Technology
Arts Sciences
TH Köln

Course
LT - Laser Physics and Technology

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General information

Long name	Laser Physics and Technology
Approving CModule	LT_BaET, LT_BaOPT
Responsible	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Level	Bachelor
Semester in the year	winter semester
Duration	Semester
Hours in self-study	78
ECTS	5
Professors	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Requirements	mathemtics: matrices differential calculus integral calculus physics / optics: basics of geometrical optics basics of wave optics
Language	German
Separate final exam	Yes

Final exam

Details

As long as the number of participants is not too high, oral examination is preferred of written exams.

Lowest competence level checked is knowledge. This could be e.g. structural components that are present in every laser, the definition of physical quantities like beam quality, beam quality factor, beam parameter product, or it could be wavelenths, typical power and fields of application of the mmost important industrialy lasers.

The next competence level is related to skills. Examination could be done by a beam calculation of a gaussian beam along an optical path with lenses, the calculation of the potential optical stability of a resonator, or by a rough calculation of the expected number of longitudianl modes of a laser with a given laser medium and given resonator parameters.

The highest competence level adressed is methodical expertise. It can be checked by the discussion of a real world task: E.g.: What are the basic parameters required for a welding process, semiconductor lithography or an medical operation of the eye. Give sound explainaitions and describe further procedure for parametrization and choice of laser source and optical equipment. Include economical and safety considerations. In a guided discussion it can be found out easily, if the underlying principles are understood and can be applied proactively, if intellectual transfer is made and if there is sufficient overview.

Minimum standard

Correct answer of at least 50 % of the questions

Exam Type

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Lecture

Learning goals

Knowledge

Types of lasers and their fileds of application

gas lasers

CO2 laser

excimer laser

argon ion laser

dye laser

solid state laser

diode laser

optical pump

telecommunication

laser material processing

laser principle

absorption, spontaneous emission, stimulated emission

Maxwell-Boltzmann distribution

inversion

3- and 4 level systems

rate equations

transversal modes

Frensel number

optical regimes: geometrical optics, Fresnel diffraction and Fraunhofer diffraction

diffraction operator, Eigenvalues and Eigenfunctions

Lagueree-Gauss modes and Hermite-Gauss modes

mathematics of Laguerre-Gauss modes

transversal monomode lasers

axial modes

resonator and standing waves

comb of modes and amplification bandwith

Fabry-Perot interferometer, Etalon

frequency bandwidth of an axial mode

quality factor and finesse

axially monomode laser

temporal coherence, coherence length

properties of the gaussian beam

complete definiton with one single parameter: beam radius or Rayleigh length

Beam quality and beam quality factor

diffraction limited beam as consequence of Heisenberg's uncertainty relation

propagation of gaussian beams

beam transfer matrices

ABCD law of beam propagation

Rayleigh length as location of strongest wavefront bending

types of - and reasons for - deviations of Gaussian beam propagation from geometrical optics

resonator design

g parameter

stability of resonators as a eigenvalue problem

stability diagram

stability and mode volume

If sufficient time in the semster left:

Ultra short pulse lasers

laser materials with high amplificationbandwidth

dispersion compensation

mode coupling and Kerr effect

hard and soft aperture mode coupling

starting mechanisms for mode coupling

orders of magnitude of physical properties of ultra short pulse lasers

average power

pulse peak power
intensity
light pressure
strength of the electrical field
energy transferred to electrons
light-matter interaction
warming an melting
vaporizing and subliming
photo disruption
electron-phonon coupling time
Coulomb explosion
generation of hard x-rays
cold material processing and its applications

Skills

classify laser materials
differentiate and classify transverse modes
calculate quality factor and finess of a Fabry-Perot interferometer
calculates the propagation of Gaussian beams
calculate the stability of a resonator
calculate the most important optical parameters of a laser
choose a suitable laser and optical system for a given application

All aquired knowledge is not ment to be fact based knowledge but should be inerconnected within by a deeper understanding of the underlying physical principles and intellectual transfer should be possible:

- physics of laser light generation and physical properties of laser light
- physics of light-matter interaction
- diffraction theory

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Lecture	2
Tutorial (voluntary)	0

Separate exam

none

Practical training

Learning goals

Skills

- build a laser, align and start it

- build a setup of measuring tranverse modes, measure traverse modes and calculate beam quality

- measure axial modes, find out the free spectral range, the spectral bandwith of a single mode, the amplification bandwidth of a laser, the coherence length of a laser

- build a diode pumped solid state laser

- build a unit for frequency doubling and use it in combination with a diode pumped solid state laser.

- write scientific report
describe the task
descirbe the idea of the solution
explain the experimental setup
explain the data processing
make error analysis
present the results and make a critical discussion

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Practical training	2
Tutorial (voluntary)	0

Separate exam

Exam Type

working on projects assignment with your team e.g. in a lab)

Details

1) Written examination questions related to the experiment have to be prepared at home and shown at the beginning of the laboratory.

2) The underlying ideas of the experiment have to be explained at the beginning of the laboratory.

3) Make the experiment alone (preferred) or in a team of two.
- Build up and adjust your own setup
- Acquire / measure date with this setup

4) Write a documentation on the experiment. It will be checked wih regard to
- completness
- scientific and precise language

- correctness

- understanding of the interrellations and interpretation of the results

Minimum standard

All written tasks must have been delt with.

The basic ideas of the experiment must have been understood.

All experiments must have been performed.

The reports must be free of systematical errors.