Multimedia in Physics Education

A Video for Teaching on „Birefringence and Polarization in Calcite“

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Abstract:
Starting from a phenomenological observation we systematically examine and analyze the double diffraction in the video on “Birefringence and Polarization in Calcite”. The movie conceived for teaching presents a vivid linkage of real experiment and theoretical knowledge from the textbooks.

Presently, Birefringence is not a standard experiment in lectures at university. Thus, the presentation is limited to textbooks. Currently, only two videos on the topic can be found. Both only show the phenomenon of double diffraction and surrender further analysis [1].
The experiment “Birefringence and Polarization in Calcite” examines the direction dependency of the velocity of propagation of light in non-isotropic crystals. Basic concepts are introduced and polarization of light-bundles is investigated.

The intention of the movie, produced at the University of Kaiserslautern is to study the birefringence in calcite systematically. Furthermore it explains the results theoretically, starting from an introduction that corresponds with the figures in textbooks [2].

Fig. 1: Phenomenological introduction

In the beginning, the video establishes the phenomenological view of the double diffraction (Fig. 1).
Thus it ties in with the textbooks and offers descriptive and motivating access.

The experimental setup is revealed with stop-motion technique (Fig. 2).
So, all components are presented step by step and explained in their functionality. In doing so, the viewer can access the experiment easily. Each component of the setup is shown enlarged and thereby easy to identify.

Fig. 2: Setup (f.l.t.r.: Hg-spectral-lamp, aperture plate, calcite-crystal, analyser)

Starting with a side view of the setup (see Fig. 2), a camera pan, which reveals a view through the analyzer, follows, showing the correlation between setup and result.
One recognizes, that only one light-bundle is entering the calcite, but two are leaving.
The first noted result is the splitting of the light inside the crystal.
Next, the polarization of the leaving beams is analyzed.
Therefore, the analyzer is rotated until one, then the other light-point disappears. The according angles are noted graphically. (Fig. 3)
The light intensity changes depending on the angle of the analyzer.

At the end of the analysis, performed in the video, the right-angled polarization of the light beams with respect to each other is displayed (Fig. 3).

To help the viewer to understand this result, the important terms *principal axis*, *ordinary* and *extraordinary ray* are illustrated by laying transparent, three-dimensional drawings over the calcite-crystal used in the experiment (Fig. 4).

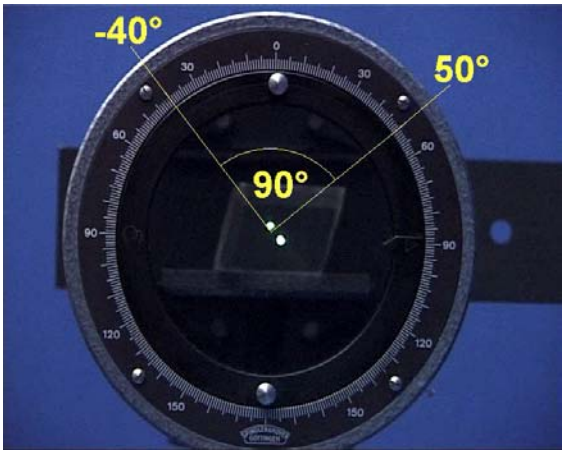

Fig. 3: Polarisation of the light beams in correlation

These abstract definitions are then transferred back to the experimental setup, helping thereby the viewer in understanding and further interpreting the findings (Fig. 5).
Finally the observations are summarized and the final statement established:

- Splitting of the light in two beams
- Ordinary and extraordinary ray are diffracted differently
- Right-angled polarisation of the light beams with respect to each other

⇒ The propagation of light is dependent on the direction of polarisation

The video experiment provides the complete procedure from observation of birefringence, the presentation of the experimental setup to the analysis of the phenomenon and systematic investigation.

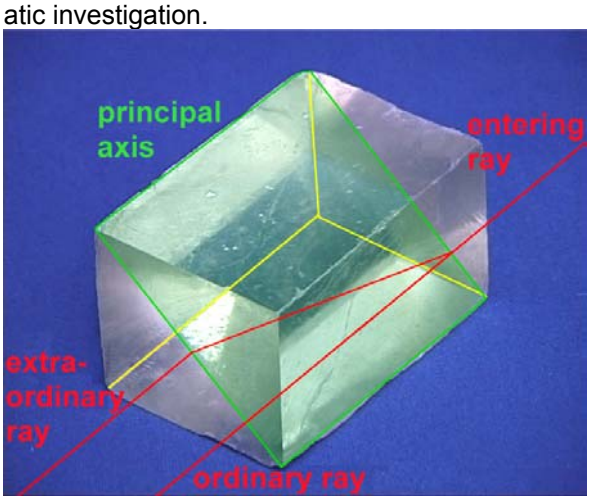

Fig. 4: Explanation of principal terms

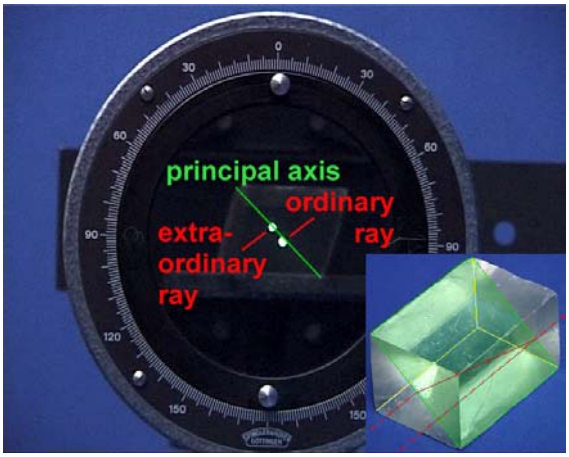

Fig. 5: Principal terms of the experiment with inserted calcite (see Fig. 4)

Thereby, the video is more demonstrative then static pictures in textbooks and furthermore it is able to point out terms and correlations theoretically and practically. With this video the dependence of light propagation and polarization is examined.
The video can be used in lectures and also in self-studies. Depending on its embedding in a teaching environment, it can be used at school and also in beginners´ courses at university.

For additional information about this and other multimedia please see the internet page of PEN (Physics Education Network, http://pen.physik.uni-kl.de). See "Informationen / Unterrichtsmaterial".

Literature:

[1] e.g..:
a) Nave, C.R.: Hyperphysics, Department of Physics and Astronomy, Georgia State University, http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/biref3.html
b) Higatsberger M.J.: Physik in 700 Experimenten, Experiment 675, Institut für Experimentalphysik, Universität Wien, http://mailbox.univie.ac.at/~higatsm4/higatsberger.html

[2] Compare for example:
a) D. Halliday, R. Resnick: Physics, 4th extended Edition, New York: John Wiley & Sons, Inc., 1992
b) Gobrecht, H. (Hrsg.): Bergmann – Schäfer – Lehrbuch der Experimentalphysik, Band III: Optik, 8. Auflage, Berlin: Walter de Gruyter , 1987.
c) Meschede, D.: Gerthsen Physik, 21., völlig neubearbeitete Auflage, Berlin: Springer, 2002.