GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2020-2021

Quantum Optics (E023930)

Due to Covid 19, the education and evaluation methods may vary from the information displayed in the schedules and course details. Any changes will be communicated on Ufora.

Course size *(nominal values; actual values may depend on programme)*

Credits 4.0 **Study time 120 h** **Contact hrs** 42.0 h

Course offerings and teaching methods in academic year 2021-2022

A (semester 2)	English	Gent	lecture	30.0 h
			seminar	3.75 h
			seminar: coached exercises	7.5 h
O (semester 2)				

Lecturers in academic year 2021-2022

Clemmen, Stéphane	TW05	lecturer-in-charge
Lurbe, David Castello	VUB	co-lecturer

Offered in the following programmes in 2021-2022

	crdts	offering
Bridging Programme Master of Science in Photonics Engineering	4	A
European Master of Science in Photonics	4	A
Master of Science in Photonics Engineering	4	A, O

Teaching languages

English

Keywords

Quantum optics, Photonics, Coherence, Photon counting, Quantum interferences, Atom-light interaction, Single-photon sources, Two-photon sources.

Position of the course

The Quantum Optics course offers the students a broad introduction to the principles and applications of quantum optics. It covers those aspects of optical science in which the quantum nature of the electromagnetics field is of primary relevence. Exemples of topics covered in this courses are: optical coherence, quantum effects in optical interferometry, interaction of light with elementary quantum systems (such as atoms and quantum dots) in free space and in resonators, quantum effects associated to optical nonlinear interactions.

The *lectures* (8 x 4 hours) are complemented by *exercices* (3 x 2 hours) and *seminars by invited speakers*. The seminars build on the knowledge acquired during the course and are intented to introduce the students to active research topics.
This course is taught at the VUB.

Contents

- Part 1: ***Quantum statistical properties of light***
  - Chapter 1: *Statistical properties of classical fields*
  - Chapter 2: *Quantum theory of the electromagnetic field*
  - Chapter 3: *Quantum states of light*
  - Chapter 4: *Quantum theory of optical coherence*
  - Chapter 5: *Quantum interferometry*

- Part 2: ***Interaction of light with matter***
  - Chapter 6: *Stucture of atoms and their interaction with light*
  - Chapter 7: *Weak atom-light coupling*
  - Chapter 8: *Strong atom-light coupling*

- Part 3: ***Sources of quantum light***
  - Chapter 9: *Single-photon sources*
  - Chapter 10: *Two-photon sources*
- Part 4: **Modern topics in quantum optics**
  - Linear optical quantum computing
  - Teleportation
  - Quantum key distribution
  - Phase super resolution and super sensitivity

Initial competences

A good background on Optics, Statistics and Quantum Mechanics is required. In case of no previous background on Quantum Mechanics, taking the course "Introduction to Quantum Physics for Electrical Engineering" of the European Master of Science in Photonics is recommended.

Final competences

After the course the student will be able to start reading specialized litterature in the field and understand conference presentations. He will not only master the formalism of the quantum optics, but also understand the most important experimental techniques for generating and detecting quantum states of light. He will be ready to start a PhD in Quantum Optics or any related field. More specifically, the student will get insight into the quantization of the electromagnetic field, quantum and classical coherence theory, direct and correlated photon counting methods, spontaneous emission and Purcell enhancement, few-photon interferometry, laser cooling and trapping of atoms, generation of single photons and photon-pairs, cavity quantum electrodynamics, quantum information processing.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, seminar, seminar: coached exercises

Extra information on the teaching methods

Lectures: 32 hours
Seminars: 4 hours
Exercises: 6 hours

Learning materials and price

The study material consists in lecture slides and exercise sheets.

References

1 M. Fox, *Quantum optics – An introduction*, Oxford University Press (2006)
2 R. Loudon, *The quantum theory of light*, Oxford University Press (2000)
3 P. Lambropoulos and D. Petrosyan, *Fundamentals of quantum optics and quantum information*, Springer (2007)
4 J. W. Goodman, *Statistical optics*, John Wiley & Sons (2000)
5 L. Mandel and E. Wolf, *Optical coherence and quantum optics*, Cambridge University Press (1995)
6 M. O. Scully and M. S. Zubairy, *Quantum optics*, Cambridge University Press (1997)

Course content-related study coaching

Private meetings with lecturer.

Evaluation methods

end-of-term evaluation

Examination methods in case of periodic evaluation during the first examination period

Oral examination

Examination methods in case of periodic evaluation during the second examination period

Oral examination

Examination methods in case of permanent evaluation

Possibilities of retake in case of permanent evaluation

not applicable

Extra information on the examination methods

The oral exam will consist in two parts:

1. **50%** The student chooses a topic from the course and prepares it at home. During the exam, he presents it in 20 min on the blackboard. The presentation is followed by questions related to that topic.
2. **50%** The lecturer asks short questions related to topics not covered by the presentation: other chapters, exercises, invited talks.

Calculation of the examination mark