VNIVERSITAT DE VALÈNCIA

Course Guide
43308 Optical fibres: guidance and devices

COURSE DATA

Data Subject	
Code	43308
Name	Optical fibres: guidance and devices
Cycle	Master's degree
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)			
Degree	**Center**	**Acad. year**	**Period**
2150 - M.D. in Advanced Physics	Faculty of Physics	1	First term

Subject-matter		
Degree	**Subject-matter**	**Character**
2150 - M.D. in Advanced Physics	7 - Optical waveguides and photonic crystals	Optional

Coordination	
Name	**Department**
CRUZ MUÑOZ, JOSE LUIS	175 - Applied Physics and Electromagnetism
DIEZ CREMADES, ANTONIO	175 - Applied Physics and Electromagnetism

SUMMARY

This course aims to give an overview of waveguides and photonic devices that operate in the frequency range corresponding to the optical spectrum (visible and near infrared). The electromagnetic fundamentals that confer the properties to these devices are discussed, as well as practical questions, including the manufacturing processes and the different applications.

After reviewing the general theory of electromagnetic wave guide systems, the general characteristics of the guided modes in optical guides are studied. We will analyze the properties of a series of photonic guides with plane and cylindrical symmetry. Specifically, we will study the modes guided by thin metallic sheets, which will allow us to introduce and study a type of electromagnetic wave with very particular properties: surface plasmons. Next, as a previous step to the detailed study of the optical fibers, and as an introduction to the integrated optical guides, we study the dielectric slab waveguide, easier to analyze mathematically but with many properties qualitatively common with optical fibers. Based on the results of the study on the dielectric slab, an introduction to dielectric resonators is made.
The electromagnetic analysis of the optical fibers allows us to know the fundamentals that endow them

with their most characteristic properties, and which have given rise to their different technological applications. In addition to purely mathematical aspects, other practical issues are discussed, such as the different types of commercial optical fibers and fibers under development, and the most relevant fields of application.

The second part of the subject focuses on the study of the most relevant photonic components made with fiber optics. In practical applications involving optical fibers, other additional components are generally necessary to perform different functions on the light (filtering, multiplexing, modulation, etc ...). As far as possible, it is convenient to implement these functions in the optical domain and preferably with fiber optic devices. This strategy simplifies fiber optic systems and makes them more robust. Therefore, in recent decades, a significant effort has been made in the development of fiber optic components. A family of fiber optic devices of interest are those whose operation is based on the coupling between modes guided by fiber. In this course, devices based on periodic structures, of different nature, and devices based on coupling by interaction with the evanescent field are studied. Finally, the study of fiber optic systems that include active optical fibers, that is, optical fibers that emit light, is addressed. Fiber optic light amplifiers, essential in today's communication systems, and fiber optic lasers, whose technological relevance and scope of application is increasingly wide, are discussed.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

OUTCOMES

2150 - M.D. in Advanced Physics

- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Ser capaz de gestionar información de distintas fuentes bibliográficas especializadas utilizando principalmente bases de datos y publicaciones internacionales en lengua inglesa.
- Poseer la capacidad para el desarrollo de una aptitud crítica ante el aprendizaje que le lleve a plantearse nuevos problemas desde perspectivas no convencionales.
- Comprender de una forma sistemática el campo de estudio de la Física y el dominio de las habilidades y métodos de investigación relacionados con dicho campo.

- Analizar una situación compleja extrayendo cuales son las cantidades físicas relevantes y ser capaz de reducirla a un modelo parametrizado.
- Saber modelizar matemáticamente los problemas físicos sencillos nuevos, conectados con problemas conocidos. Ser capaz de expresar en términos matemáticos nuevas ideas.
- Comprender las técnicas de fabricación y caracterización de componentes de fibra óptica y sus aplicaciones.
- Comprender las bases teóricas de la propagación de la luz, tanto en el espacio libre, como en medios dieléctricos lineales y no lineales, así como en guías ópticas.
- Ser capaz de diseñar sistemas ópticos y dispositivos fotónicos para aplicaciones específicas de procesamiento de señales.
- Conocer los avances recientes en materiales, dispositivos y tecnologías emergentes de interés para la fotónica.

LEARNING OUTCOMES

At the end of the teaching-learning process the student will have learned:

1. Understanding the techniques of fabrication and characterization of fiber optic components and applications.
2. Understanding the theoretical basis of the propagation of light, both in free space, as in dielectric media and non-linear, as well as optical waveguides.
3. Being able to design optical systems and photonic devices for specific applications of signal processing.
4. Understanding the recent advances in materials, devices and emerging technologies relevant to photonics.

DESCRIPTION OF CONTENTS

1. Introduction to optical fibers

1.1.- Why does an optical fiber guide?
1.2.- What material are they made of?
1.3.- Manufacture of an optical fiber.
Demonstration 1: Light guiding through an optical fiber

2. Planar waveguides

2.1.- Introduction.
2.2.- Modes guided by a metallic sheet. Surface plasmons.
2.3.- Dielectric slab.
2.4.- Curved dielectric slab.
2.5.- Dielectric optical micro-resonators.
2.6.- Applications of integrated waveguides.
Demonstration 2: Dielectric slab waveguide and WGMs in dielectric resonators

3. Optical fibers.

3.1.- The spectrum of modes of step-index fibers.
3.2.- LP approach.
3.3.- Characteristics of the fundamental mode.
3.4.- Cladding modes.
3.5.- Types of optical fibers.
Demonstration 3: Microstructured optical fibers

4. Nonlinear effects in optical fibers

4.1.- Elastic effects: SPM, XPM, FWM/MI.
4.2.- Inelastic: Raman scattering, Brillouin scattering.
Demonstration 4: Nonlinear effects in optical fibers

5. Devices based on mode coupling

5.1.- Modal coupling in periodic structures: Bragg filters, long period networks.
5.2.- Modal coupling between waveguides: couplers and wavelength multiplexers.
5.3.- Interaction between electromagnetic waves and acoustic waves.

Demonstration 5: Fabrication of fiber Bragg gratings.
Demonstration 6: Acousto-optic interaction in optical fibers
Demonstration 7: Sensing

6. Optical fiber amplifiers

6.1. Rare earth doped fiber amplifiers.
6.2. Pulse amplification.
6.3. Raman effect amplifiers.
6.4. Optical fiber lasers. Pulsed lasers.

8. Laboratori work

Optical fiber laser. Assembly and characterization.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	33,00	100
Laboratory practices	6,00	100
Other activities	4,00	100
Seminars	3,00	100
Preparation of evaluation activities	35,00	0
Preparing lectures	20,00	0
Preparation of practical classes and problem	5,00	0
Resolution of case studies	30,00	0
TOTAL	**136,00**	

TEACHING METHODOLOGY

- Standar theory lecture.
- Problems solving.
- Laboratori experiments.
- Seminars.
- Visit to external scientific facilities.
- Conducted debate or discussion.

EVALUATION

The evaluation of the subject is based on:

- Written exams on the theory classes, based on the learning outcomes and on the specific objectives of the subject (40%).

- Continuous assessment of the student in the theory classes, in which it will be considered the participatory attendance, the realization of exercises in the classroom, presentation of proposed problems, etc... (45%).

- Evaluation of laboratory activities (15%).

REFERENCES

Basic

- R.E. Collin. Field theory of guided waves. IEEE Press 1991.
- A.W. Snyder y J.D. Love. Optical waveguide theory. Chapman and Hall, 1983.
- G.H. Owyang. Foundations of Optical Waveguides. E. Arnold 1981.
- R. März, Integrated Optics. Design and Modelling. Artech House, 1995.
- G. P. Agrawal. Fiber-Optic Communication Systems. John Wiley & Sons, 2002.
- N. Kashima. Passive optical componentes for optical fiber transmission. Artech House 1995.
- H.A. Haus. Waves and fields in optoelectronics. Prentice-Hall 1984.
- Rare earth doped fiber lasers and amplifiers. Edited by M.J.F. Digonnet. Marcel Dekker 1993.
- R. Kashyap. Fibre Bragg grating. Academic Press 1999.