

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:	2015 - 2016		
Degree:	Master's Degree in Photonics Erasmus Mundus Master's Degree in Photonics Engineering, Nanophotonics and Biophotonics		
ECTS credits:	3	Teaching languages:	English

Academic staff

Coordinator:	Morgan W. Mitchell (ICFO)	morgan.mitchell@icfo.es
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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. 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.
3. 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.
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:

- Laboratory tours

Objectives and short description of the course

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:	22.5h	30%
	Hours medium group:	0h	0%
	Hours small group:	0h	0%
	Guided activity:	2.25h	3%
	Self study:	50.25h	67%



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Course index

1. Quantization of the electromagnetic field
2. Quantum states of light: single photons, coherent states, squeezed states, entangled states.
3. Detection of quantum light: photon counting, coincidence counting, phase-sensitive detection.
4. Generation of quantum light by non-linear optical processes.
5. Experimental signatures of quantum behaviour.
6. Interaction of light with atomic ensembles.
7. Spin squeezing and quantum-enhanced measurements.
8. Experimental quantum communication: Quantum teleportation, entanglement swapping, quantum repeaters
9. Quantum memories based on Electro-magnetically Induced Transparency, Photon echoes, DLCZ.

Qualification system

Homework assignments and quizzes (45%)

Final exam (45%)

Participation and presentation (10%)

Bibliography

- **On line**
 - <http://mitchellgroup.icfo.es/MEQO/>
- **Classic texts**
 - M.O. Scully, M.S. Zubairy, Quantum Optics, Cambridge U. P., 1997.
 - Walls, G.J. Milburn, Quantum Optics, Springer-Verlag, 1994.
 - R. Loudon, The Quantum Theory of Light, Oxford Science Publications, 2001