

Academic Year: (2023 / 2024)

Review date: 24-04-2023

Department assigned to the subject: Physics Department

Coordinating teacher: TORRONTEGUI MUÑOZ, ERIK

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus
 Quantum physics
 Advanced quantum physics
 Electromagnetic fields and waves

DESCRIPTION OF CONTENTS: PROGRAMME

1. Quantum control of atoms with light
 - Atomic transitions, Bloch vector and Bloch equations
 - ac-Stark shift and optical potentials
2. Photons for quantum technologies
 - Photons in cavities and free space
 - Quantum states of light: Fock and coherent states. Squeezed states.
 - The spectrum of light
 - Quantum metrology with photonic states
3. Atoms and qubits interacting with quantum light
 - Jaynes-Cummings model
 - Interaction of atoms with photons in free space
 - Radiative decay and the optical master equation
 - Generation of quantum states of light by atoms (laser and single-photon emission)
4. Introduction to quantum optical setups
 - Cavity and circuit QED systems
 - Trapped ions
5. Quantum computing with quantum optical systems
 - Quantum gates mediated by photonic modes
 - Trapped ion quantum computing
 - Quantum computing with photon states
6. Applications of quantum optics
 - Single photons for quantum communications (g^2 , characterization of single-photon states)
 - Electromagnetically Induced Transparency
 - Optical tweezers and optical trapping
 - Atomic ensembles for quantum networks
7. Quantum optics laboratory.
 - Experiment 1: Entangled photon pairs. Hong-Ou-Mandel Interferometry
 - Experiment 2: Saturation Spectroscopy
 - Experiment 3: Optical Tweezers

LEARNING ACTIVITIES AND METHODOLOGY

1. Educational activities:
 - Theory lessons
 - Tutorial sessions
 - Laboratory practice
 - Individual student work
2. Educational Methodologies:
 - Classroom lessons by lecturers in which the main concepts will be developed. Bibliography will be provided to students as a complement to the main lessons

- Solution of practical exercises in the classroom and also individually by students.
- Laboratory practice and writing of laboratory reports on the experimental work.

ASSESSMENT SYSTEM

SE2: Individual or group homework

SE3: Final exam

% end-of-term-examination: 60

% of continuous assessment (assignments, laboratory, practicals...): 40

BASIC BIBLIOGRAPHY

- D.F. Walls, Gerard J. Milburn Quantum Optics, Springer.

ADDITIONAL BIBLIOGRAPHY

- Marlan O. Scully and M. Suhail Zubairy Quantum Optics, Cambridge University Press.