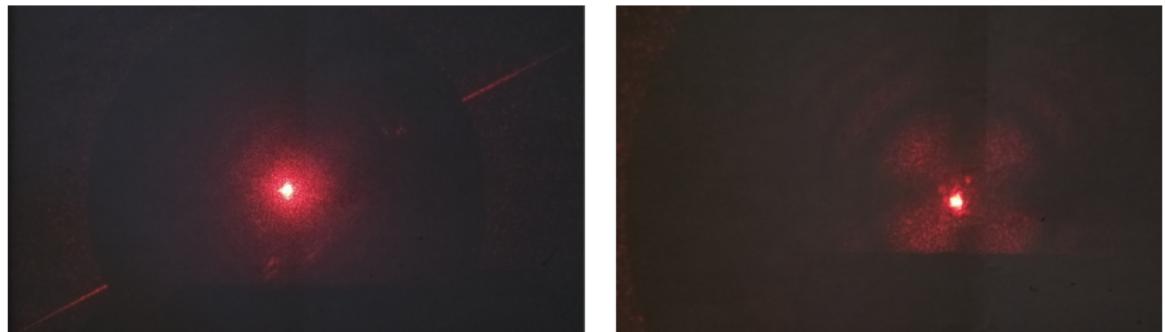


Figure: Photo of the maximum (left) and minimum (right) spot brightness observed with a change in voltage U .

	U, kV	
	$\uparrow\uparrow$	$\leftarrow\uparrow$
$U_{\lambda/2}$	0.45	0.45
U_λ	0.94	0.93
$U_{3\lambda/2}$	1.38	1.35

The error is determined both by the division value of the voltmeter and by the eye of the experimenter: $\sigma_U \approx 0.06 \text{ kV}$

Quarter-wave voltage

Oscilloscope



Figure: Photo waveforms for parallel polarizations.



Figure: Photo waveforms for perpendicular polarizations.

Results

Investigated the interference of scattered light passing through the crystal. Determined birefringence difference:

$$\Delta n = (0.098 \pm 0.004) \text{ (reference value } n_o - n_e = 0.10\text{).}$$

Observed the change in the nature of the polarization of light when an electric field was applied to a crystal. Estimated half-wave voltage:

$$U_{\lambda/2} = (0.45 \pm 0.06) \text{ kV}$$