Last update: 06-05-2019

230558 - EXPQO - Advanced Quantum Optics with Applications

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering

Teaching unit: 893 - ICFO - Institute of Photonic Sciences

Academic year: 2019

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional)

ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Morgan W. Mitchell (ICFO) (Coord.)

Others: Hugues de Riedmatten (ICFO)

Degree competences to which the subject contributes

Basic:

CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CB8. (ENG) Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicio.

CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE2. (ENG) Màster en Fotònica:
Demostrar que comprende las peculiaridades que comporta el modelo cuántico para la interacción luz-materia.

CE9. (ENG) Màster en Fotònica:
Capacidad para sintetizar y exponer los resultados de investigación en fótonica según los procedimientos y convenciones de las presentaciones científicas en inglés.

Generical:

CG1. (ENG) Màster en Fotònica:
Capacidad para proyectar, diseñar e implantar productos, procesos, servicios e instalaciones en algunos ámbitos de la fotónica como los relacionados con la ingeniería fotónica, la nanofotónica, la óptica cuántica, las telecomunicaciones y la biofotónica

CG2. (ENG) Màster en Fotònica:
Capacidad para la modelización, cálculo, simulación, desarrollo e implantación en centros de investigación, centros tecnológicos y empresas, particularmente en tareas de investigación, desarrollo e innovación en todos los ámbitos relacionados con la Fotónica.

CG4. (ENG) Màster en Fotònica:
Capacidad para entender el carácter generalista y multidisciplinario de la fótonica viendo su aplicación por ejemplo a la medicina, biología, energía, comunicaciones o la industria

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

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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

- Lectures
- Activities

Learning objectives of the subject

This course presents the modern understanding of light as a quantum phenomenon, and explores how quantum applications such as quantum communications and quantum sensing are developed using quantum light. We describe optics at the individual-photon level, entangled and squeezed states of light, quantum non-locality, quantum memories and related advanced topics. The course gives necessary background for understanding contemporary experiments. Special attention is given to applications with atomic ensembles including quantum-enhanced sensing, and quantum memory.

Study load

Total learning time: 75h	Hours large group:	24h	32.00%
	Self study:	51h	68.00%

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Content

Issue 1	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Quantization of the electromagnetic field

Issue 2	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Estats quàntics de la llum: fotons individuals, estats coherents, estats 'squezzed', estats entrelligats.

Issue 3	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Detection of quantum light: photon counting, coincidence counting, phase-sensitive detection.

Issue 4	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Generation of quantum light by non-linear optical processes.

Tema 5	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Experimental signatures of quantum behaviour.

Issue 6	Learning time: 2h 30m Theory classes: 2h 30m

Description:
Interaction of light with atomic ensembles.

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Issue 7	Learning time: 2h 30m Theory classes: 2h 30m
Description: Spin squeezing and quantum-enhanced measurements.	

Issue 8	Learning time: 2h 30m Theory classes: 2h 30m
Description: Experimental quantum communication: Quantum teleportation, entanglement swapping, quantum repeaters	

Issue 9	Learning time: 2h 30m Theory classes: 2h 30m
Description: Quantum memories based on Electro-magnetically Induced Transparency, Photon echoes, DLCZ.	

Planning of activities

Visit to ICFO laboratories	Hours: 2h 18m Theory classes: 2h 18m

Qualification system

- Homework assignments and quizzes (45%)
- Final exam (45%)
- Participation and presentation (10%)

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Bibliography

Basic:

Scully, Marlan O; Zubairy, M. Suhail. Quantum optics. Cambridge University Press, 1997. ISBN 9780524235959.

Walls, D. F; Milburn, G. J. Quantum optics. 2nd. Springer-Verlag, 2008. ISBN 9783540285731.

Loudon, R. The quantum theory of light. 3rd. Oxford Clarendon Press, 2001. ISBN 0198501765.

Others resources:

Hyperlink

http://mitchellgroup.icfo.es/MEQO/

Notes of the course