Technology
Arts Sciences
TH Köln

Course Manual 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
Valid from	winter semester 2022/23
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

Literature

Eichler, Eichler: Laser - Bauformen, Strahlführung, Anwendungen (Springer)

Poprawe: Lasertechnik (Copy-Shop AC-UNI-COPY)

Pedrotti, Pedrotti, Bausch, Schmidt: Optik für Ingenieure. Grundlagen (Springer)

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	EN mündliche Prüfung, strukturierte Befragung

− Lecture / Exercises

Learning goals

Goal type	Description
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

Special requirements

none

Accompanying material	lecture notes as downloadable file
Separate exam	No

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

− Practical training

Learning goals

Goal type	Description
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

Special requirements

none

Accompanying material	Instrcutions for the experiments as downloadable files. Operating manuals for complex equipment as downloadable files.
Separate exam	Yes

Separate exam

Exam Type	EN Projektaufgabe im Team bearbeiten (z.B. im Praktikum)

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.