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A MICHELSON INTERFEROMETER FOR A VIRTUAL LABORATORY

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SYNOPSIS

We report on a simulation of a Michelson interferometer which has been developed as a first step on a more ambitious project to implement a complete Virtual Laboratory (Lawenda *et al*, 2004) at FEUP. Two different simulations have been developed. A schematic one in 2 dimensions and a more realistic one in 3 dimensions. Those simulations are being used to teach students the principles of the Michelson interferometer and to help them become familiar with its setting and usage. They are also a good way to motivate students, since they allow some interactivity with the user. Students can explore freely, without the fear to break down some expensive equipment, at anytime and from any computer with Web access.

INTRODUCTION

The Michelson interferometer (Serway *et al*, 2005) can be used in several fields of Engineering and Science, to measure micro-displacements. A laser beam is split into two perpendicular beams, which after reflection on two plane mirrors are projected to the same point in a screen (figure 1). The interference among the two beams generates a pattern of clear and dark fringes. When one of the plane mirrors is displaced a distance equal to one quarter of the laser's wavelength, the distance travelled by that beam increases in half a wavelength, and the clear fringes move to the position of the nearest dark fringes.

Counting the number of clear fringes that pass through a point in the screen as the mirror moves, each fringe counted will correspond to a displacement of the mirror equal to one half of the laser's wavelength. The laser we use at FEUP is a ruby laser, with a wavelength of 694 nm. Thus, we can detect displacements as small as 347 nm.

RESULTS

The 2-dimensional simulation of the Michelson interferometer (figure 1) has been used to explain the working principle of the interferometer and light interference in general. It has been implemented as a Flash animation that can be plugged into a Web page.

The 3-dimensional simulation of the interferometer (figure 2) was developed in C++ language, using the OpenGL graphic libraries and it will run in all major operating systems. This simulation gives a very realistic picture of the real interferometer and it allows several changes by the user, in real time: moving the point of view, adjusting the angle of the splitting mirror, changing the position of the moving mirror, changing the laser's wavelength, putting a lens on the laser beam to simulate a point source with interference circles instead of fringes, turning the room lights on or off and introducing some fog to see the laser paths.

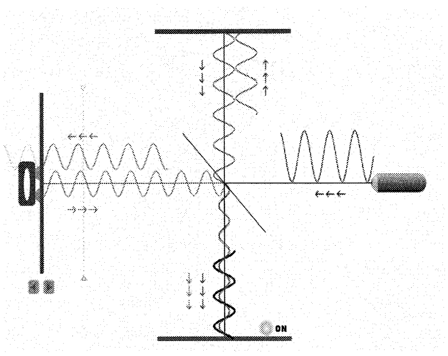

Fig. 1. Two-dimensional simulation.

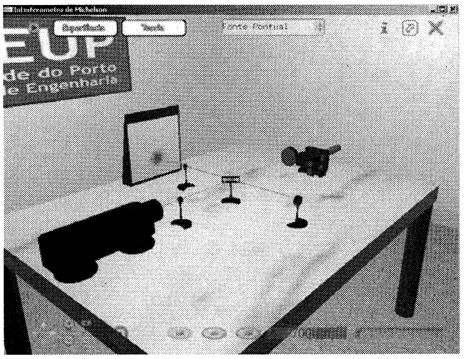

Fig. 2. Three-dimensional simulation.

The two simulations have been used in combination with a real interferometer. The simulation serves as a stepping stone for students who are going to use the real interferometer but its use is not restricted to that initial phase: after students move on to work with the real interferometer they get new ideas that they might want to explore in the virtual system.

CONCLUSIONS

The simulations of a Michelson interferometer have proved to be a very useful tool for teaching. Through those simulations we have also been able to explore the advantages of a virtual laboratory: improved accessibility, easier configuration, no risks of equipment breakage, better motivation for information-age students. In the case of the Michelson interferometer reported on this communication, there has been a useful interplay of the virtual and the real experiment, resulting in a better learning experience.

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