

PHYS-453

Quantum electrodynamics and quantum optics

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Cursus	Sem.	Type
Electrical and Electronical Engineering	MA1, MA3	Opt.
Ing.-phys	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	4 weekly
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course on one hand develops the quantum theory of electromagnetic radiation from the principles of quantum electrodynamics. On the other hand it explores the main consequences of light-matter interaction in applications like optical spectroscopies and devices.

Content**1. Introduction to quantum optics**

From Einstein to our days : a historical perspective.

2. Classical and quantum fields

Quantization of the radiation field in Coulomb gauge. Summary of second quantization formalism for fermions. Particular quantum states of radiation (Fock states, coherent states, thermal mixture, squeezed states)

3. Semi-classical theory of the light-matter interaction : optical resonances and non-linearities, the laser

Dynamics of the light-matter interaction. Optical Bloch equations. Classification of optical non-linearities. The laser equations. Static and dynamical phenomena.

4. Classical and quantum noise, quantum theory of measurement, quantum correlations

Correlation functions of the radiation field and coherence. Quantum theory of measurement and photodetection. Interferometry and correlation functions. Entangled states of the electromagnetic field. Quantum spectroscopies

Learning Prerequisites**Recommended courses**

Quantum physics

Learning Outcomes

By the end of the course, the student must be able to:

- Understand the quantum theory of electromagnetic radiation
- Understand the different effects of light-matter interaction
- Master the calculational techniques

Teaching methods

Ex cathedra with exercises, presentation of scientific articles by the students

Assessment methods

oral (75%), presentation and discussion of a scientific article in a team of two (25%)