Education in Optics at the University of Valencia

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ABSTRACT

A brief outline of the courses concerning Optics which are taught at the University of Valencia is presented. At present, Optics is taught only in BS, MS and PhD degree courses in Physics. Some comments about how the current obligatory reform of curricula may influence the teaching of Optics in the near future are made. We think that the interest of the information here provided resides in an interchange of information which may be used to improve the teaching of Optics in our University.

2. INTRODUCTION

When receiving the first announcement of a Conference, we usually think of the latest results of our research. It is true that it is very important to produce and to present scientific results as a part of our work in the University, but also no less important is the other part of our work connected with the transmission of knowledge in our field of specialization.

At present, Optics is increasing its importance in Science and Technology but at the same time is a changing discipline[1]. For these reasons it is of great interest to discuss what should be taught in our discipline and how to do it. Access to information about the experience of people explaining Optics in different countries from basic to very high levels, seems to me a key to the answers to the above considerations.

3. OPTICS AT THE UNIVERSITY OF VALENCIA

In this context, what interest could there be in presenting a paper concerning education in Optics at the University of Valencia?. In my opinion, because it is the most direct way to participate in the information exchange propiciated by the Conference and, at the same time, because it can provide a general idea about the teaching of Optics in Physics courses in Spain. A more in depth study of education in Optics for physicits will be presented in another paper[2].

At present, Optics is taught in BS, MS and PhD degree courses in Physics. The BS degree course lasts for five academic years, divided into two cycles; the first, with a duration of three years provides a basic training in Physics, where an *Optics* course is obligatory during the third academic year. Also the students should follow another obligatory course on *experimental techniques* connected with Optics. The second cycle allows the students to study a discipline in depth and to obtain a certain degree of specialization. Although a true specialization in Optics does not exist at our University, those students who decide to receive an in depth training in Optics have four additional courses during this

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second cycle each of them lasting one year. Two of these courses are devoted to *Optical Image Processing*, the other two to *Quantum Optics* and *Vision Physics*.

So, to summarize, the Optics Department of the University of Valencia has to impart the courses, totally identified with Optics, which can be seen in Table 1.

Course	Ac. year	Hours / week Theory & Problems	Laboratory
Optics	3 rd	5	-
Experimental Techniques II	3 rd	1	4
Fourier Optics	4 th	4	3
Optical Image Processing	5 th	3	3
Quantum Optics	5 th	3	3
Vision Physics	5 th	3	3

Table 1. BS Optics courses explained at the University of Valencia. They all last one academic year.

3.1. Optics and Experimental Techniques

The course on *Optics* during the third academic year belongs to the first cycle and it is obligatory for all the students. Its characteristic of being a basic course together with the fact that it is imparted in the last year of the cycle, just when the students should decide in which directions they will continue their studies, makes it the cornerstone of all the teaching in the Optics Department. So, its content should accomplish a double purpose. First, it should provide a solid foundation of basic optical phenomena for students wishing to extend their studies in Optics. Second, the course should serve to present the students a panorama wide enough to obtain the minimum necessary knowledge about the main subjects in this field and other related fields. Thus, the students receive fundamental training in geometrical and physical optics, basic phenomena of radiation - matter interaction, lasers and applied optics.

During the same academic year, the students have to follow the course on *Experimental Techniques II*, which in great part corresponds to a classical laboratory of Optics matched more or less to the program of the previous Optics course.

Concerning the rest of courses in Table 1, the situation is quite different with relation to the

atmosphere in which they are explained. These courses are optional and are taken by students desiring to increase their knowledge of Optics. Thus, the number of students following the courses is usually small and they have a high degree of interest in Optics.

3.2. Fourier Optics

Many optical imaging systems present properties of linearity and invariance. In this case, they can be described in a simple and elegant manner, from a mathematical point of view, using frequency analysis techniques. Thus, an optical imaging system can be characterized through its spatial frequency response. An important part of the course on *Fourier Optics* is devoted to establishing the bases allowing the study of imaging systems, their spatial frequency analysis and their characterization through appropriate transfer functions.

On many occasions an optical system providing a response according to our needs is required. If this is not the case with a given system, we can manipulate the spectra of the 2-D functions representing the objects to obtain the desired result; that is, the tranfer function can be intentionally modified. In this case we do not analyse only the system response but we try to synthesize the system which matches the best to our needs. So, in a natural way, we reach the problems of filtering and optical processing. The course ends considering the cases of real filters and simple phase filters. Thus, the objective of this course on *Fourier Optics* is the study of linear systems, diffraction phenomena, diffractional theory of imaging, frequency analysis of optical systems and an introduction to optical filtering.

3.3. Optical Image Processing

When the filtering operations to be performed are either very specific or sophisticated, also the filters to be used need special techniques to be built. In fact, complex filters were not obtained in a relatively easy way until the holographic methods were applied. Hence, an important part of the course on *Optical Image Processing* is devoted to the study of Holography either for its own interest or because it is a method used to record different kinds of filters.

During the course, the importance of matched and phase - only filters applied to pattern recognition is pointed out. To avoid the inconveniences of these filters concerning detection of patterns with several scales and orientations, we also consider partially matched filters allowing scale and rotation invariant detection with good discrimination. As in many cases, for the design of these filters, the computer generated holograms are very important, we dedicate some lectures to explain this kind of holograms.

However, the objective of the course does not consist in presenting only one type of optical processing, namely pattern recognition. Thus, different kinds of optical processors are presented, allowing image modifications concerning structure, color or some kind of enhancement. During the course, we try to present the students a panorama of optical processing wide enough to show the importance of the field. So, processing with partially coherent ilumination and anamorphic systems are studied in different applications. Finally we also consider an introduction to space - variant systems and to nonlinear optical processing.

In both courses, the theoretical explanations are complemented with laboratory work, where the students verify part of the theory that they have previously learned.

3.4. Quantum Optics

The purpose of the course on *Quantum Optics* is to present an ensemble of problems, usually connected with the interaction between radiation and matter, under the different models for the light: classic, semiclassic and quantum. First, we consider the nature and properties of the electromagnetic field, its behaviour as photons or as waves and classic and non-classic states. Second, we study several radiation - matter interaction phenomena at an atomic level. And third, we study basic applications as the laser - fundamentals, types and properties -, high - resolution spectroscopy and problems of generation and detection of light.

In order to place this course among the others, we establish some limits to its content. Concerning the electromagnetic field only the optical range (from IR to UV) is considered. In this case, the relativistic quantum mechanics is not necessary to describe the great variety of interaction phenomena of light with the electronic shell of atoms, molecules and solids. Concerning the matter, only stable matter is taken into account: atoms, molecules and solids. The interaction of radiation with the electronic shell can give rise to rotation, vibration and electronic transitions.

It should be emphasized that this course on *Quantum Optics* is a complement for others courses in Optics which usually deal only with wave propagation and interaction phenomena; matter in this case plays the role of either an obstacle or a recording material; moreover, conversely to the course on Quantum Optics, only the classical model of the light, usually valid for waves of relatively high intensity, is used.

3.5. Vision Physics

The course on *Vision Physics* deals with the phenomenon of vision exclusively from the optical point of view and from the information processing point of view. It does not deal with the anatomic support carrying out that process; i.e., physiology and neurophysiology. The course is essentially divided into two parts: 1) Vision, where this process is treated with some detail; the most important parameters concerning the visual process are studied and the models which explain the behaviour of the eye under given conditions. 2) Color, where color vision as a very important part of the visual process is considered, as well as colorimetry due to its evident practical importance.

This course is clearly of specialization because it makes use of the general concepts which have been studied in others courses in Optics but applied to the particular case of the visual system. First, using geometrical optics, image formation and quality of the image in the eye are studied. The processing of the information taken out from the primary optical image is carried out using Fourier techniques. The characterization of the visual system is usually made through the contrast sensibility functions which are proportional to the modulation transfer function. Also, in many cases, interferometric techniques for the study of the vision process are used.

Moreover, this course complements other courses in Optics too. Apart from the study of such an important everyday optical phenomenon as the visual process, it can be particularly useful for those people interested in any aspect of machine vision.

After the BS degree, if the students want to obtain the MS degree, they have to complete a

master thesis project, which usually lasts for one year. As the master thesis is orientated as an initiation to research, it is usually performed by those students admitted to the PhD programs offered by the University of Valencia.

3.6. PhD program

The *PhD program in Optics* is designed to prepare the students to carry out research in Optics at a high level in an academic or industrial laboratory. To achieve this goal, the students have to follow, for at least two academic years, courses of different kinds. Each of these courses has assigned a number of credits (1 credit is equivalent to 10 hours of lecturing) and a student has to accomplish 32 credits before presenting the PhD Thesis. Most of the courses are tauhgt by members of the staff of the University of Valencia, mainly from the Optics Department, and deal with either methodology and techniques of research or the research which is developed by the different teams in the Department. The rest of the courses are imparted by well known researchers in the field, who each academic year are invited to participate in the program.

4. FINAL COMMENTS

Concerning the current obligatory reform of curricula in Spain, in order to adapt them to the standard of the European Community, we should first emphasized that, despite the increasing importance of Optics, it has been a struggle to keep it as a core subject for physicists.

The curricula reform can be summarized as follows: a) A system of credits, similar to that in the PhD program, has been introduced to obtain a BS degree. The minimum number of credits in 300, divided into two cycles. The studies may last between four and five years. b) There are two main kinds of courses: obligatory core courses, common for all public Universities in Spain, and courses characteristic of each University. Some of these courses may be obligatory, the rest being elective. c) The laboratory work is increased in order to improve the experimental formation of students. d) The students have the possibility of choosing up to 10% of the credits they have to pass, among all offered by the University. e) There is no official speciality.

At present, after great struggle, Optics appears as a core discipline in the first cycle of the BS degree in Physics. On the contrary, in the second cycle, almost no subject related to Optics exists as core discipline. However, we hope that it will be not necessary to fight very hard in order to introduce some courses related to Optics as characteristic courses of the University of Valencia. So, we would be able to offer an opportunity to those students desiring to study Optics more in depth. It is also our opinion that the mechanism allowing the change of different optional courses has to be flexible enough to adapt to the continuous changes in our field.

5. REFERENCES

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