Last update: 13-05-2015

230563 - NLO - Non-Linear Optics

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 721 - FEN - Department of Physics and Nuclear Engineering
Academic year: 2015
Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Jose Trull, UPC (coord).

Others: Crina Cojocaru, UPC.

Opening hours

Timetable: jose.francisco.trull@upc.edu
crina.maria.cojocaru@upc.edu

Degree competences to which the subject contributes

Transversal:

1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
2. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology

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Learning objectives of the subject

This course will render an overview on the basic principles of second and third order nonlinear effects in optics and their most important applications, providing a sound background in this field. Starting from the basic equations governing different nonlinear processes, detailed solutions and approximations will be discussed. We will then extend to more complex systems, interactions and applications of nonlinear effects. The last part of the course aims to provide an overview in recent advances and state of the art of the field.

BIBLIOGRAPHY

·Basic

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"Nonlinear Optics" (3ed edition) by R. Boyd (Academic Press, Boston), 2008.
"Quantum Electronics" (3rd edition) by A. Yariv (Wiley, VCH), 1988.
"Physical Optics" by S.A. Akhmanov and S.Y. Nikitin (Oxford University Press), 1997.
"Fundamentals of Photonics" (2nd edition) by B.E.A. Saleh amd M.C. Teich (Wiley series in pure and applied optics) 2007.

·Advanced
"Introduction to Nonlinear Optics" by Y. R. Shen (John Wiley, New York), 1984.
"Nonlinear Optics" by A.C. Newell and J.V. Moloney (Addison-Wesley), 1992.

Study load

Total learning time: 75h	Theory classes:	22h 30m	30.00%
	Practical classes:	0h	0.00%
	Laboratory classes:	0h	0.00%
	Guided study:	2h 15m	3.00%
	Self study:	50h 15m	67.00%

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Content

1 Maxwell equations and polarization

Degree competences to which the content contributes:

Description:
1.1 Maxwell equations
1.2 Polarization and susceptibility: Lorentz model for bounded charges, index of refraction, hydrodynamic model for free electrons

2 Optics of Crystals

Degree competences to which the content contributes:

Description:
2.1 Maxwell equations and material relations in birrefringent crystals
2.2 Normal modes of propagation in crystals
2.3 Propagation of ordinary and extraordinary waves in crystals

3 Nonlinear polarization

Degree competences to which the content contributes:

Description:
3.1 Nonlinear polarization
3.2 Classical derivation of nonlinear susceptibility: second and third order interactions
3.3 Nonlinear susceptibility symmetries
3.4 Effective nonlinear coefficient

4 Nonlinear wave equations

Degree competences to which the content contributes:

Description:
4.1 Wave equations for nonlinear optics
4.2 Coupled mode theory for plane waves: quasi-monochromatic plane wave approximation, separation on frequencies approximation, slowly-varying amplitude approximation
4.3 Energy and phase relations in nonlinear optics

5 Second order nonlinear effects (plane wave approximation)

Degree competences to which the content contributes:

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Description:
5.1 General description of the second order processes
5.2 Coupled-wave equations for sum-frequency generation: coupled-amplitude equations, solution for non-depleted input waves, phase-matching considerations, Manly-Rowe relations, the case of one depleted input beam.
5.3. Second harmonic generation: phase matching techniques, different materials for SHG, applications
5.4 Difference-frequency generation and parametric amplification (OPA);
5.5 Optical parametric oscillations (OPO)

6 Third order nonlinear effects (plane wave approximation)

Degree competences to which the content contributes:

Description:
6.1 Third harmonic generation and optical Kerr effect
6.2 Self and cross-phase modulation
6.3 Four-wave mixing: coupled wave theory for three wave mixing and third harmonic generation
6.4 Optical phase conjugation

7 Nonlinear optics with beams and pulses

Degree competences to which the content contributes:

Description:
7.1 Basic equations for beams and pulses
7.2 Nonlinear interactions in Kerr media: self-phase modulation, self-focusing, filamentation and optical solitons
7.3 Parametric processes in quadratic media
7.4 Short pulse characterization

8 Nonlinear light scattering and absorption

Degree competences to which the content contributes:

Description:
8.1 Light scattering
8.2 Brillouin scattering
8.3 Raman scattering
8.4 Two-photon absorption

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Qualification system

- Written exam (60%) (exam week)
- Homework: exercises and problem collection (30%) (to be delivered with the exam)
- Class and seminars attendance (10%)

Bibliography