Course guide
230588 - QINTERF - Quantum Light-Matter Interfaces: Modern Systems and Applications

Last modified: 29/05/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 893 - ICFO - Institute of Photonic Sciences.

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

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

It is recommended to have previously studied the courses on "Quantum Optics" and "Advanced Quantum Optics with Applications"

TEACHING METHODOLOGY

- Lectures
- Activities

LEARNING OBJECTIVES OF THE SUBJECT

Quantum light-matter interfaces are expected to constitute an important cornerstone for future quantum technologies. The objective of this course is to introduce students to the major experimental platforms being used today, including the historical workhorses of cavity QED and atomic ensembles, and upcoming paradigms such as atom-nanophotonic interfaces, quantum optomechanics, and superconducting circuit QED. We will also investigate in detail several important protocols for major applications within quantum technologies, such as quantum memories for light, photon-photon gates, coherent microwave-to-optical links, and quantum metrology, and understand the fundamental limits to how faithfully they can be implemented.

STUDY LOAD

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

Total learning time: 75 h

CONTENTS

Single atom

Description:
How efficient can the interaction of a single atom and photon be? And why does this motivate other approaches to attain efficient interactions?

Full-or-part-time: 2h
Theory classes: 2h

Cavity QED

Description:
•Brief review of Jaynes-Cummings model, and introduction to key concepts of cavity cooperativity and photon blockade
•Input-output equation
•Major protocols and their limitations: quantum memory, single-photon generation, atom-photon and photon-photon gates, spin squeezing

Full-or-part-time: 6h
Theory classes: 6h

Atomic ensembles

Description:
• Brief review of Maxwell-Bloch equations and the key concepts of collective enhancement and optical depth
• Major protocols and their limitations: quantum memory (electromagnetically induced transparency), spin squeezing
• A new approach to nonlinear optics: Rydberg atomic ensembles

Full-or-part-time: 6h
Theory classes: 6h

Quantum optomechanics

Description:
• Introduction to canonical optomechanical Hamiltonian
• Major applications: quantum memory, quantum microwave-to-optical conversion, force sensing

Full-or-part-time: 6h
Theory classes: 6h

Overview of new quantum platforms

Description:
• Atom-nanophotonics interfaces
• Atom-nanophotonics interfaces
• Chiral atom-light interactions
• Atomic arrays
• Superconducting circuit quantum electrodynamics

Full-or-part-time: 4h
Theory classes: 4h

GRADING SYSTEM

- Homework assignments and quizzes (40%)
- Final exam (30%)
- Participation and presentations (30%)

BIBLIOGRAPHY

Basic:
- Steck, Daniel Adam. Quantum and atom optics [on line]. 2007 [Consultation: 25/06/2021]. Available on: https://atomoptics-nas.uoregon.edu/~dsteck/teaching/quantum-optics/quantum-optics-notes.pdf.