GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2015-2016

Lasers (E900480)

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

Credits 4.0	Study time 120 h	Contact hrs	30.0 h

Course offerings and teaching methods in academic year 2017-2018

A (semester 1)	English	seminar: coached exercises	7.5 h
		lecture	22.5 h
B (semester 1)	Dutch	guided self-study	22.5 h
		seminar: coached exercises	7.5 h

Lecturers in academic year 2017-2018

Vermeulen, Nathalie	VUB	lecturer-in-charge
Morthier, Geert	TW05	co-lecturer
Verschaffelt, Guy	VUB	co-lecturer

Offered in the following programmes in 2017-2018	crdts	offering
European Master of Science in Photonics	4	A
Master of Science in Photonics Engineering	4	B

Teaching languages

Dutch, English

Keywords

resonators, laser theory, laser beams, laser types

Position of the course

To understand the optical properties of laser light. To understand the operation of different laser types. Being able to transform a given laser beam to a beam with the desired properties. Being able to select to best suited laser type for a certain application.
The sections preceded by an asterisk (*) are considered as prerequisite knowledge: they are not explicitly treated in the class (or only briefly reviewed).

Contents

1 CHAPTER 1: THE BASICS
- Basic laser physics: Introduction; Absorption; Spontaneous and stimulated emission of light; Amplification; Basic laser setup; Gain, saturation and line broadening
- Basic properties of laser light: One direction; One frequency; One phase; Laser light is intense

2 CHAPTER 2: LASER THEORY
- Introduction: The need for more than two energy levels; Rate equations for a 4-level laser
- Continuous-wave (cw) laser action: Output power in cw regime; Influence of experimental parameters; Transients
- Pulsed laser action: Introduction; Gain switching; Q-switching; Cavity dumping; Mode-locking; Ultra-short pulses

3 CHAPTER 3: LASER RESONATORS AND THEIR MODES
- Introduction
- Modes in a confocal resonator: Wave fronts; Frequencies; Transverse light distribution
- Modes in a non-confocal resonator: Stability criteria; Frequencies
- Modes in a waveguide resonator: Modes in a fiber waveguide resonator; Modes in

an on-chip waveguide resonator
- Modes in a (free-space/waveguide) ring resonator
- Modes in a real laser: Line broadening; Selection of modes
- Saturation and hole-burning effects: Spatial hole burning; Spectral hole burning

4 CHAPTER 4: LASER BEAMS
- Gaussian beams: Basic Formulas; Propagation; Transformation by a lens and focusing; Transmission through a circular aperture
- Multimode beams: Introduction; Spot radius *W* for a multimode beam; Beam Propagation Factor *M*; A more theoretical approach; Practical use

5 CHAPTER 5: TYPES OF LASERS
- General introduction
- Gas lasers: General; Neutral gas (He-Ne); Ionized gas (argon ion); Molecules (CO_2); Excimer lasers (ArF)
- Liquid lasers (dye laser)
- Solid-state lasers: General; Rare-earth-doped lasers (Nd:YAG and Er:fiber); Transition-metal-doped lasers (Ti: Sapphire); Changing the wavelength by optical nonlinear effects
- Other lasing mechanisms: Raman lasing

6 CHAPTER 6: LASER DIODES: OPERATION PRINCIPLES:
- Geometry and important characteristics
- Material aspects: heterostructures, gain and absorption, low dimensional materials, gain saturation, ...
- Fabry-Perot laser diodes: cavity resonance
- Fabry-Perot laser diodes: dynamic operation: Rate equations, Dynamic operation, Noise: power spectrum and phase noise, Injection locking
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7 CHAPTER 7: OVERVIEW OF SEMICONDUCTOR LASER TYPES:
- Distributed Feedback and Distributed Bragg Reflector laser diodes
- Vertical Cavity Surface Emitting Laser diodes
- Tunable laser diodes
- Quantum Cascade lasers
- Laser diode packaging

Initial competences

introductory photonics course

Final competences

1 Designing laser resonators
2 Handling Gaussian beams
3 Explaining the operation of different laser types
4 Explaining and deriving the dynamic behaviour of lasers
5 Analysing stimulated and spontaneous emission and absorption in semiconductors, gases, etc
6 Selecting laser types according to the applications

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

Guided self-study, lecture, seminar, seminar: coached exercises

Learning materials and price

lecture notes (English, to be printed out by students)

References

- O. Svelto, Principles of Lasers (4th Edition), Plenum Press, New York.

Course content-related study coaching

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

During examination period: oral closed-book exam, written preparation. The exam will always cover the 2 parts of this course (lasers and semiconductor lasers).

Calculation of the examination mark