EPFL

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. |
| Photonics minor | H | Opt. |
| Physicien | MA1, MA3 | Opt. |

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| 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%)