Course guide
230555 - QO - Quantum Optics

Last modified: 14/12/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 1022 - UAB - (ANG) pendent.

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Ahufinger Breto, Verónica

Others: Valles Mari, Adam

PRIOR SKILLS

Basic knowledge on quantum physics

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. Demonstrate the understanding of the peculiarities of the quantum model for light-matter interaction.
CE9. Ability to synthesize and present photonics research results according to the procedures and conventions of scientific presentations in English.

Generical:
CG1. Ability to project, design and implement products, processes, services and facilities in some areas of photonics, such as photonic engineering, nanophotonics, quantum optics, telecommunications and biophotonics.
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry

Transversal:
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.

CT4. SOLVENT USE OF INFORMATION RESOURCES. Manage the acquisition, structuring, analysis and visualization of data and information in the field of the specialty and critically assess the results of this management.
5. 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.

Basic:
CB7. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB8. Students should be able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgment.
CB10. Students should possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

- Lectures
- Resolution of exercises in the classroom

LEARNING OBJECTIVES OF THE SUBJECT

This course will provide a wide-ranging introduction to the field of quantum optics, developing in detail the semiclassical and quantum theories of light-matter interaction.

STUDY LOAD

Type	Hours	Percentage
Hours large group	24,0	32.00
Self study	51,0	68.00

Total learning time: 75 h

CONTENTS

1. Semiclassical theory of light-matter interactions

Description:
Rate equations. Schrödinger equation. Two-level atom under the rotating wave approximation. AC-Stark splitting. Dressed atom. Rabi oscillations. Mollow triplet. Autler-Townes doublet. Dipole force. Density matrix formalism. Two and three-level atoms. Coherent population trapping. Electromagnetically Induced Transparency. Stimulated Raman Adiabatic Passage.

Full-or-part-time: 11h
Theory classes: 11h

2. Quantum theory of light-matter interaction

Description:
Classical Electrodynamics. Quantization of the e.m. field. Quantum states of the free e.m. field. Vacuum states. Fock states. Coherent States. Squeezed states. Jaynes-Cummings model. Weisskopf-Wigner treatment for spontaneous emission. Quantum Rabi Oscillations. Collapses and revivals. Cavity quantum electrodynamics.

Full-or-part-time: 11h 30m
Theory classes: 11h 30m

GRADING SYSTEM

Two activities will be evaluated:
- Written exam (60%)
- Homework assessments (40%)
In addition, there will be an oral recovery exam for those students who have not passed the subject once the written exam and the delivery of problems have been evaluated.

BIBLIOGRAPHY

Basic:
- Walls, D. F.; Milburn, G. J. Quantum optics. Springer-Verlag, cop. 2008. ISBN 9783540285731.
- Gerry, C.; Knight, P. Introductory quantum optics. Cambridge University Press, 2005. ISBN 052152735X.
- Meystre, P.; Sargent, M. Elements of quantum optics. 4th. Springer-Verlag, 2007. ISBN 9783540742098.
- Scully, M.O. Quantum optics. Cambridge University Press, 1997. ISBN 0521435951.

Complementary:
- Cohen-Tannoudji, C; Dupont-Roc, J; Grynberg, G. Atom-photon interactions: basic processes and applications. John Wiley & Sons, 1998. ISBN 0471293369.
- Cohen-Tannoudji,C.; Dupont-Roc,J.; Grynberg, G. Photons and atoms: introduction to quantum electrodynamics. John Wiley & Sons, 1997. ISBN 0471184330.

RESOURCES

Computer material:
- Oregon Center for Optics and Department of Physics. Oregon University. Resource

Hyperlink:
- Steck, D.A. Quantum and atom optics (2007). Resource. https://discovery.upc.edu/discovery/fulldisplay?docid=alma991001120249706711&context=L&vid=34CSUC_UPC:VU1&lang=ca- http://atomoptics.uoregon.edu/ dsteck/teaching/quantum-optics/quantum-optics-notes.pdf. Resource