Optics study and research by computer aided training

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ABSTRACT

The engineering education in optics needs new computer aided methods, to increase the information in this field and to facilitate thus the students work.

We organized in our computational laboratory two workshops in flexible computer aided learning and interactive physics. Packages of the CUPS series and Interactive Physics simulations were exemplified.

Teachers, researchers, students, engineers and technical staff participated in; the interest of the participants was remarkable, and it materialized in two new research projects, involving the "Politehnica" University, the Research and Technology Ministry and the "MATPUR" Enterprise of Pure Materials.

Keywords: engineering education in optics. computer aided learning (CAL), interactive physics

1. INTRODUCTION

New models of the work with students, which redefine the teacher's role, began to be used in many universitary and research environments. The idea to use the computers facilities in education is world-widely extended, combining both traditions and new methods.

The paper deals with the impact of some interactive and flexible software for teaching and learning, and also for research in optics.

We organized two workshops, in which some CUPS and Interactive Physics packages were presented and used by people belonging to the university, gymnasium, research, and business fields.The workshops were open to everyone who whishes to learn about these facilities, independently of one's previous educational background.

2. SOFTWARE CAPABILITIES

The programs include calculations, graphical representations, animated displays, numerical output of models of physical systems.

The Optics package we exemplified on this occasion contains: Interference and Diffraction together with their applications, Ray Tracing in Geometrical Optics with applications in Optical Fibers for example, Fourier Analysis, Modes, Pulse Propagation, Transient and Nonlinear Phenomena, Multilayer Films, etc.[1]

There are texts and accompanying diskettes covering these problems. One can use them together or run the programs without reading the text. The programs have been written in the Pascal language, and adapted for both PC and Macintosh platforms. The possibility to slow down or speed up the program that uses animation is included. To install the programs, they must be copied onto the hard driver of the computer. Both the keyboard and the mouse can be used. All input screens should have a set of default values entered for all parameters, easily to be changed. The user is also allowed to enter expressions of one or more variables, evaluated by the program; the function parser can recognize many functions. They are also available for the users who wish to use them for their own projects.

In the beginning,, the main screen will display the respective program behind an introductory help screen. Along this screen top we find the MENU. After choosing a menu option, an Input Screen appears. This allows the user to enter parameters for the program; it has data windows with default values which can be changed.

The proposed exercises refer to the programmes use; there are also some propositions to modify the initial program for completely new situations. Also new running regimes can be simulated:

-wavepackets for classical wave equations, with or without dispersion;

-linear or nonlinear solutions (solitons).

One can use such a software for making calculations by entering real data collected from experiments One can use them both for demonstrations and for one's own work.

New useful packages in optics, laser and optoelectronics occured. They are also useful for the research staff, to test new experimental situations and to compute the results of some new models, before proposing them.

3. EXAMPLE WITH THE REFRACTIVE INDEX OF A GAS MEASUREMENT

The Michelson interferometer has many applications, among them being the refractive index of a gas measurement. A cell is placed in one arm of the interferometer and this cell is emptied; then a fringe system appears. When the gas enters the cell, the optical path in this arm will increase. As this change is of $\lambda/2$, one new fringe will be created in the field of view.

By counting the number of fringes that pass over a given point, as a function of pressure, the refractive index of the gas can be calculated.

In this case, the Input Screen is used to select the interferometer parameters. There is a default gas, the air, having an assumed known refractive index. We selected the following options: Michelson; Spectrum; Configurations (File); Change colours; Black/white to obtain the screen as presented in Fig.1.

Generaly, the window shows the fringe pattern in the field of view as a function of the pressure as it increases from zero to approximately one atmosphere; this rate can be changed (slowing down or speeding up), started or stopped. The final pressure is determined by the rate that the program run; the default rate will give a final pressure of exactly 760 mm Hg. The refractive index value is calculated from the cell length and the mirror travel distance. It is conventional to quote an index relative to one standard atmosphere. The parameter values and the gas in the cell are indicated on the screen.

The Michelson interferometer can be used also to measure the refractive index of a solid.

Other interesting examples are related to the computation of some parameters of an optical fiber (step index and graded index fiber) or for thin and thick lenses. The fiber parameters can be varied and the modal dispersion effect illustrated for a given input pulse.

These software are valuable for basic training in Optics, enhancing the understanding, retraining, requalification when social changes claim a redistribution of the human potential.

In the future, one can choose the appropriate teaching manner or learning manner, by selecting the appropriate software.

Even in this stage, new interesting and useful for physics learning products occured[2].

4.RESEARCH WORK OF TEACHERS AND STUDENTS

The use of these software gave to people a new competence, which creates the possibility to perform new agreements with the participants belonging to certain enterprises. We have written together with people from MATPUR - S. A. - Bucharest, some proposals for common scientific research projects, to be financed by the Ministry of Science and Technology and Ministry of Education. As topics of these agreements we have, for example, the semiconductors and organics characterization by optical and nonlinear optical methods; materials for the IR optics; nonlinear optics of the vitrous materials, dopped with semiconductors; optical tarnsmission in IR and UV-VIS, the results being of common use. The students participation in such a research work is performed by graduation projects.

Another platform concerns the study of injected signal nonlinear systems (bistable systems, harmonic generators, superradiant devices, optical delay lines, etc.) and systems with modulated parameters.

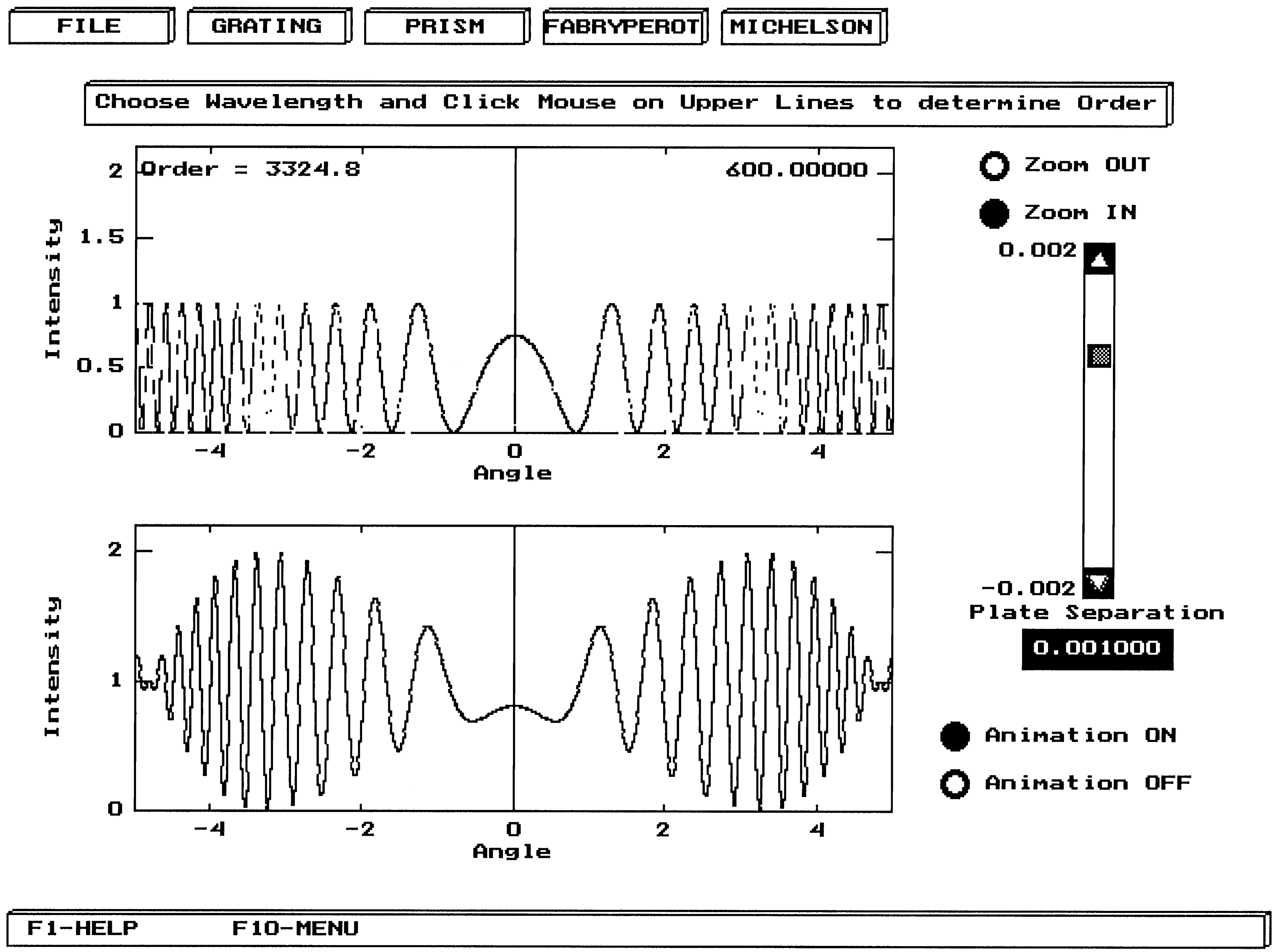

Fig.1 Michelson-Spectrum

Investigating the transitions "old structure-instable structure-new structure", an essential role is played by the instabilities due to external parameters modification (control parameters) and the additional noise, spontaneously created in the systems; the fluctuations determine the mean values of the new macroscopic state (order by fluctuations).

The study of such cooperative behaviour shows that the "symmetry breaking" in the quantum optical systems cannot be outside the concepts of "optical and atomic coherence", which imply self-organisation, the cooperative optic phenomena being synergetic.

Thus, besides the advanced quantum optics and opto-electronics researches, in order to carry out these themes we have to use special software, permitting the initial parameters modification, and lots of calculations and iterative procedures, specific to nonlinear equations[3].

5.CONCLUSIONS

Flexible programs represent the first step for training by online materials from different traditional universities offered by comunication services.

Our intention is to cooperate in order to develop new computer based course materials, in General and Technical Applicative Physics and especially in Modern Optics. New modern tools, a multimedia station, more performant computers, computer controlled experiments are planned as future investment of the department funds.

Also new future ways to cooperate were established with the Swedish-Romanian participation, concretised in a grant awarded by the Swedish Institute at Kungliga Tekniska Högskolan (KTH)-Optics Research Institute, Stockholm, for a Romanian scientist and a TEMPUS Individual Mobility Grant proposal to develop course material in Modern Optics, by using CAL methods, at the same institute (KTH).

We have in vue to strengthen the cooperation between "Politehnica" and KTH also by a future students and faculty exchange, by using the experience and help of the Internationalisation Program at KTH.

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