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On-line Multimedia Support for Student Experiments in Ferroelectric Physics

The presentation gives an example on how expression media such as images, pictures, video stream and plain explanations can support a teaching process in experimental physics. Our on-line site aims to support studies of the spontaneous polarization in ferroelectrics prior to the experimental work students are to do. The method that the students can learn and see earlier what they will be undergoing at the laboratory is suitable also for other experimental branches. With a minor modification, such multimedia sites can be used in a long-distance teaching.

Introduction

Applied science is a specific matter in a teaching process. It covers a theory explaining particular phenomena and observations of the particular phenomena. Typically a teacher requires that a student can do and can understand both (Fig.1). Most physics experiments are really exciting, some of them are difficult, and some a little bit abstract, but all are very educational.

Fig. 1. General physics laboratories and lecture halls
at the Wroclaw University of Technology (Wroclaw).

There are two methods of combining of an experiment and a theory in the teaching process. One assumes a heuristic approach, i.e. some kind of trial-and-error experimental methods which are excellent for the initial state of a knowledge discovering [1]. The other is based on an honest theoretical background prior to experimenting. The other method is recommended for an advanced studying of the nature [2]. Since we are concerned with physics teaching at the university level we adopt the second method. A comprehensive theoretical basis is given to our students before they start laboratory experiments. This can be accomplished by listening to plain lectures, reading of academic books, and surfing through the Internet. This article describes the last medium used for our ferroelectric physics laboratory (Fig.2).

Fig. 2. Ferroelectric physics laboratory in the Institute of Physics,
Wroclaw University of Technology (Wroclaw).

Why www?

Since 1992 when Tim Berners-Lee invented the hypertext markup language and the hypertext transfer protocol the www platform has become the widest plane for global publications, available in a large scale from anywhere connected to the Internet. Therefore we have chosen the www platform as a center for our teaching compilations prepared for students. Students prefer to read an Internet document than to go to a library (guess why). So this lazy nature of a human being must be focused on easily accessible laboratory instructions. This article is to describe an instance of it.

On-line instructions manual

The instructions should prepare a student to carry out a research experiment individually. This means it should explain theoretical aspects of the observed phenomena, it should also describe a measurement method, as well as relevant expectations. We demonstrate an on-line instructions manual for an exemplary experiment on the spontaneous polarization in ferroelectrics (Fig.3).

This exemplary instructions manual can be viewed in the site:

http://www.if.pwr.wroc.pl/dydaktyka/ferroelektryki/polarization/

Its content is divided into four sections:

1. Theoretical background
2. Measurement
3. Tasks
4. Results

There is a cross-navigation system between the sections.

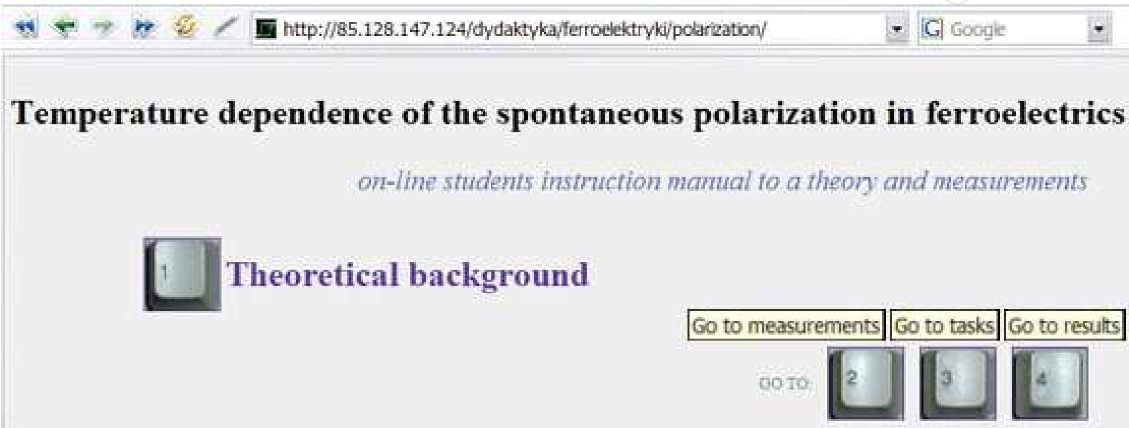

Fig. 3. The page top with the navigation buttons (with helpful tooltips).

The theoretical background has an explanatory character and is constructed to be as simple as possible. Omitting burdensome derivations from the Landau theory, a simple equation for the free energy of the crystal is meant to be solved:

$$\Phi = \Phi_0 + \frac{1}{2}AP^2 + \frac{1}{4}BP^4 + \frac{1}{6}CP^6 + \ldots - EP$$

Φ_0 is the free energy of the paraelectric phase,
A, B, C are the development coefficients.

Under zero field (E=0) the minimum of the free energy is to be discussed while the derivative is equal to zero:

$$\left.\frac{d\Phi}{dP}\right|_{E=0} = 0$$

$$P = P_s \text{ at } E = 0$$

Therefore a student gets P(T) relation (Fig.4) after some artless mathematical transformations.

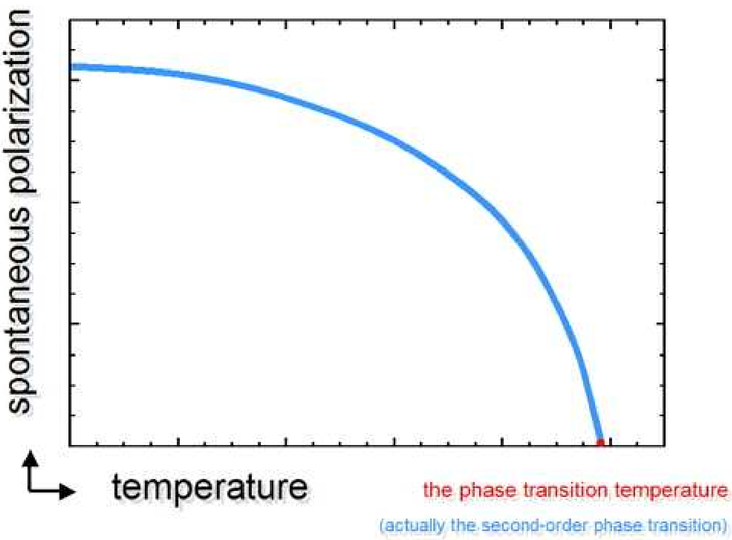

Fig. 4. A solution of the minimum of the free energy for ferroelectrics.

The next section describes how to measure the polarization (a temperature measurement seems to be trivial). The polarization can be measured either by the Sawyer-Tower method [3], or by the Diamant-Drenck-Pepinsky bridge [4]. The other is faster and is easy to be performed as a classroom experiment. So the DDP method is used and described in details (Fig.5).

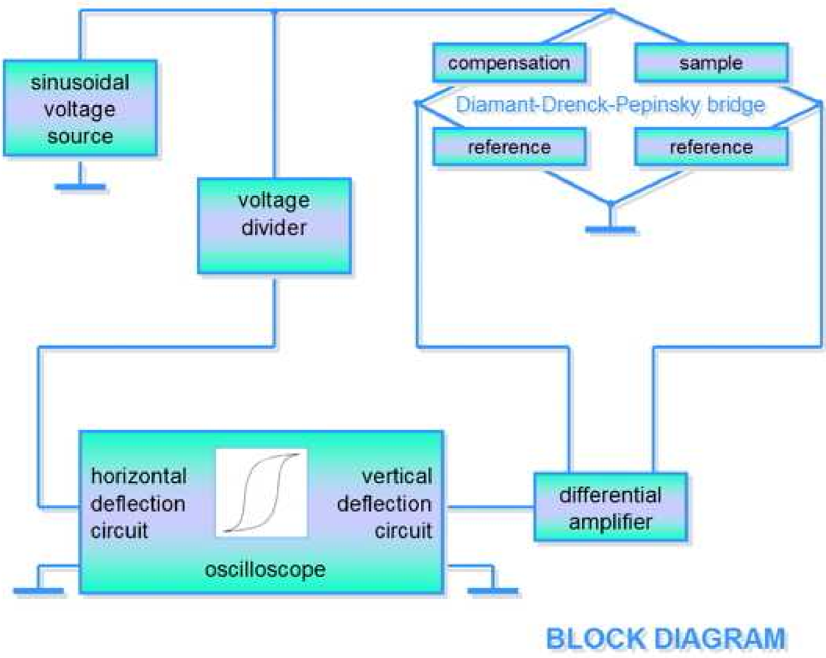

Fig. 5. Block diagram of the DDP method.

In effect a student can observe a hysteresis loop (Fig.6) on the oscilloscope screen (Fig.7).

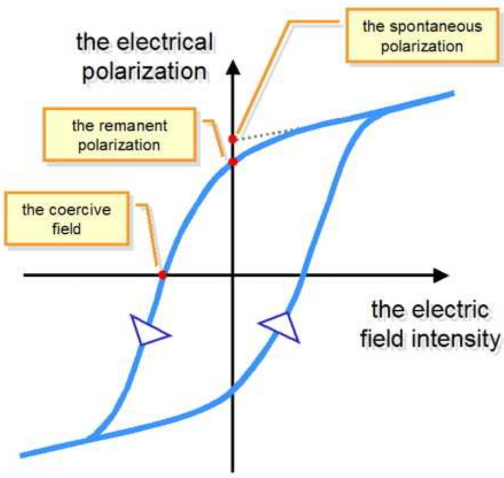

Fig. 6. A hysteresis loop of P(E) for ferroelectrics.

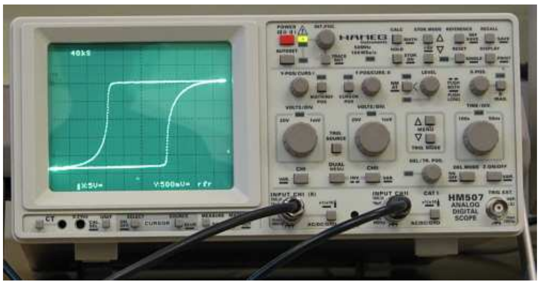

Fig. 7. A hysteresis loop on the oscilloscope screen.

The whole measurement system is computerized and easy to work with, but at first contact it is dreadfully unknown to students. So to make it more friendly and easy there is a video stream on the web showing the setup on operation. The other video displays a hysteresis change with the changing temperature, i.e. the goal of this experiment. Both videos are prepared in the flash technology (Fig.8) which is compatible with most internet browsers.
In our opinion an implementation of videos (with sound), pictures, diagrams and text explanations is much more helpful than a plain chapter in a handbook!

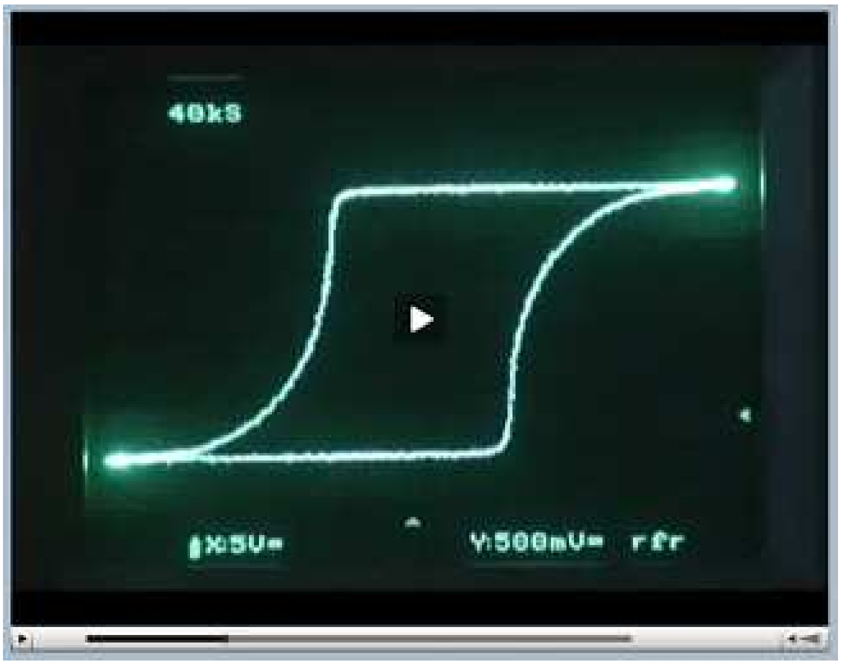

Fig.8. Screenshot of the video interface used in the on-line manual.

The next two sections describe what is expected to do (to measure) and how results should be processed to successfully complete this laboratory.

Conclusions

It was shown that expression media such as images, pictures, video stream and text explanations can support a teaching process in experimental physics which is not easy to be taught. Our exemplary on-line manual supported studies of the spontaneous polarization in ferroelectrics prior to the experimental work students were to do. The method that students can learn and see earlier what they will be undergoing at the laboratory is suitable also for other experimental branches. With a minor modification, such multimedia sites can be used in a long-distance teaching [5].

Literature

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