Quantum optics

Academic Year: (2023 / 2024) **Review date: 24/04/2023 11:23:43**

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

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

SE2: Individual or group homework
SE3: Final exam

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.