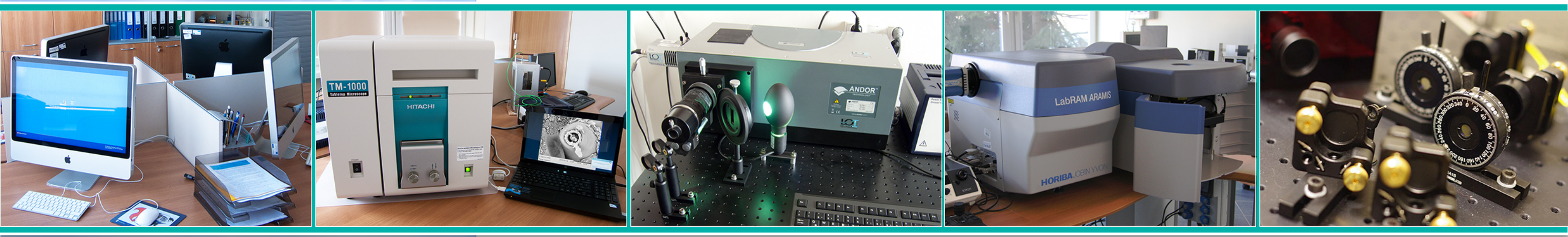
DYDAKTYCZNE LABORATORIUM FIZYCZNE

Instytut Fizyki Doświadczalnej
Wydział Matematyki, Fizyki i Informatyki
UNIWERSYTET GDAŃSKI

Experiment 32

Kerr effect in electro-optical ceramic (PLZT)

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
UNIWERSYTET GDAŃSKI
UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ SPOŁECZNY

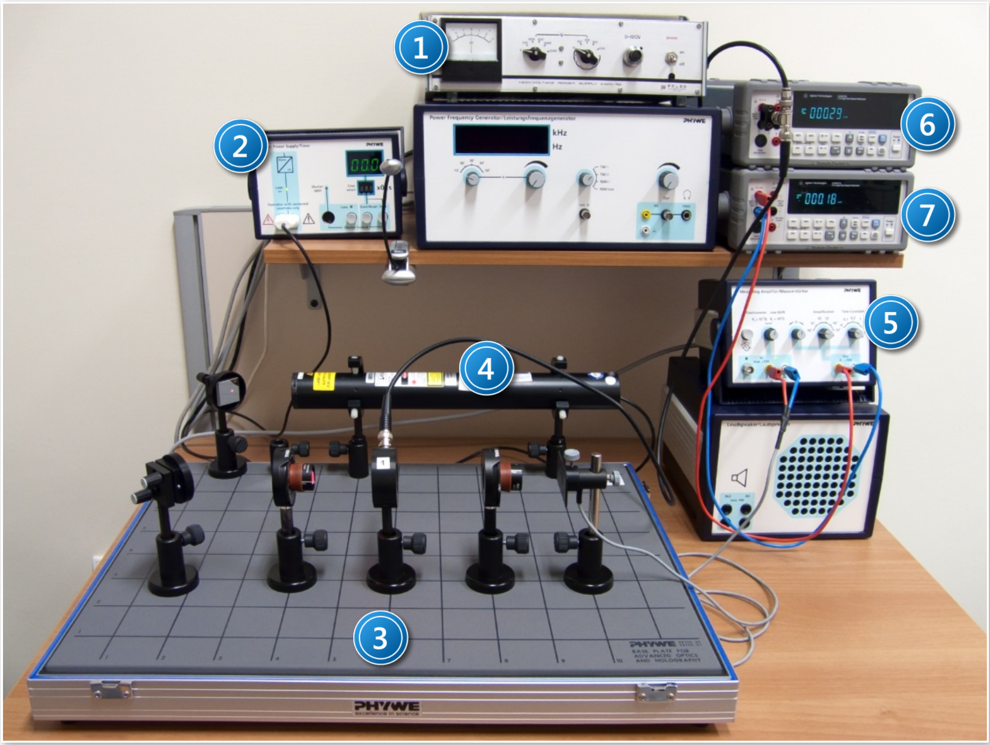


I. Background theory.

1. Electromagnetic waves and their properties.
2. Polarization of light:
   a) non-polarised light;
   b) types of light polarisation: linear, circular and elliptical;
   c) how linear, circular and elliptically polarised light is produced;
   d) Malus' law.
3. Refractive index of a medium (interpretation of the real and imaginary parts of the refractive index).
4. Bi-refringent phenomena in crystals.
5. Influence of a constant electric field on the atomic structure.
6. Quantum description of the Kerr effect
7. Kerr's law.
8. Properties of ferroelectric crystals:
   a) domain structure;
   b) ferroelectric hysteresis loop;
   c) phase transitions.
9. PLZT ceramics:
   a) structure of PLZT ceramics;
   b) optical and ferroelectric properties of PLZT ceramics.
10. Structure of Kerr cell made from PLZT ceramic.
11. Experimental set-up to study the Kerr effect.
12. He-Ne gas laser:
    a) spontaneous and stimulated emission;
    b) laser construction;
    c) active medium in an He-Ne laser;
    d) condition for population inversion;
    e) optical resonator;
    f) properties of laser light;
13. Applications of the Kerr effect:
    a) light modulators;
    b) laser technology;
    c) magneto-optical storage media.

II. Experimental tasks.

1. Refer to the measurement system shown in *Picture 1*.



Picture 1: Measuring system for observing the Kerr effect: 1 – Kerr cell power supply, 2 – laser power supply, 3 - optical Kerr cell (discussed in greater detail in Picture 2), 4 – helium-neon laser, 5 – measuring amplifier, 6 – multimeter for reading Kerr cell voltage, 7 – multimeter for reading photodiode output voltage

2. Turn on the power to the helium-neon laser (2, *Picture 1*) at least one hour before the start of the measurements. Pay attention to whether the laser shutter is open (set to "OPEN").

ATTENTION!

Kerr cell power supply voltage must not exceed 1000 V, as this will permanently damage it! Exceeding the voltage range is indicated by a beep.

3. Ensure that the directions of polarization of the polarizer and the analyser (items 3 and 5 in *Picture 2*) are **perpendicular** to each other and form an angle of 45 degrees with the direction of the electric field in the PLZT cell.
4. Ensure that the power to the Kerr cell **is not turned on** (part 1, *Picture 1*), then **reset** the multimeter display (7, *Picture 1*), using the measuring amplifier controls (1, *Picture 3*).
5. By turning the dial of the analyser (5, *Picture 2*), set the polarization direction of both polarisers **parallel** to each other. Measure the light intensity I_0 incident on the photodetector by using the multimeter (7, *Picture 1*) to record the voltage across the photodetector (6, *Picture 2*).

6. Turn the analyser knobs precisely in order to "cross" the polarization directions of the polarizer and analyser.
7. Ensure that all the knobs on the panel of the power to the Kerr cell (*Picture 4*) are set to the "0" position. If not, set the voltage to zero for each of the knobs. Turn on the power to the Kerr cell (1, *Picture 1*).
8. Take measurements of the laser light intensity I after passing through the optical system as it depends on the voltage U across the Kerr cell.
   To do this, change the Kerr cell voltage U from **0** to **1000 V** in **50 V** steps and take a reading of the voltage across the photodetector by using a multimeter (7, *Picture 1*). After each voltage change, it is necessary to wait 5 minutes before reading the multimeter indicator.
9. After reaching the maximum voltage of 1000 V, repeat the measurements, reducing the voltage from 1000 V to 0 V in steps of 50 V.
10. Plot the graph $\frac{I}{I_0} = f(U)$.
11. Record the half-wave voltage $U_{\lambda/2}$.
12. Plot the square of the Kerr cell voltage U^2 as a function of the phase shift Δ between the ordinary and extraordinary beams.
13. Determine the Kerr constant K using linear regression.
14. Compile and interpret the results of the measurements.

III. Apparatus.

1. He-Ne Laser, λ = 632,8 nm.
2. Laser power supply.
3. High-voltage power supply unit ZWN-42 POLON.
4. 2 polarising filters Glan-Thompson.
5. PLZT Ceramic Kerr cell.
6. Universal measuring amplifier.
7. 2 Digital multimeters.
8. Silicon photodetector.
9. 2 Mirrors.

IV. Literature.

1. J.H. Moore, C. C. Davis, M.A. Coplan – "*Building Scientific Apparatus",* Published in 2002 in USA by Westview Press.
2. C. Rulliere – "*Femtosecond Laser Pulses: Principles and Experiments*", Second Edition, Springer Science + Business Media Inc., 2005.
3. André Moliton – "*Optoelectronics of Molecules and Polymers*" , Springer 2006
4. H.A.Enge, M.R.Wehr, J.A.Richards – "*Introduction to Atomic Physics*", Addison-Wesley Publishing Company 1972.
5. W.A.Shurcliff, S.S.Ballard – "*Polarized Light*", D.Van Nostrand Company, Inc., Princeton 1964.
6. R.P. Feynman, R.B.Leighton, M.Sands – "*The Feynman Lectures on Physics*", Addison-Wesley Publishing Company, Inc.
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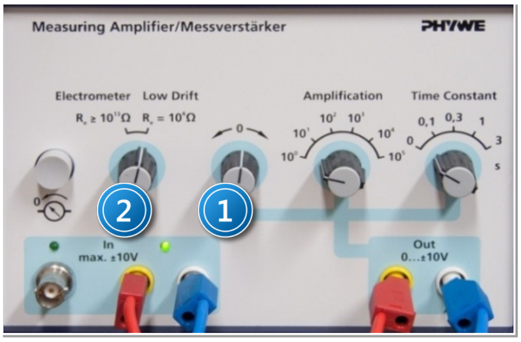
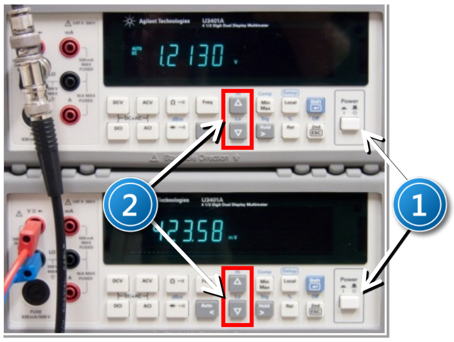
Appendix

Pictures of the experimental layout for measuring the Kerr effect

Picture 2. Kerr cell optical set-up: 1 – Helium-Neon laser, 2 – mirror, 3 – polariser, 4 – Kerr cell, 5 – analyser, 6 – silicon photodiode



Picture 3a. Measuring amplifier control panel: 1 – zero-output calibration dial, 2 – operating-mode dial (should be set to "Low Drift")



Picture 3b. Multimeters to measure the voltage across the Kerr cell (top) and the silicon photodiode (bottom): 1 – power switch, 2 – buttons to decrease and increase the range of reading devices

Picture 4. High-voltage power supply control panel "POLON ZWN-42", to power the Kerr cell: 1 – power switch (before turning on power, make sure that the knobs are set to "0"!), 2 – control LED, 3 – coarse adjustment knob with increments of 500 V, 4 – coarse adjustment knob in increments of 100 V, 5 – fine adjustment knob ranging from 0 to 100 V