EPFL

MICRO-422

Lasers: theory and modern applications

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

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	3 weekly
Exercises	1 weekly
Number of positions	

Summary

This course gives an introduction to Lasers by both considering fundamental principles and applications. Topics that are covered include the theory of lasers, laser resonators and laser dynamics. In addition to the basic concepts, a variety of interesting laser systems and applications are covered

Content

1. Introduction (Overview: History of the laser, Market application, Nobel Prizes,)- demo laser printer.
2. Basics of resonators and Gaussian beam optics.
3. Principle of laser operation: Lorentz model, dispersion theory.
4. Principle of laser operation: Laser oscillation, threshold, coherence.
5. Semiconductor and photonic nanostructured lasers
6. Laser dynamics : Laser oscillation, laser line-width, coherent population oscillations - AM, PM Noise.
7. (Gas and) Solid state lasers Optical fibers
8. Fiber laser and amplifiers Optical fibers
9. Ultrafast lasers, Femtosecond laser Frequency Metrology, Mode locked lasers, autocorrelation, FTIR
10. Ultrafast lasers, Femtosecond laser Frequency Metrology, Mode locked lasers
11. Detection of laser light (detector basics)
12. Optical parametric oscillators (OPO), Raman Lasers
13. Tools of laser light manipulation

Learning Prerequisites

Important concepts to start the course

This course requires an understanding of introductory physics in wave theory (incl. complex numbers) and familiarity with Maxwell equations and electromagnetism.

Learning Outcomes

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

- Able to compute absorption cross-section
- explain in details YAG, He-Ne, Ti-saphirre, external cavity lasers, fiber lasers
- Know shot and thermal noise, laser linewidth, relaxation oscillation
- know passive and active modelocking, methods to caracterize pulse duration
- Know phase matching, method to obtain phase matching
- know parametric gain, singly and doubly resonant lasers

Teaching methods

2 hours of class + 1 hour of exercises
Part of the class will be given via MOOC videos.

Assessment methods

The course grading is composed of a final written exam counting for 80% of the grade and of a topical presentation in the form of 45 minute presentation during class counting for 20% of the grade
Homework will be given every week. Solutions will be handed out. Homework will not be graded.It is strongly advised to make the effort to do the homework weekly.

Resources

Bibliography

Main text book:
Milonni, Eberly "Laser Physics" (Wiley Interscience)
Additional chapters will be selected from:
Saleh, B. E. A., and M. C. Teich. Fundamentals of Photonics. New York, NY: John Wiley and Sons, 1991. ISBN: 0471839655.
Yariv, A. Optical Electronics in Modern Communications. 5th ed. New York, NY: Oxford University Press, 1997. ISBN: 0195106261.Amnon Yariv "Quantum Electronics" (Wiley)

Ressources en bibliothèque

- Quantum Electronics / Yariv
- Laser Physics / Milonni
- Optical Electronics in Modern Communications / Yariv
- Fundamentals of Photonics / Saleh

Notes/Handbook

Polycopié:
"Theory and applications of lasers" by Tobias J. Kippenberg and Christophe Moser (available as pdf on Moodle)