Quantum nanophotonics

Academic Year: (2023 / 2024) **Review date: 24-04-2023**

Department assigned to the subject: Physics Department

Coordinating teacher: TORRONTEGUI MUÑOZ, ERIK

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Quantum optics

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to nanophotonics

2. Green functions in quantum nanophotonics.
- Mathematical definition of Green's function.
- Green's function of a waveguide.
- Green function of a surface.
- Numerical methods.

3. Review of concepts of electromagnetism & optical response materials.
- Drude-Lorenz model
- Review of optical response of different materials.

4. Macroscopic quantum electrodynamics.
- Light-matter interaction in absorbent media.
- Quantum master equations.

5. Quantum electrodynamics of lossy microcavities.
- Wigner-Weisskopf formalism
- Strong & weak coupling regimes.

6. Quantum noise & photodetection techniques
- Open quantum systems, input/output theory and quantum noise.
- Photon counting and homodyne techniques.
- Measurement of photon correlations (quantum coherence, Hong-Ou-Mandel effect)
- Photon scattering theory, reflection and transmission measurements.
- Measurement of the spectrum of photons and resonant fluorescence.

7. Implementations of quantum nanophotonics systems
- Microcavity systems & optomechanics
- Waveguide systems.
- Non-linear optics

LEARNING ACTIVITIES AND METHODOLOGY

LEARNING ACTIVITIES:

Theorical class
tutorials
Team work
Individual student work

TEACHING METHODOLOGIES:

Presentations in class by the teacher with the support of computer and audiovisual media, in which the main concepts of the subject are developed and the bibliography is provided to complement the learning of the students.

Critical reading of texts recommended by the professor of the subject: Press articles, reports, manuals and/or academic articles, either for later discussion in class, or to broaden and consolidate knowledge of the subject.

Resolution of practical cases, problems, etc. raised by the teacher individually or in groups

Presentation and discussion in class, under the moderation of the teacher, of topics related to the content of the subject, as well as practical cases

Preparation of work and reports individually or in groups

The knowledge, abilities and skills acquired throughout the course will be assessed globally through a brief presentation on a research article on a list of articles that will be provided at the beginning of the course.

ASSESSMENT SYSTEM

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

SE1. Class participation
SE2. CONTINUOUS EVALUATION. Assesses papers, projects, class presentations, debates, exercises, internships and workshops throughout the course.
SE3. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course.

BASIC BIBLIOGRAPHY

- C. W. Gardiner and P. Zoller Quantum Noise , Springer Series in Synergetics, 2004

- Markus Aspelmeyer, Tobias J. Kippenberg, and Florian Marquardt Cavity optomechanics, Rev. Mod. Phys. 86, 1391, 2014

- Novotny & Hecht Principles of Nano-Optics, Cambridge University Press, 2012

- Stefan Scheel, Stefan Yoshi Buhmann Macroscopic QED - concepts and applications. , https://arxiv.org/abs/0902.3586..

- The Quantum World of Ultra-cold atoms and light. Book II: The Physics of Quantum-Optical Devices - C. W. Gardiner and P. Zoller, Imperial College Press.