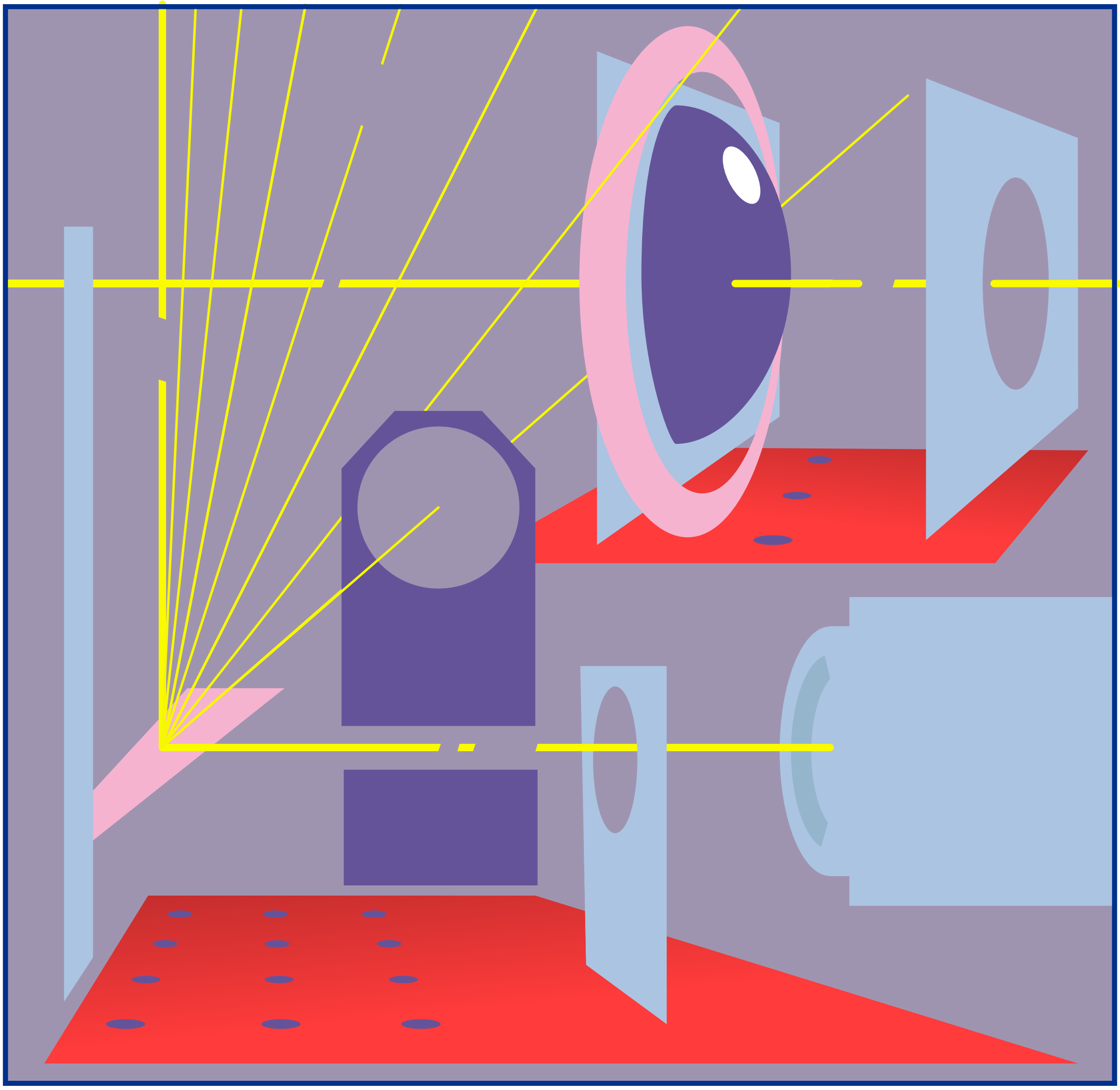
Course Catalogue Optical Technologies

Master of Science



Leibniz Universität Hannover

Course and Module Catalogue

for Examination Regulations 2017

Optical Technologies:
Photonics and Laser Technology

Master of Science

summer semester **2026**

Impressum

Faculty of Mechanical Engineering of the Leibniz Universität Hannover

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Introduction

Dear Students,

Hereby, you receive the current module catalogue of the Master Course "Optical Technologies". This course was established by the Faculty of Mechanical Engineering as well as the Faculty of Mathematics and Physics in cooperation with the Laser Zentrum Hannover e.V. in order to strengthen and promote the field of optical technologies in science and research in Hannover.

With this new master course you receive an education, which combines cutting edge basic and applied research in the fields of optics and photonics, physics and engineering and thus qualifies you for both the optics industries and academic research. In combination with your educational background - Bachelor of Science or Bachelor of Engineering – you acquire skills to apply scientific theory in research practice.

If required, the Office of Student Affairs supports you in planning and organizing your study. Do not hesitate to make use of this possibility. Furthermore, you will receive support from experienced students, scientific staff members of the institutes and the Hannover Centre for Optical Technologies (HOT).

We wish you the best for your studies

Prof. Dr.-Ing. M. Wurz

- Dean of studies -

*European Credit Transfer System

Contents Page

Introduction

Master of Science

Study profile

The master's degree program has the goal to train professionals and executives for the entire optics industry with a focus on "German Agenda Optical Technologies for the 21st Century".

On the national scale, Lower Saxony is already well positioned in the teaching of optics and photonics. Favorable conditions are specifically given in Hanover as a particularly close cooperation between the basic disciplines engineering and physics is well established. Furthermore, the Laser Zentrum Hannover constitutes a link between academic research and industry to involve the industrial partners in the current research and science and introduces academic students to the industry.

This interdisciplinary master's degree program is not primarily associated with only one faculty but combines the fundamental skills of the Faculty of Mathematics and Physics with the application knowledge of engineering.

Educational goals of the master's degree course optical technologies – Knowledge, Skills, Competence

It is expected from the future professionals in optics and photonics to not only be able to solve tasks and problems on the basis of engineering methods but also to have knowledge on the important basic principles of optical technologies.

This is ensured by corresponding compulsory courses offered in the master´s Degree program. The theoretical and practical training in physics is completed with specific topics in engineering, which can be selected from different competence areas. Practical training in the context of laboratory tests and an internship in an industrial area prepares the students for their professional activity in research based companies of the optical industry.

In addition, the Student Project and the master thesis help students to acquire skills for the independent handling of projects. Gaining experience in the planning and implementation of projects and the transfer of knowledge for the preparation of a proper project documentation and presentation of the project results are also among the primary objectives of this work. Building on the physical and engineering skills taught during the courses, the graduates are empowered to solve tasks and problems in the field of optical technologies. A target matrix of the master's degree program can be found in the appendix.

Didactic results

Graduates of the master´s degree program will acquire a broad knowledge in the field of optical technologies. Thus, the program teaches knowledge, skills and methods, which, due to the faculties' high proportion of research, represent the state-of-the-art in optics and photonics. Due to the internship in the field of industry, practical laboratory work as well as Student Project and master thesis, experience in project management, teamwork and scientific care in research activities can be gained.

Master's degree program Optical Technologies

The standard period of study is four semesters of which one semester is for the master thesis. Overall, 120 credit points (CP) are to be achieved, which are split into the following individual modules:

Basic courses	20 CP
Optional courses	35 CP
Master Lab	5 CP
Studium Generale and Tutorials	4 CP
Student Project	10 CP
Advanced Internship (12 weeks)	15 CP
Master Thesis	30 CP

Master Lab

The objective of the master lab is the practical application and consolidation of the theoretical knowledge gained in the attended lectures and exercises. The master lab includes experiments in mechanical engineering and physics but also in the fields of computer science and electrical engineering.

Several practical experiments are carried out, which are managed by the participating institutes. Although under supervision, the tests are carried out independently by student teams. Dates and registration details will be announced by the respective institutes.

Studium Generale

The Studium Generale serves the extra-professional qualification of the students. All courses at Leibniz University are recognized as part of this module. Courses for the student's native language as well as language courses below the course requirements are not credited.

Tutorials

Tutorials are used for conveying of key competences. Most tutorials include approximately 25 hours of attendance time or self-study time, corresponding to a 3-day seminar. Skills are taught in the fields of scientific research, media presentation, self and team organization, or the handling of scientific software.

The tutorial program will be expanded continuously. It can be picked up in the office of the dean of the faculty of mechanical engineering as either print or pdf version. Dates and registration details will be announced by the respective institutes.

Student Project

In the Student Project, students learn to work with a scientific task independently. From literature research to problem solving and subsequent presentation, the students will be introduced to working in the scientific field. The project requires a processing time of 300 hours.

Advanced Internship

The Advanced Internship prepares students for the productive cooperation in research based companies in the optical industry and in companies of other industries that use optics for quality control in the production or as part of a total product.

During the internship, the focus is laid on work which is closely related to the field of engineering within a development team or a research and development area. Usually, the student receives a subtask which he will work on, document, and present after proper training in the course of the internship.

The Advanced Internship lasts twelve weeks. Internships already completed can be credited. Further details are defined by the Internship Regulations and the Internship Office of the Faculty. In the case of previously completed internship, courses in the area of elective and elective courses with a total volume of 15 CP must be taken instead.

Master Thesis

The students have the opportunity to participate in an international research environment, and to work on a relevant scientific problem independently in accordance with a project plan developed by them. This includes the execution of respective experiments and calculations as well as the evaluation of their results. The students are able to document their work according to the problem and results in written form, and present and discuss it in a suitable way. Despite the expertise needed for this performance, they will, furthermore, improve their methodological skills, team skills, and self-competence.

The Master's degree thesis has a processing time of 900 hours. This corresponds to about 22.5 40-hour weeks.

Registration and De-registration of Examinations

From the winter semester of 2022/2023, the new master examination regulations of Leibniz Universität Hannover will come into force for the degree programmes at the Faculty of Mechanical Engineering. The most important change for students concerns the registration and deregistration of examinations as well as the amendment in the hearing procedure.

From the winter semester of 2022/2023 to take the examination, registration for the corresponding examination must be done during the exam registration period of the examination office for the corresponding examination. A subsequent registration is only possible in exceptional cases. The registration period will be announced at the beginning of the semester. Examination registration must be done online. In case the student does not wish to take part in an examination, it must be deregistered without quoting reasons either online through the portal or in writing to the examiner within the period provided for examination. If failed to do so, the examination will be assessed as "failed" in future. Further details on this are regulated under § 13 and § 15 of the master examination regulations valid from the winter semester of 2022/2023.

Failure to Pass and Exmatriculation

An individual examination can be repeated as often as a student like to, but only credit points for passed examinations will be offered. It is recommended to achieve an average of 30 ECTS credits per semester, but at least 15 ECTS must be achieved in a semester. On falling short of the 15 ECTS, there is a risk of exmatriculation. This can only be averted either through citing a valid reason or through applying for a hearing procedure. If a student fails to reach 15 LP in the semester, the hearing invitation will be sent by post, and the student will be requested to attend a hearing. Make sure to take the hearing post seriously, otherwise, it can lead to exmatriculation from the University.

More detailed information on the hearing procedure and a list of valid reasons can be found on the faculty homepage under "Studies → During studies →Exams → Hearing Procedure". In the master examination regulations, the hearing procedure is regulated under § 14. Valid reasons are intended to compensate for disadvantages caused by university involvement, or which are the result of external circumstances beyond control (e.g., illness). During the hearing procedure, the student will discuss their previous course of studies with an academic staff member and will check under what conditions and with which kind of support desired degree can be achieved.

Therefore, Students should contact the student consultation service as soon as possible if encounter these difficulties in their studies in order to eliminate such problems in advance!

Forms of Examination

Written or oral exams are administered by the teaching professor.

Forms of examination	
K	Written exam
KA	Multiple choice exam
MP	Oral exam
BA	Bachelor thesis
MA	Master thesis
ST	Student research project
HA	Assignment
PB	Internship report
SL	Course achievement
VbP	Examination accompanying the course

Further explanations can be found in the PO under:

Anlage 2 Prüfungsformen

Anlage 2.1 Definitionen zu Prüfungsformen

Exam Registration Period

Exam registration period from WiSe 2022/23		
Wintersemester		
	Timeperiod ONLY for VbP*	Timeperiod for all form of examination (EXCEPT VbP*)
Registeration period	15.10. - 31.10.	15.11. - 30.11.
Examination Period	01.11 - 28.02.	15.12. - 14.04.
Summersemester		
	Timeperiod ONLY for VbP*	Timeperiod for all form of examination (EXCEPT VbP*)
Registeration period	15.04. - 30.04.	15.05. - 31.05.
Examination Period	01.05. - 31.08.	15.06. - 14.10.

*VbP= Vorlesungsbegleitende Prüfungen (refer to Anlage 2.1 in Examination regulation)

Master´s degree Plan

Leibniz Universität Hannover

STUDIENDEKANAT MASCHINENBAU

Master´s Degree Programm Optical Technologies (MSc)
Examination Regulations 2017 - Photonics and Laser Technology

<table>
<tr><th>CP</th><th>1./2. Semester</th><th>1./2. Semester</th><th>3. Semester</th><th>4. Semester</th></tr>
<tr><td>1
2
3
4
5</td><td>Optical Measurement Technology
(5 CP)</td><td>Design and Simulation of Optomechatronic Systems
(5 CP)</td><td rowspan="2">Student Project
(10 CP)</td><td rowspan="5">Master Thesis
(30 CP)</td></tr>
<tr><td>6
7
8
9
10</td><td>Photonics
(5 CP)</td><td>Master Lab
(5 CP)</td></tr>
<tr><td>11</td><td rowspan="2">Laser Spectroscopy in Life Science
(5 CP)</td><td rowspan="3">Elective Modules
(20 CP)</td><td>Oral Presentation (1 CP)</td></tr>
<tr><td>12
13
14
15</td><td>Tutorials or
Studium Generale (4 CP)</td></tr>
<tr><td>16
17
18
19
20
21
22
23
24
25
26
27
28
29
30</td><td>Elective Modules
(15 CP)</td><td>Professional Qualification
(15 CP)

consisting of::
Intenship
12 Weeks
or
Electice Modules</td></tr>
</table>

CP	30	30	30	30

<table>
<tr><th colspan="4">Area of Competence</th></tr>
<tr><td>Compulsory</td><td>Elective</td><td>Key Competence</td><td>Student Project</td></tr>
<tr><td></td><td colspan="2">Master Thesis</td><td></td></tr>
</table>

https://www.maschinenbau.uni-hannover.de

Stand: 01.07.2024

Program Description

The Master of Science in Optical Technologies program is offered by the faculties of mechanical engineering and mathematics and physics and is coordinated by the faculties of mechanical engineering at the Leibniz University Hannover. It provides students with scientific knowledge and research training in optics and photonics. The program prepares students for seeking employment in industry and academia in areas as diverse as optical technologies, product development, and commercialization.

The study program includes a balanced course including interdisciplinary scientific courses and research training in the field of optical technologies, which is widely used in industry, telecommunications and modern consumer devices, ranging from the tiny lasers in many disc drives to the thousands of kilometers of optical fibers carrying signals between continents.

Admissions to the program occur both in the winter and summer term of each year and students are expected to finish the degree within two years. Upon successful completion of the program, the student is awarded a Master of Science (M.Sc.) degree.

Personal Prerequisites

Great interest in optical problems is certainly necessary; however, very good skills in physics and engineering or related areas are indispensable. Also, a systematic description of optical phenomena is not possible without mathematical formulations. Therefore, mathematical skills are also recommended. Abstraction abilities, inter- and transdisciplinary thinking and the ability to think and work logical are also helpful.

Essentially, the program is intended for students with a Bachelor of Science (B. Sc.) degree in mechanical engineering or physics or related area.

Obligatory and Optional Modules

Postgraduate students must ensure that they have a total of 120 Credits.

Obligatory Modules			
Winter Semester	**Credits**	**Summer Semester**	**Credits**
Laser Spectroscopy in Life Sciences	5	Design and Simulation of optomechatronic Systems	5
Optical Measurement Technology	5		
Photonics	5		

Optional Modules			
Winter Semester	**Credits**	**Summer Semester**	**Credits**
Advanced Nonlinear Optics	4	Advanced Photonics	5
Applied Wave Optics	4	Applied Wave Optics	4
Fundamentals and Configuration of Laser Beam Sources	5	Biophotonics – Imaging Physics and Manipulation of Biological Cells	4
Grundlagen der Lasermedizin	5	Computational Photonics	6
Grundlagen der Mikroskopie II	3	Grundlagen der Mikroskopie I	3
Image Sequence Analysis	5	Introduction to Computational Optics	5
Introduction to Nanophotonics	5	Journal Club - Optics and Photonics	2
Introductory Biophysics for Physics	3	Laser Material Processing	5
Journal Club - Optics and Photonics	2	Laser Measurement Technology	5
Laser Scanning – Modelling and Interpretation	5	Non-linear Optics	5
Optical Coatings and Layers for Engineering	5	Optical Clocks	5
Optik, Atomphysik und Quantenphänomene	8	Optical Radiometry	5
Photogrammetric Computer Vision	5	Proseminar Biophotonik	3
Production of Optoelectronic Systems	5	Quantum Information Processing	5
Radar Remote Sensing	5	Seminar Extreme Optics	3
Seminar Numerische Optik	3	Simulations in photonics (wave-optics)	5
Strong Field Physics	3	Ultrakurze Laserpulse	2

Course Descriptions

In this chapter, the descriptions of the individual courses (compulsory and elective) follow. For each course the course title as listed in the lecture list, the type of lecture, the course number, the responsible lecturer, the corresponding institute and a contact address in case of questions can be taken.

A short descriptive text is followed by the indication of study time as well as the ECTS credits to be awarded, which are to be evaluated as follows:

Presence and Self-Study time

The presence- or self-study time indicates how many hours the student has to invest in the course. The time the student actively participates in the lecture is considered to be the presence-time. The time it takes for the student to work up the content on his own or to work through the exercises is considered to be the self-study time.

ECTS-CP

The ECTS credit points are a measure of the processing time that students invest in a course. According to the stipulations of the Conference of Ministers of Education, one (1) ECTS-CP will be awarded per 25-30 hours of study time.

Course Volume

One semester week hour means 45 minutes of the course per week during the lecture period (around 14 to 15 weeks per semester)

L: Lecture

E: Exercise

La: Laboratory

S: Seminar

Modul: Design and Simulation of optomechatronic Systems

Module: Design and Simulation of Optomechatronic Systems

Type of module				Area of competence			
Pflicht				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	5	90 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Roland Lachmayer
Lecturer	Dr.-Ing. Tobias Biermann M. Sc. Malte Falkner
Institute	Institut für Produktentwicklung und Gerätebau
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Design and Simulation of optomechatronic Systems - Vorlesung	2	Written exam
Design and Simulation of optomechatronic Systems - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	keine

Qualification goals

The development of optomechatronic systems requires a profound understanding of physical principles as well as the ability to integrate optical, mechanical, and electronic components. Through the use of simulation tools and systematic development processes, students learn to design innovative solutions and make technically sound decisions.

In the module Design and Simulation of Optomechatronic Systems, students acquire the ability to methodically analyze complex optical systems, apply suitable modeling and simulation tools, and integrate both technical and design requirements into interdisciplinary development processes. They learn to purposefully select optical components, understand their interactions, and develop innovative solutions for optical applications.

After completing the module, students are able to:
• analyze and model optical systems regarding their function, structure, and requirements.
• select appropriate optical materials and manufacturing technologies for specific applications.
• apply optical simulation software for the calculation and optimization of systems.
• integrate light sources, sensors, and measurement instruments into optomechatronic systems

Contents

• Fundamentals of light propagation, optical components, and optomechatronic systems
• Introduction to the physiology of human vision and its significance for technical applications
• Modeling and simulation of optical systems using specialized software
• Overview of light sources, sensors, and measurement techniques in optical applications
• Systematic development and analysis of optomechatronic applications (e.g., vehicle headlights, LIDAR, spectroscopy)

Special features

Lecture and exercise will be held in English. Alongside the exercise there will be an optional project. Der alte Name des Moduls lautet Konstruktion Optischer Systeme.

Modul: Design and Simulation of optomechatronic Systems

Module: Design and Simulation of Optomechatronic Systems

Literature
Umdruck zur Vorlesung
Applicability in other degree programs
AI Driven Mechatronics and Robotics M. Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optische Technologien M.Sc.;

Modul: Laser Spectroscopy in Life Sciences

Module: Laser Spectroscopy in Life Sciences

Type of module				Area of competence			
Pflicht				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	5	90 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Bernhard Roth
Lecturer	Dr. Axel Günther
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Spectroscopy in Life Sciences - Vorlesung	2	Written exam
Laser Spectroscopy in Life Sciences - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	Basic physics, optics and laser physics, laser applications optical components and measurement principles, spectroscopy, laser interferometry.

Qualification goals

The aim of this lecture course is the introduction to the fundamentals and methods in laser spectroscopy for application in the life sciences. The exercise course aims at consolidating the understanding of the basic principles given as well as at their application for practical examples.

Contents

Apart from the basic principles of laser spectroscopic techniques and methods applied in the various up-to-date areas of fundamental research, practical applications in the life sciences such as biology, chemistry, and medicine will be taught. The students will also gain insight into modern measurement devices and methods which are broadly employed. The main applications field will be presented in depth.

Special features

Recommended for second semester and higher (Master course).

Literature

Wolfgang Demtröder: Laserspektroskopie 1: Grundlagen (Springer), 2011
Wolfgang Demtröder: Laserspektroskopie 2: Experimentelle Techniken (Springer), 2012
Jürgen Eichler, Hans Joachim Eichler: Laser - Bauformen Strahlführung Anwendungen (Springer), 2006; These and other sources are available as free download from www.springer.com, in German and English.

Modul: Laser Spectroscopy in Life Sciences

Module: Laser Spectroscopy in Life Sciences

Applicability in other degree programs
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Optische Technologien M.Sc.;

Modul: Masterarbeit

Module: Master Thesis

Modultyp				Kompetenzbereich			
Pflicht				Masterarbeit			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe/SoSe	1 Semester	Deutsch/Englisch	30	Zulassung WiSe:	4. Semester	Zulassung SoSe:	4. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
PL	Masterarbeit	29	50-60 Seiten (ohne Literatur)	benotet
SL	Präsentation	1	20 min	unbenotet

Workload	900 h
Präsenzstudienzeit	0 h
Selbststudienzeit	900 h
Modulverantwortliche-r	Prof. Dr.-Ing. Marc-Christopher Wurz
Dozent-in	Dozenten der Fakultät für Maschinenbau
Institut	Diverse Institute der Fakultät für Maschinenbau
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls		
Veranstaltungstitel und Form	SWS	PL / SL
		Masterarbeit Präsentation

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
mind. 60 LP + Studienarbeit + 12 Wochen Fachpraktikum	keine

Qualifikationsziele

Das Modul dient der Erstellung der Masterarbeit.

Nach dem erfolgreichen Absolvieren des Moduls sind Studierende in der Lage,
- ein wissenschaftliches Projekt selbständig zu planen und in einem begrenzten Zeitraum durchzuführen,
- eine wissenschaftliche Problemstellung aus einer Fachrichtung des Maschinenbaus mit wissenschaftlichen Methoden zu bearbeiten,
- Ergebnisse theoretisch einzuordnen und zu beurteilen,
- Ergebnisse nach fachwissenschaftlichen Standards in schriftlicher Form darzustellen und einem Fachpublikum zu präsentieren.

Inhalte

Fragestellungen aus den Ingenieurwissenschaftlichen Schwerpunktbereichen.

Besonderheiten

Um eine Masterarbeit anmelden zu können, werden ein/eine Erstprüfer/in der Fakultät für Maschinenbau und ein/eien Zweitprüfer/in der Fakultät für Maschinenbau oder einer anderen Fakultät benötigt.

Modul: Masterarbeit

Module: Master Thesis

Literatur
Diverse
Verwendbarkeit in anderen Studiengängen
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Modul: Masterlabor

Module: Master Lab

Modultyp	Kompetenzbereich
Pflicht	Schlüssselkompetenzen

Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe/SoSe	1 Semester	Deutsch/Englisch	5	Zulassung WiSe:	1/2. Semester	Zulassung SoSe:	1/2. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)

Art		ECTS	Dauer / Umfang	Notenskala
SL	Labor	5	Versuche aus fünft verschiedenen Laboren	unbenotet

Workload	150 h
Präsenzstudienzeit	14 h
Selbststudienzeit	136 h
Modulverantwortliche-r	Prof. Dr.-Ing. Marc-Christopher Wurz
Dozent-in	Diverse
Institut	Institut für Mikroproduktionstechnik
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Masterlabor - Labor	1	Labor

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	keine

Qualifikationsziele

In den Masterlaboren werden anwendungsbezogene ingenieurwissenschaftliche Kompetenzen vermittelt. Die Studierenden erlangen praktische Kompetenzen im experimentellen und simulatorischen Vorgehen. Sie sind nach Abschluss des Masterlabores in der Lage, Versuche eigenständig zu planen und durchzuführen.

Inhalte

Im Modul Masterlabor werden laborpraktische Veranstaltungen der Fakultät für Maschinenbau belegt. Es müssen fünf verschiedenen Labore belgt werden, ausgewählt werden kann zwischen

- Augmented Reality Labor Quanten Kryptographie
- Dämpfung in Lichtwellenreitern
- Faraday Effekt
- Michelson Interferometer
- Optische Technologien
- Speckle Interferometer
- Videoprojektotechnologie

Besonderheiten

Studierende, die im Rahmen der Masterzulassung Auflagen erhalten haben, müssen diese vor Beginn des Masterlabores bestanden haben.

Literatur

Verwendbarkeit in anderen Studiengängen

Optische Technologien M.Sc.;

Modul: Optical Measurement Technology

Module: Optical Measurement Technology

Type of module				Area of competence			
Pflicht				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam / Oral exam	5	90 min/20 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr.-Ing. Christian Pape
Lecturer	Dr.-Ing. Christian Pape
Institute	Institut für Mess- und Regelungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optical Measurement Technology - Vorlesung	2	Written exam / Oral exam
Optical Measurement Technology - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
none	Measurement Technology I

Qualification goals

The module gives an overview on theory, methods and devices in optical metrology.

After successful completion of the module, students are able
- to explain and apply basic concepts of optical metrology,
- to apply the basics of geometrical optics and wave optic,
- to compare different light sources and sensors and assign them to the measurement task,
- to explain fibre optic systems,
- to compare methods from the fields of surface metrology and geometric metrology and evaluate them for the application case.

Contents

At the beginning, fundamentals of optics and photonics such as ray and wave optics are revised, which are essential for the understanding of concepts in optical metrology. Focusing on metrology in research and industrial applications, the lecture covers optical methods for measurement of topography, distance, and deformation as well as fiber optical sensors, which include concepts such as interferometry, holography and confocal microscopy. In addition, semi-optical methods such as atomic force microscopy and near field microscopy are addressed and compared to non-optical methods, e.g., scanning electron microscopy. To gain an in-depth understanding of the concepts involved in optical metrology, all devices and optical setups are explained in detail including light sources, cameras, and optical elements.

Special features

Examination depending on the number of participants: Individual examination 20 minutes orally or 90 minutes in writing.

Literature

Born, Wolf. Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light; Demtröder: Experimentalphysik; Saleh, Teich: Grundlagen der Photonik; Lauterborn, Kurz: Coherent Optics; Goodman: Introduction to Fourier Optics; Hugenschmidt: Lasermesstechnik; These and other sources are available as free download from www.springer.com in German and English.

Modul: Optical Measurement Technology

Module: Optical Measurement Technology

Applicability in other degree programs
AI Driven Mechatronics and Robotics M. Sc.; Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Medizintechnik B.Sc.; Nanotechnologie M.Sc.; Optische Technologien M.Sc.;

Modul: Photonics

Module: Photonics

Type of module	Area of competence						
Pflicht	Photonics and Laser Technology						
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Oral exam	3	20 min	graded
PL	Project-oriented form of examination	2	Seminar presentation	graded

Workload	150 h
Attendance study period	70 h
Self-study time	80 h
Module coordinator	Prof. Dr. Boris Chichkov
Lecturer	Prof. Dr. Boris Chichkov
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Photonics - Vorlesung Photonics - Übung Photonics - Seminar	2 1 2	Oral exam Project-oriented form of examination

Requirements for participation:	Recommended for participation:
none	Kohärente Optik, Nichtlineare Optik

Qualification goals

The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents

- Waves in Media and at Boundaries
- Dielectric Waveguides (planar, fiber), Integrated Waveguides
- Waveguide Modes
- Nonlinear Fiber Optics
- Fiber optic components (Circulators, AWG, Fiber-Bragg-Gratings, Modulators), Optical Communication (WDM/TDM)
- Fiberlaser
- Laserdiodes, Photodetectors
- Plasmonics, Photonic Crystals
- Transformation Optics

Special features

Notenzusammensetzung: 80% Note der mündlichen Prüfung oder der Klausur; 10% Note für Inhalt und 10% Note für Form des Seminarvortrags

Literature

Literatur: Saleh: Fundamentals of Photonics, Wiley.Reider: Photonik, Springer; Menzel: Photonik, Springer. Originalliteratur.

Applicability in other degree programs

Nanotechnologie M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Studienarbeit

Module: Project Work

Modultyp				Kompetenzbereich			
Pflicht				Studienarbeit			
Angebot im	**Dauer**	**Sprache**	**ECTS**	**Empfohlen ab**			
WiSe/SoSe	1 Semester	Deutsch	11	**Zulassung WiSe:**	3. Semester	**Zulassung SoSe:**	3. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		**ECTS**	**Dauer / Umfang**	**Notenskala**
PL	Studienarbeit	10	20-30 Seiten	benotet
SL	Präsentation	1	20 min	unbenotet

Workload	330 h
Präsenzstudienzeit	0 h
Selbststudienzeit	330 h
Modulverantwortliche-r	Prof. Dr.-Ing. Marc-Christopher Wurz
Dozent-in	Dozenten der Fakultät für Maschinenbau
Institut	Institut für Mikroproduktionstechnik
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls		
Veranstaltungstitel und Form	**SWS**	**PL / SL**
		Studienarbeit Präsentation

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	keine

Qualifikationsziele

Das Modul dient der Einübung wissenschaftlicher Arbeitstechniken.

Nach erfolgreichem Abschluss sind die Studierenden in der Lage,
- eine wissenschaftliche Fragestellung zu formulieren,
- geeignete wissenschaftliche Methoden auszuwählen, um in Test- und Laborreihen zu wissenschaftlichen Ergebnissen zu erlangen
- die Ergebnisse der Studienarbeit dem Betreuungspersonal zu präsentieren, darzulegen und zu hinterfragen

Inhalte

- Standards und Methoden des wissenschaftlichen Arbeitens
- Bearbeitung eines wissenschaftlichen Themas unter Betreuung eines der am Studiengang beteiligten Institute

Besonderheiten

Modul: Studienarbeit

Module: Project Work

Abweichend vom Studiengang Maschinenbau haben die anderen Masterstudiengänge der Fakultät für Maschinenbau nachfolgende Verantwortliche Personen: Mechatronik und Robotik: Alle Institute der Fakultät für Maschinenbau und der Fakultät für Elektrotechnik und Informatik sowie der Fakultät für Bauingenieurwesen und Geodäsie Optische Technologien: Fakultät für Mathematik und Physik und Fakultät für Maschinenbau Biomedizintechnik: Fakultät für Maschinenbau und ausgewählte Professoren*innen der Fakultät für Elektrotechnik und Informatik
Literatur
keine
Verwendbarkeit in anderen Studiengängen
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc. PO 2017; Nachhaltige Ingenieurwissenschaft M.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Modul: Tutorien oder Studium Generale

Module: Tutorials or Studium Generale

Modultyp				Kompetenzbereich			
Pflicht				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe/SoSe	1 Semester	Deutsch/Englisch	4	Zulassung WiSe:	3. Semester	Zulassung SoSe:	3. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala

Workload	120 h
Präsenzstudienzeit	0 h
Selbststudienzeit	120 h
Modulverantwortliche-r	Prof. Dr.-Ing. Marc-Christopher Wurz
Dozent-in	Diverse
Institut	Institut für Mikroproduktionstechnik
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	keine

Qualifikationsziele

Die Studierenden sind in der Lage, übergreifende fachliche und überfachliche Themenkomplexe aufzuarbeiten und in einen ingenieurwissenschaftlichen Zusammenhang zu stellen.

Inhalte

Im Modul Tutorien oder Studium Generale besteht die Möglichkeit Tutorien der Fakultät für Maschinenbau (Beschreibungen im Tutorien und Labore Katalog) zu belegen oder Module der Leibniz Universität Hannover. Bei den uniweiten Modulen erhalten Sie weitere Informationen in den
Modulbeschreibungen der jeweiligen Fakultäten oder zentralen Einrichtungen (ZQS).

Besonderheiten

keine

Literatur

keine

Verwendbarkeit in anderen Studiengängen

Biomedizintechnik M.Sc.; Maschinenbau B.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc. PO 2017; Produktion und Logistik M.Sc.;

Modul: Advanced Nonlinear Optics

Module: Advanced Nonlinear Optics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	4	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Oral exam	2	60 min	graded
SL	Academic achievement	2	questions during the lecture	ungraded

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Prof. Dr. Andrea Trabattoni
Lecturer	Prof. Dr. Andrea Trabattoni
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Advanced Nonlinear Optics - Vorlesung	2	Oral exam Academic achievement

Requirements for participation:	Recommended for participation:
none	Basic knowledge of optics, laser physics, atomic physics. “Nonlinear optics” course.

Qualification goals

The students will acquire knowledge on advanced light-matter interactions, from the mathematical and physical point of view. They will learn about the nonperturbative physics of ultraintense and strong laser fields, and important concepts around light-driven dynamics in atoms, molecules and materials. The lecture will be accompanied by numerical exercises and practical examples to guide the students through cutting-edge topics of light-matter interactions.

Contents

- Overview of light-atom interactions.
- The photoelectric effect and beyond.
- Overview of perturbative nonlinear optics.
- The breakdown of the perturbative picture.
- Above-threshold ionisation.
- Multi-photon absorption vs. electron tunnelling.
- Atoms interacting with high-energy photons.
- Light-driven electronics in matter.
- Photo-driven electron-nucleus interactions in nuclear transitions.

Special features

Literature

Boyd, Nonlinear Optics, Academic Press. J.C. Diels, W. Rudolph: Ultrashort Laser Pulse Phenomena, 2 Ed. (Elsevier, 2006). Thomas Brabec, "Strong Field Laser Physics”, Springer Series in optical sciences (2008). Published research papers will be suggested during the course.

Applicability in other degree programs

Optische Technologien M.Sc.;

Modul: Advanced Photonics

Module: Advanced Photonics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1/2. Semester	Admission SoSe:	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Oral exam	5	45 min	graded

Workload	150 h
Attendance study period	84 h
Self-study time	66 h
Module coordinator	Prof. Dr. Georg von Freymann
Lecturer	Dr. Julian Schulz
Institute	Institut für Photonische Systeme und Technologien/ Quanten-Technologie und Photonik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Advanced Photonics - Vorlesung	4	Oral exam
Advanced Photonics - Übung	2	

Requirements for participation:	Recommended for participation:
none	knowledge of Maxwells equations, wave propagation, fundamental optics

Qualification goals

The students gain in-depth knowledge about modern optical materials like photonic crystals, quasicrystals and photonic crystal fibres, metamaterials and -surfaces, transformation optics, and photonic quantum simulation. They can describe and apply the corresponding mathematical methods, read and understand photonic bandstructures. Fabrication technologies as well as numerical tools and approaches will be discussed. Numerical methods will be trained and recent literature will be discussed in the excercises. Furthermore, students develop their methods in literature research as well as their ability to lead scientific discussions.

Contents

• Optical properties of dielectric and metallic matter (Drude-Lorentz model), waveguides, plasmonics
•1D, 2D, 3D photonic crystals photonic quasicrystals and photonic crystal fibres: bandstructures, materials and fabrication and experimental characterization techniques
•photonic metamaterials and metasurfaces, negative-index materials, transformation optics, invisible cloaks, metalenses: design, materials and fabrication and experimental characterization techniques
•foundations of photonic quantum simulation, topological photonics

Special features

none

Literature

- "Optik", E. Hecht, De Gruyter Studium (just as a reminder)
- "Periodic nanostructures for photonics", K. Busch et al., Physics Reports 444, 101 (2007) (review article on photonic crystals and photonic metamaterials)
- "Photonic Crystals, Molding the Flow of Light, second edition", J.D. Joannopoulos, S. G. Johnson, J.N. Winn, R.D. Meade, Princeton University Press (2008), (nice textbook, free download: http://ab-initio.mit.edu/book/)
- "Optical Properties of Photonic Crystals", K. Sakoda, Springer (2001), (advanced theory, mostly 2D, good introduction into symmetry properties)
- "Principles of Nano-Optics", L. Novotny, B. Hecht, Cambridge University Press (2012), (introduction to nano-optics with some emphasize on SNOM, nice chapters on photonic crystals and plasmonics)

Modul: Advanced Photonics

Module: Advanced Photonics

Applicability in other degree programs
Optische Technologien M.Sc.;

Modul: Applied Wave Optics

Module: Applied Wave Optics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe/SoSe	1 Semester	Englisch	4	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam / Oral exam	4	90 min/ 30 min	graded
SL	Oral exam	0	30 min	ungraded

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Dr.-Ing. Reinhard Caspary
Lecturer	Dr.-Ing. Reinhard Caspary
Institute	Cluster of Excellence PhoenixD
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Applied Wave Optics - Vorlesung	2	Written exam / Oral exam Oral exam

Requirements for participation:	Recommended for participation:
none	Electromagnetism, Maxwell’s equations, geometrical optics.

Qualification goals

The students describe the physical principles of dielectric waveguides. They derive the behaviour of electromagnetic fields and waves at interfaces from Maxwell’s equations. Based on this, they describe the prerequisites and properties of total reflection. From the conditions for total reflection and constructive interference, they develop the characteristic equation of wave guidance. They solve the wave equation graphically for simple film waveguides and develop the transverse modes in more complicated waveguiding structures based on this. They use the concept of mode expansion to describe non-ideal waveguides as well as coupling structures in practice. The students explain the significance of stable or unstable laser resonators and derive stability criteria for simple resonators using the transfer matrix method. They explain the concept of coherence of optical radiation and describe experiments for measuring the coherence length. They derive the basic terms of the rate equation for lasers and name important consequences from the rate equation in the steady state. They derive laser threshold and laser modes from the transmission of the Fabry-Perot resonator. The students describe the recording and reproduction of transmission holograms and derive important boundary conditions. They compare holography with photography and tomography. They identify the holographic recording as an interferogram and derive its diffraction properties mathematically. They name the two basic concepts of digital holography and explain digital holographic microscopy as an application example.

Contents

- Maxwells equations, wave equation
- Plane waves, Poyntings theorem
- EM fields at interfaces
- TE/TM waves, Fresnel equations
- Wave guiding, transversal modes
- Mode expansion, mode coupling
- Coupling structures
- Laser resonator, resonator stability
- Optical coherence
- Rate equations, gain equations
- Transmission holograms

Modul: Applied Wave Optics

Module: Applied Wave Optics

- Digital holography, computer generated holograms
Special features
keine
Literature
A. Ghatak: Optics; F. A. Jenkins, H. E. White: Fundamentals of Optics; K. J. Ebeling: Integrated Optoelectronics; F. K. Kneubühl, M. W. Sigrist: Laser; J. W. Goodman: Introduction to Fourier Optics
Applicability in other degree programs
Optische Technologien M.Sc.;

Modul: Biophotonics - Imaging Physics and Manipulation of Biological Cells

Module: Biophotonics - Imaging Physics and Manipulation of Biological Cells

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	4	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	4	90 min	graded

Workload	120 h
Attendance study period	28 h
Self-study time	92 h
Module coordinator	Prof. Dr. Alexander Heisterkamp
Lecturer	Prof. Dr. Alexander Heisterkamp
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Biophotonics - Imaging Physics and Manipulation of Biological Cells - Vorlesung	2	Written exam

Requirements for participation:	Recommended for participation:
keine	Basic knowledge in coherent optics, Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics

Qualification goals

The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions

Contents

Within the lecture "Biophotonics" laser technologies and optical methods will be introduced, which are applied within modern cell biology, regenerative medicine and the field of tissue engineering. Especially laser-based imaging technologies, applied at the cellular level, will be covered, as well as tissue characterization and 3D volumetric imaging.
This includes:
- the fundamentals of microscopical imaging
- different contrast mechanisms and optical clearing
- optical coherence tomography
- laser scanning microscopy and super resolution approaches
- application within biotechnology, such as biochips
- cell sorting and cell surgery and interaction with nanoparticles and nanostructures will be discussed.

Special features

keine

Literature

Prasad, Paras N.: Introduction to Biophotonics. John Wiley & Sons 2003. Jürgen Popp: Handbook of Biophotonics, Volume 1: Basics and Techniques, Jürgen Popp (Editor), Valery V. Tuchin (Editor), Arthur Chiou (Editor), Stefan H. Heinemann (Editor), ISBN: 978-3-527-41047-7 (TIB-Signatur: T 12 B 5852) Min Gu: Femtosecond Biophotonics: Core Technology and Applications. Cambridge University Press, 2010. ISBN: 0521882400 (TIB-Signatur: T 10 B 5962) Adam Wax: Biomedical Applications of Light Scattering, New York, NY [u.a.] : McGraw-Hill, 2010, ISBN: 978-0-07-159880-4 (TIB-Signatur: T 09 B 8078)

Modul: Biophotonics - Imaging Physics and Manipulation of Biological Cells

Module: Biophotonics - Imaging Physics and Manipulation of Biological Cells

Applicability in other degree programs
Biomedizintechnik M.Sc.; Nanotechnologie M.Sc.; Optische Technologien M.Sc.;

Modul: Computational Photonics

Module: Computational Photonics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
SoSe	1 Semester	Englisch	6	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Written exam	4	90 min	graded
SL	Academic achievement	2	Course work	ungraded

Workload	180 h
Attendance study period	56 h
Self-study time	124 h
Module coordinator	apl. Prof. Dr. Ayhan Demircan
Lecturer	Priv.-Doz. Dr. Ihar Babushkin apl. Prof. Dr. Ayhan Demircan Dr. Oliver Melchert
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Computational Photonics - Vorlesung	2	Written exam
Computational Photonics - Hörsaalübung	2	Academic achievement

Requirements for participation:	Recommended for participation:
none	Nonlinear Optics

Qualification goals

The lecture explains various main numerical methods and techniques to solve scientific problems in linear and nonlinear optics. The studends deepen the knowledge in photonics by performing computer experiments. After successful completion of the module, the students are able to elaborate strategies to solve complex problems in optics using a computer.

Contents

The lecture is organized in two parallel-running tracks: Photonics Fundamentals, and Numerical Methods.

The course has a practical exercise component providing the student with basic computer simulation experience.
Topics:

•Light-matter interaction (Chromatic and geometric dispersion, secondand third-order susceptibility, Raman scattering, supercontinuum generation, multiphoton und tunneling ionization, low-order harmonic radiation)
•Light transport in turbid media
•Photoacoustics
•Matrix optics
•Pulse propagation equations
•Atoms in strong optical fields (Schrödinger equation for atoms, Higher-Harmonic generation, Brunel/THz radiation, attosecond optics)
•Computer modeling methods in electromagnetics (Time-domain solvers, frequency domain methods, finite element methods)
•Monte Carlo method
•Spectral and Pseudospectral methods
•Runge-Kutta and operator splitting approach
•Parallel computing (openMP, openMPI)

Modul: Computational Photonics

Module: Computational Photonics

Special features
In order to pass the module, the course work must be successfully completed in addition to the examination work.
Literature
Obayya: Computational Photonics; Joachain/Kylstra/Potvliege: Atoms in Intense Laser fields; Lux/Koblinger: Monte Carlo Particle Transport Methods: Neutron and Photon Calculations
Applicability in other degree programs
Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Fundamentals and Configuration of Laser Beam Sources

Module: Fundamentals and Configuration of Laser Beam Sources

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Written exam / Oral exam	5	90 min.	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. rer. nat. Dietmar Kracht
Lecturer	Prof. Dr. rer. nat. Dietmar Kracht
Institute	Laser Zentrum Hannover e.V.
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Fundamentals and Configuration of Laser Beam Sources - Vorlesung	2	Written exam / Oral exam
Fundamentals and Configuration of Laser Beam Sources - Übung	1	

Requirements for participation:	Recommended for participation:
none	

Qualification goals

The lecture gives an overview of different types of laser beam sources. In the basic part the concepts for the generation of laser radiation in various active media for different applications as well as requirements for optical resonators are presented. Different pumping schemes and concepts are discussed for the various laser systems, especially gas-, diode and solid-state lasers. In addition, the operating modes continuous, pulsed and ultrashort pulsed will be explained in more detail. Based on the basic considerations and concepts, real laser beam sources are presented and analyzed.

Contents

The following contents will be taught in the course and through demonstrations: basics of laser beam sources, operation modes of lasers, laser characterization, laser diodes, optical resonators, CO2 lasers, excimer lasers, laser concepts and laser materials, rod lasers and disk lasers, fiber lasers and amplifiers, frequency conversion, lasers for space applications and ultrashort pulse lasers.

Special features

The lecture will take place at Laser Zentrum Hannover e.V. (LZH) Hollerithallee 8, 30419 Hannover. The course is taught in English. Contents equal to German course "Grundlagen und Aufbau von Laserstrahlquellen" taught in winter term. Students are only allowed to receive the 5 credit points once, either from this course or from "Grundlagen und Aufbau von Laserstrahlquellen" course.

Literature

keine

Applicability in other degree programs

Modul: Grundlagen der Lasermedizin

Module: Fundamentals of Laser Medicine

Type of module		Area of competence					
Wahl		Photonics and Laser Technology					
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Written exam	4	90 min	graded
SL	Academic achievement	1	Online Tests	ungraded

Workload	150 h
Attendance study period	28 h
Self-study time	122 h
Module coordinator	Prof. Dr. Alexander Heisterkamp
Lecturer	Prof. Dr. Alexander Heisterkamp
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Grundlagen der Lasermedizin - Vorlesung	2	Written exam Academic achievement

Requirements for participation:	Recommended for participation:
keine	Coherent Optics, Photonics or Nonlinear Optics recommended

Qualification goals

The lecture explains laser medicine with basics from biophotonics. The laser principle, types of medical lasers and their effects on biological tissue are presented. As current clinical application, laser surgery of the eye based on ultrashort pulse lasers is discussed. After a fundamental introduction to tissue optics with its various absorption and scattering processes, imaging techniques such as optical coherence tomography (OCT) and two-photon microscopy will be explained. After the lecture, an excursion with laboratory and company visit is offered.

Contents

- Laser systems for the application in medicine and biology
- Beam guiding systems and optical medical devices
- Optical properties of tissues
- Thermal properties of tissues
- Photochemical interaction
- Vaporization/coagulation
- Photoablation, optoacoustics
- Photodisruption, nonlinear optics
- Applications in ophthalmology, refractive surgery
- Laser-based diagnostics, optical biopsy
- Optical coherence tomography, theragnostic
- Clinical examples

Special features

Possible separate module: Block seminar with topics from Laser in Medicine (has to be selected separately).

Literature

Eichler, Seiler: "Lasertechnik in der Medizin"; Springer-Verlag Welch, van Gemert: "Optical-Thermal Response of Laser-Irradiated Tissue"; Plenum Press Berlien, Müller: "Angewandte Lasermedizin"; Bd. 1,2, eco med Verlag Berlien, Müller:

Modul: Grundlagen der Lasermedizin

Module: Fundamentals of Laser Medicine

"Applied Laser Medicine"; Springer-Verlag Berns, Greulich: "Laser Manipulation of Cells and Tissues"; Academic Press
Applicability in other degree programs
Biomedizintechnik M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Grundlagen der Mikroskopie I
Module: Introduction to Microscopy I

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
SoSe	1 Semester	Deutsch/Englisch	3	Zulassung WiSe:	1/2. Semester	Zulassung SoSe:	1/2. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
PL	Project-oriented form of examination	3		graded

Workload	90 h
Präsenzstudienzeit	42 h
Selbststudienzeit	48 h
Modulverantwortliche-r	Dr. Axel Günther
Dozent-in	Dr. Axel Günther
Institut	Hannoversches Zentrum für Optische Technologien
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Grundlagen der Mikroskopie I - Seminar	3	Project-oriented form of examination

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	keine

Qualifikationsziele

Im Rahmen dieses Moduls erlernen die Studenten grundlegende Kenntnisse zum Aufbau und der Funktionsweise von Mikroskopen die im Rahmen des praktischen Modulteils vertieft werden. Zu dem praktischen Teil des Moduls, der in Gruppen ausgeführt wird, sollen die Studenten Berichte anfertigen, die am Ende final diskutiert werden. Neben der fachlichen Kompetenz erlernen die Studierenden die selbstständige Arbeit im optischen Labor, die Umsetzung technischer und wissenschaftlicher Erkenntnisse und vertiefen ihre Fähigkeiten wissenschaftliche Diskussionen zu führen.

In this module, students will learn basic knowledge about the construction and operation of microscopes, which is deepened in a practical part of the module. In the practical part, which is carried out in groups, the students are expected to prepare reports which are discussed at the end of the module. In addition to their technical competence, students will learn to work independently in the optical laboratory, to implement technical and scientific knowledge and their ability to lead scientific discussions.

Inhalte

- Grundlagen der Bildgebung
  - Aberrationen und Beleuchtung
  - Abbe-Theorie in der Bildgebung
  - Kontrastmethoden
  - Köhler Beleuchtung
  - Dunkelfeld-Mikroskopie
  - Kontrastverfahren
- Moderne Mikroskopietechniken
  - Introduction to Optical Imaging
  - Aberrations and Illumination
  - Abbe Theory of Image Formation
  - Köhler Illumination
  - Dark Field Imaging
  - Contrast Methods
  - Recent developments in microscopy

Modul: Grundlagen der Mikroskopie I

Module: Introduction to Microscopy I

Besonderheiten
keine
Literatur
Saleh und Teich: Grundlagen der Photonik Meschede: Optik, Licht und Laser Meschede: Optik, Licht und Laser Switz and Fletcher: Optical Microscopy Course
Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Grundlagen der Mikroskopie II
Module: Fundamentals of Microscopy II

Modultyp	Kompetenzbereich
Wahl	Photonics and Laser Technology

Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe	1 Semester	Deutsch/Englisch	3	Zulassung WiSe:	1/2. Semester	Zulassung SoSe:	1/2. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)

Art		ECTS	Dauer / Umfang	Notenskala
PL	Projektorientierte Prüfungsform	3		benotet

Workload	90 h
Präsenzstudienzeit	56 h
Selbststudienzeit	34 h
Modulverantwortliche-r	Dr. Axel Günther
Dozent-in	Dr. Axel Günther
Institut	Hannoversches Zentrum für Optische Technologien
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Grundlagen der Mikroskopie II - Vorlesung Grundlagen der Mikroskopie II - Labor	2 2	Projektorientierte Prüfungsform

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	Grundlagen der Mikroskopie I

Qualifikationsziele

Im Rahmen dieses Moduls erlernen die Studenten fortgeschrittene Kenntnisse zum Aufbau und der Funktionsweise von unterschiedlichen Mikroskopen. Im Rahmen des praktischen Modulteils werden verschiedene Mikroskopietechniken vertieft. Zu dem praktischen Teil des Moduls, der in Gruppen ausgeführt wird, sollen die Studenten Berichte anfertigen, die am Ende final diskutiert werden. Neben der fachlichen Kompetenz erlernen die Studierenden die selbstständige Arbeit im optischen Labor, die Umsetzung technischer und wissenschaftlicher Erkenntnisse und vertiefen ihre Fähigkeiten wissenschaftliche Diskussionen zu führen.

As part of this module, students acquire advanced knowledge of the structure and function of different microscopes. In the practical part of the module, various microscopy techniques are deepened. In the practical part of the module, which is carried out in groups, the students are expected to prepare reports which are discussed at the end. In addition to technical skills, students learn how to work independently in the optical laboratory, how to implement technical and scientific findings and deepen their ability to conduct scientific discussions.

Inhalte

- Kontrastverfahren und Abbe Theorie
- Fluorescenzmikroskopie und darauf basierte Bildgebungsverfahren (FLIM, LSFM)
- Spektren und Filter
- Fourier-Optik
- Moderne Mikroskopietechniken:
  - hochauflösende Mikroskopie (STED
  - 2-Photonen / Multiphotonenmikroskopie
  - Elektronenmikroskopie
  - Rasterkraftmikroskopie

- Contrast Methods and Abbe Theory

- Fluorescence Microscopy

Modul: Grundlagen der Mikroskopie II
Module: Fundamentals of Microscopy II

•Spectra and Filters •Fourier Optics •Modern Microscopy Techniques: •High resolution Microscopy (STED,...) •2-Photonen / Multi Photon Microscopy •Scanning Electron Microscopy •Atomic Force Microscopy
Besonderheiten
keine
Literatur
Saleh und Teich: Grundlagen der Photonik Meschede: Optik, Licht und Laser Switz and Fletcher: Optical Microscopy Course
Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Image Sequence Analysis

Module: Image Sequence Analysis

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Oral exam	4	15 min	graded
SL	Academic achievement	1	Various home exercises	ungraded

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Dr.-Ing. Max Mehltretter
Lecturer	Dr.-Ing. Max Mehltretter
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Image Sequence Analysis - Vorlesung	2	Oral exam
Image Sequence Analysis - Hörsaalübung	2	Academic achievement

Requirements for participation:	Recommended for participation:
keine	Photogrammetric Computer Vision . Prior knowledge on image processing

Qualification goals

At the end of the course, students have a good insight into the goals, tasks and methods of image sequence analysis. They are able to evaluate monoscopic and stereoscopic image sequences with regard to 3D geometry and content and know the limits of the automatic methods used for this purpose: foreground/background separation, optical flow , object tracking etc. They are also able to integrate motion models into the evaluation, for example on the basis of Kalman filter, EKF; particle filters are also known in principle. In individual areas, the students have exemplary detailed knowledge, e.g. in the area of tracking-by-detection and data association. As a basis for further Master’s studies, the students should develop their analytical and transfer skills through exercises, also from current research projects.

Contents

- Introduction to the field of image sequence analysis (incl. sensors and general considerations)
- Background subtraction
- Motion of pixels / points: Optical flow and Scene flow
- Object detection and tracking (incl. motion models and filtering approaches)
- Re-Identification
- Body pose estimation
- Action Detection

Special features

To achieve the 5 ETCS, the lab must be successfully completed. The course is taught in English

Literature

- David A. Forsyth and Jean Ponce (2003): Computer Vision, A Modern Approach.
- Richard Hartley and Andrew Zisserman (2003): Multiple View Geometry in Computer Vision.
- Wolfgang Förstner and Bernhard P. Wrobel (2016): Photogrammetric Computer Vision.
- Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016): Deep Learning.
- Christopher M. Bishop (2006): Pattern Recognition and Machine Learning.

Modul: Image Sequence Analysis

Module: Image Sequence Analysis

Applicability in other degree programs
AI Driven Mechatronics and Robotics M. Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optische Technologien M.Sc.;

Modul: Introduction to Computational Optics

Module: Introduction to Computational Optics

Type of module				Area of competence			
Wahl							
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1/2. Semester	Admission SoSe:	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam / Oral exam	5	90 Min/20 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Computational Optics - Vorlesung	2	Written exam / Oral exam
Introduction to Computational Optics - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Knowledge of electrodynamics and theoretical optics (Grundlagen der Optik I und II).

Qualification goals

The course introduces the programming language Python and presents the solution of several problems in optics by means of computational approaches.

After successfully completing the course, students are able to:
- Use Python for data processing, visualization, and analysis.
- Use numerical methods to solve various optics problems.
- Understand some numerical methods for the solution of Maxwell´s equations, such as FDTD and FDFD.

Contents

Some optical problems can be solved analytically, but some involve complex geometries and must be solved numerically. In both cases, translating equations into code that can be executed on a computer allows us to find solutions and post-process the data. This course introduces one of the main programming languages for scientific computing, Python, which is then used to solve many relevant optics problems.

The content of the course is as follows:
- Introduction to the Python programming language.
- Introduction to the Python libraries NumPy, SciPy and Matplotlib: arrays and matrices, numerical differentiation, integration, root finding, minimization/maximization, eigenvalue problems, discrete Fourier transform, differential equations, generation of figures, movies, read/write of files, examples of optimization.
- Selected examples from theoretical optics.
- Intro to numerical methods: FDTD (finite-difference time-domain) for light propagation in media; FDFD (finite-difference frequency-domain) for mode analysis and propagation in waveguides.

Modul: Introduction to Computational Optics

Module: Introduction to Computational Optics

Special features
none
Literature
none
Applicability in other degree programs
Nachhaltige Ingenieurwissenschaft M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Introduction to Nanophotonics

Module: Introduction to Nanophotonics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	5	90 min.	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Introduction to Nanophotonics - Vorlesung	2	Written exam
Introduction to Nanophotonics - Übung	1	

Requirements for participation:	Recommended for participation:
none	Knowledge of electromagnetic theory (Maxwells equations, wave propagation, etc).

Qualification goals

Nanophotonics studies light-matter interactions at the nanoscale, and how to engineer the properties of light by exploiting its interaction with nanostructured materials. The course will focus on the theoretical foundations of nanophotonic systems, such as plasmonic nanoantennas, dielectric resonators, metasurfaces, metamaterials, and photonic crystals. The course is enriched with the use of simulation software for nanophotonics, such as Ansys Lumerical and Comsol Multiphysics.

After successfully completing the module, students are able to:
- Understand the optical properties of dielectric/metals and the theory of plasmonics.
- Understand the theory of light scattering by nanostructures.
- Understand metasurfaces/metamaterials/photonic crystals and design such systems for light manipulation.
- Understand some numerical techniques and use simulation software for nanophotonics modeling.

Contents

- Optical properties of matter: dispersive media, and fundamentals of plasmonics (surface plasmon polaritons).
- Light scattering by metallic and dielectric nanostructures: Rayleigh approximation, plasmonic resonances, Mie theory, Mie-type resonances, and multipole decomposition.
- Theory of periodic systems: diffraction, beam steering, and photonic bandgaps.
- Engineering of light properties (amplitude, polarization, phase, propagation direction, spectrum) through arrays of nanostructures: metasurfaces, metamaterials, and photonic crystals.
- Numerical techniques: finite-difference time-domain (FDTD) method.
- Software for the simulation of nanophotonic systems: Ansys Lumerical and Comsol Multiphysics.
- Selected topics of current research.

Special features

keine

Literature

Novotny, L., & Hecht, B. (2012). Principles of Nano-Optics (2nd ed.). Cambridge: Cambridge University Press.

Modul: Introduction to Nanophotonics

Module: Introduction to Nanophotonics

Gaponenko, S. (2010). Introduction to Nanophotonics. Cambridge: Cambridge University Press. Maier, S. (2007). Plasmonics: Fundamentals and Applications. Springer, New York.
Applicability in other degree programs
Nanotechnologie M.Sc.; Optische Technologien M.Sc.;

Modul: Introductory Biophysics for Physics

Module: Introductory Biophysics for Physics

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe	1 Semester	Deutsch/Englisch	3	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
SL	Präsentation	3	20 min	unbenotet

Workload	90 h
Präsenzstudienzeit	28 h
Selbststudienzeit	62 h
Modulverantwortliche-r	Prof. Dr. Alexander Heisterkamp
Dozent-in	Prof. Dr. Alexander Heisterkamp
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Introductory Biophysics for Physics - Vorlesung	2	Präsentation

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
none	-

Qualifikationsziele

Der Fokus liegt dabei auf einer detaillierten Darstellung der Zellbiologie, der zentralen Moleküle des Lebens und den physikalischen Grundlagen ihrer Interaktion. Als Beispiel wird die Struktur von Säugetierzellen analysiert und zelluläre Prozesse wie Replikation, Transkription und Translation erörtert. Im Weiteren werden dann experimentelle Techniken diskutiert, die im historischen Kontext und immer noch genutzt werden, um Information über die zentralen Moleküle des Lebens, die zelluläre Homöostase, Zellbewegung, oder die Entstehung von Kräften in einer Zelle, zu erschließen. Am Ende der Veranstaltung werden neue Forschungsfelder, wie Nanotechnologie oder Quantenphysik, in den Kontext Biophysik integriert.

Inhalte

•Was ist Leben? – Einheiten, Zeitskalen, Organismen
•Die Zelle und ihre Biologie
•zentrale Moleküle des Lebens DNA, RNA und Proteine
•Kristallstrukturanalyse zum Verständnis der zentralen Moleküle des Lebens
•Physikalische Prinzipien der Kristallstrukturanalyse
•"biophysikalischer Verkehr": Membranen und Kanäle
•Wie misst man „biophysikalischen Verkehr“?
•Zellkräfte und Zellbewegung
•experimentelle Techniken zur Analyse von Zellbewegung und Kontraktion
•Wie Nanotechnologie unser Biologieverständnis ergänzt
•Wie Quantenphysik unser Biologieverständnis ergänzt In der Vorlesung werden grundlegende biophysikalische und biologische Konzepte eingeführt.

Besonderheiten

Die Prüfungsform ist eine unbenotete Studienleistung in Form eines Vortrags.

Literatur

Grundlegende Literatur:
•Molecular Biology of the Cell (Garland Science)
•Biophysics: An Introduction (Springer)

Modul: Introductory Biophysics for Physics

Module: Introductory Biophysics for Physics

•Campbell Biology •Originalliteratur
Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Journal Club - Optik und Photonik

Module: Journal Club - Optics and Photonics

Modultyp				Kompetenzbereich			
Wahl							
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
SoSe/WiSe	1 Semester	Deutsch/Englisch	2	Zulassung WiSe:	1. Semester	Zulassung SoSe:	2. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
SL	Präsentation	2	30 min	unbenotet

Workload	60 h
Präsenzstudienzeit	28 h
Selbststudienzeit	32 h
Modulverantwortliche-r	Dr. Axel Günther
Dozent-in	Dr. Axel Günther
Institut	Hannoversches Zentrum für Optische Technologien
Fakultät	Fakultät für Maschinenbau

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Journal Club - Optik und Photonik - Seminar	2	Präsentation

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	Interesse an aktuellen Themen der Optik und Photonik

Qualifikationsziele

- Students are able to search autonomously for further literature to a given paper
- Students are able to work out independently an actual science field
- Students are able to structure and make a presentation about a complex issue from the modern physics, which could be followed by physical competent audience. By presenting the layout they are able to interest the audience for a complex special topic.
- Students are able to develop an appealing presentation (e.g. PowerPoint)
- Students are able to conduct a scientific discussion (on topics of theirs own and theirs classmates as well)
- Students are able to communicate fluently in German and English

Inhalte

The focus of this seminar lies on the recent applications in optics and photonics. Students should apply the fundamental knowledge they have learned to understand, reproduce and discuss current research topics. Furthermore, the structure of a good paper will be discussed, as well as how to maintain good standards in science and how to recognise predatory journals.

Besonderheiten

none

Literatur

none

Modul: Journal Club - Optik und Photonik

Module: Journal Club - Optics and Photonics

Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Laser Material Processing

Module: Laser Material Processing

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	5	90 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Ludger Overmeyer
Lecturer	Prof. Dr.-Ing. Ludger Overmeyer
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Material Processing - Vorlesung	2	Written exam
Laser Material Processing - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Basic optics, basics of laser sources recommended

Qualification goals

The module provides basic knowledge about the spectrum of laser technology in production as well as the potential of laser technology in future applications.

After successfully completing the module, students will be able to
- classify the scientific and technical basics for the use of laser systems and the interaction of the beam with different materials,
- recognize the necessary physical requirements for laser processing and to select specific process, handling and control technology for this purpose,
- explain the basic and current requirements for laser technology in production technology,
- estimate the process variables that can be realized by means of laser material processing.

Contents

- Photonic system technology
- Beam guiding and forming
- Marking
- Removal and drilling
- Change material properties
- Cutting including process control
- Welding of metals including process control
- Hybrid welding processes
- Welding of nonmetals
- Bonding / soldering
- Additive manufacturing

Special features

Lectures and exercises in the rooms of the Laser Zentrum Hannover e.V. (laboratories / experimental field). Lecture und

Modul: Laser Material Processing

Module: Laser Material Processing

examination are offered in English and German. The courses name on Stud.IP is Lasermaterialbearbeitung
Literature
Recommendation is given in the lecture, Lecture notes
Applicability in other degree programs
Maschinenbau M.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;

Modul: Laser Measurement Technology

Module: Laser Measurement Technology

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam	5	90 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr. Bernhard Roth
Lecturer	Dr. Axel Günther
Institute	Hannoversches Zentrum für Optische Technologien
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Laser Measurement Technology - Vorlesung	2	Written exam
Laser Measurement Technology - Hörsaalübung	1	

Requirements for participation:	Recommended for participation:
keine	Fundamentals of measurement technology, Basics of laser physics and laser technology

Qualification goals

The aim of this module is the introduction to the basic principles and methods of state-of-the-art optical measurement technology based on laser sources. An overview of the broad spectrum of laser sources, measurement techniques, and typical practical applications for various optical measurement, monitoring, and sensing situations in research and development will be provided. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and practical laboratory training.

Contents

- Basic physics
- Optical elements/detection techniques
- Lasers for measurement applications
- Laser triangulation and interferometry
- Distance and velocity measurement

Special features

Recommended for second semester and higher (Master course)

Literature

A. Donges, R. Noll, Lasermesstechnik, Hüthig Verl.; M. Hugenschmidt, Lasermesstechnik, Springer Verl.; W. Lange, Einführung in die Laserphysik, Wissenschaftliche Buchgesellschaft, Darmstadt; Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.

Applicability in other degree programs

Biomedizintechnik M.Sc.; Optische Technologien M.Sc.;

Modul: Laser Scanning - Modelling and Interpretation

Module: Laser Scanning - Modelling and Interpretation

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Oral exam	3	15 mim	graded
SL	Academic achievement	2	Exercise	ungraded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	apl. Prof. Dr.-Ing. Claus Brenner
Lecturer	Tim Schimansky
Institute	Institut für Kartographie und Geoinformatik
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module		
Title and form of the course	**Semester hours**	**Ep / Aa**
Laser Scanning - Modelling and Interpretation - Vorlesung	2	Oral exam
Laser Scanning - Modelling and Interpretation - Hörsaalübung	1	Academic achievement

Requirements for participation:	Recommended for participation:
keine	Programming Skills

Qualification goals

This lecture imparts the basic principles about laser scanning and its respective application areas. After successful completion of the lecture, students are able to explain and apply selected techniques and algorithms for the low-, intermediate- and high-lever processing of laser scanning data

Contents

Airborne, terrestrial and mobile mapping laser scanning: scan geometry and technical characteristics. Low-, intermediate and high-level tasks. Representation of 3D rotations: matrix, angles, axis and angle, quaternions. Estimation of similarity transforms and the iterative closest point algorithm. Estimation and segmentation of lines and planes. Region growing, RANSAC and MSAC, Hough transform. Robust estimation. Mapping (integration of scans). Point cloud classification: decision trees and random forests.Markov chains and Markov chain Monte Carlo methods and their use for high-level interpretation. Deep learning for point clouds. In the exercises, selected algorithms will be programmed.

Special features

Lecture is given in English

Literature

Skript

Applicability in other degree programs

AI Driven Mechatronics and Robotics M. Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Non-linear Optics

Module: Non-linear Optics

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
SL	Studienleistung	5		unbenotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Michael Kues
Lecturer	Prof. Dr. Michael Kues
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module		
Title and form of the course	**Semester hours**	**Ep / Aa**
Non-linear Optics - Vorlesung	3	Studienleistung
Non-linear Optics - Übung	1	

Requirements for participation:	Recommended for participation:
keine	Physik II, Experimentalphysik, Atom- und Molekülphysik / Physics II, Experimental Physics, Atomic and Molecular Physics

Qualification goals

The students acquire special knowledge of nonlinear laser optics and can apply the necessary mathematical methods themselves.

Contents

- Nonlinear optical susceptibility
- Crystal optics, tensor optics
- Wave equation with nonlinear source terms
- Frequency doubling, sum-, difference-frequency generation
- Optical parametric amplifier, oscillator
- Phase-matching schemes, quasi phase-matching
- Electro-optical effect
- Electro-acoustic modulator
- Frequency tripling, Kerr-effect, self-phase modulation, self-focusing
- Raman-, Brillouin-scattering, four wave mixing
- Nonlinear propagation, solitons

Special features

The courses name on Stud.IP is "Nichtlineare Optik"

Literature

Agrawal: Nonlinear Fiber optics, Academic Press; Boyd: Nonlinear Optics, Academic Press; Shen: Nonlinear Optics; Dmitriev: Handbook of nonlinear crystals, Springer;

Modul: Non-linear Optics

Module: Non-linear Optics

Applicability in other degree programs
Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Optical Clocks
Module: Optical Clocks

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Oral exam	3	30 min	graded
SL	Academic achievement	2	Exercises weekly, 45 min	ungraded

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Piet Schmidt
Lecturer	PD Christian Lisdat
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optical Clocks - Vorlesung	2	Oral exam
Optical Clocks - Hörsaalübung	2	Academic achievement

Requirements for participation:	Recommended for participation:
keine	Coherent optics, Atomic and molecular physics

Qualification goals

Students understand the basic concepts of optical clocks and their characterisation. They know advanced experimental methods of the field and can apply them under guidance. They are familiar with applications of optical clocks and can evaluate them independently and competently. Achieving the competence goals of the laboratory exercise requires continuous participation.

Contents

-Introduction to optical clocks
-Atom-light interaction
-Trapped-ion physics
-Atoms in opitcal lattices
-Statistical uncertainty
-Clock laser
-Clock feedback loop
-Systematic effects& mitigation I - Neutrals
-Sysrematic effects& mitigation II - Ions
-Examples of clocks
-Frequency comb& directions

Special features

Hybrid lecture

Literature

Fritz Riehle, “Frequency standards: basics and applications”

Applicability in other degree programs

Optische Technologien M.Sc.;

Modul: Optical Coatings and Layers for Engineering

Module: Optical Coatings and Layers for Engineering

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam / Oral exam	4	90 min/30 min	graded
SL	Academic achievement	1	Home exercises	ungraded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Dr. Marco Jupé
Lecturer	Dr. Marco Jupé
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optical Coatings and Layers for Engineering - Vorlesung	2	Written exam / Oral exam
Optical Coatings and Layers for Engineering - Hörsaalübung	1	Academic achievement

Requirements for participation:	Recommended for participation:
none	Fundamentals of optics and physics recommended.

Qualification goals

The course offers a large variety of practical information on optical coatings, which may be of value for engineers and physicists heading towards a career in photonics.

Contents

•General basis (applications, impact, and functional principle of optical coatings, state of the art in coatings for laser technology)
•Theoretical fundamentals (compilation of formulae and consideration of fundamental phenomena, calculation of single layers and layer systems)
•Production of optical components (substrates, coating materials and techniques, control of coating processes)
•Optics characterization (measurement of optical transfer properties, optical losses: Total Scattering and absorption, laser induced damage thresholds of laser components, non-optical properties) Optical coatings can be considered as essential key-components in modern Photonics. For example, present laser sources, optical systems and products or even a major part of fundamental research could never be realized without optical coatings. In the course the fundamentals of coating design, production and characterization of functional layer systems will be presented. Recent research areas of optical coating technology, especially in the fields of high precision industrial production and the optimization of coating systems for high power lasers will be introduced and discussed.

Special features

Three exercise sheets for homework, solution of exercises discussed during the course, course assessment by written test. Both, exercises and written test have to be passed to finalise the course with 5 ECTS. The courses name on Stud.IP is Optische Schichten für Ingenieure.

Literature

Will be announced during the course, for an introduction: Macleod, H.A.: Thin Film Optical Filters, Fourth Edition, CRC Press 2010

Applicability in other degree programs

Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Optical Radiometry

Module: Optical Radiometry

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Written exam / Oral exam	3	30 min	graded
SL	Academic achievement	2	Exercise	ungraded

Workload	150 h
Attendance study period	28 h
Self-study time	122 h
Module coordinator	apl. Prof. Dr. Milutin Kovacev
Lecturer	apl. Prof. Dr. Milutin Kovacev Prof. Dr. Andrea Trabattoni
Institute	Institut für Quantenoptik
Faculty	Fakultät für Mathematik und Physik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Optical Radiometry - Vorlesung	2	Written exam / Oral exam Academic achievement

Requirements for participation:	Recommended for participation:
none	Basic knowledge on optical physics

Qualification goals

The lecture presents an interdisciplinary overview on the science of how light works. You will learn how the energy content of the electromagnetic radiation field is transferred from a source, through a medium and finally received at a detector. The students will gain knowledge in various aspects of photon sources and photointeractions, with a particular focus on coherent and incoherent light sources, photon detection, light source characterization, laser safety.

Contents

The general topic of the lecture will be radiometry, which is the science and technology of the measurement of radiation from all wavelengths and at all optical power levels within the optical spectrum. Our lecture is an introduction which covers the four following chapters:
• Review of optical physics.
• Sources of optical radiation.
• Detection of optical radiation.
• Optical radiation safety.

Special features

This lecture will be interactive. Students will perform short exercises and give a short-talk on a chosen topic at the end of the lecture.

Literature

Springer Handbook of Lasers and Optics, Springer, 2007
Optics, E. Hecht, Pearson, 2017
Fundamentals of photonics, B.E.A. Saleh, M.C. Teich, Wiley, 2019.

Applicability in other degree programs

Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Optik, Atome, Moleküle, Quantenphänomene

Module: Optics, Atoms and Quantum Phenomena

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe	1 Semester	Deutsch	8	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
PL	Klausur	4	90 min	benotet
SL	Studienleistung	4	Labor/Übung	unbenotet

Workload	240 h
Präsenzstudienzeit	98 h
Selbststudienzeit	142 h
Modulverantwortliche-r	Prof. Dr. Silke Ospelkaus-Schwarzer
Dozent-in	Prof. Dr. Christian Ospelkaus
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Optik, Atome, Moleküle, Quantenphänomene - Vorlesung	3	Klausur
Optik, Atome, Moleküle, Quantenphänomene - Übung	1	Studienleistung
Optik, Atome, Moleküle, Quantenphänomene - Labor	3	

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	keine

Qualifikationsziele

Die Studierenden können Grundlagen der Optik und der Welleneigenschaften des Lichts erklären.

Inhalte

Geometrische Optik, Welleneigenschaften des Lichts: Interferenz, Beugung, Polarisation, Doppelbrechung, Optik, optische Instrumente, Materiewellen, Welle-Teilchen-Dualismus, Aufbau von Atomen, Wasserstoff-Atom (Energiezustände, Drehimpuls, magnetisches Moment, Pauli-Prinzip), Spektroskopie, spontane und stimulierte Emission, Ausblick auf Mehrelektronensysteme; Praktikumsexperimente (Linsen, Interferometer, Beugung, Mikroskop, Prisma, Gitter, Fotoeffekt, Spektralapparat, Polarisation)

Besonderheiten

Zum Erlangen der Studienleistung und zur Teilnahme an der Klausur ist das Erreichen von 50% der Hausübungspunkte notwendig. Es finden Übungen mit Beispielaufgaben zu Themen aus der Vorlesung statt, diese ähneln sehr den späteren Klausuraufgaben. Innerhalb der Vorlesung finden zu jedem Themenfeld anschauliche Experimente statt.

Literatur

Demtröder: "Experimentalphysik 2 und 3"; Springer Verlag; Berkeley Physikkurs; Bergmann/Schäfer; Haken, Wolf: "Atom- und Quantenphysik".

Verwendbarkeit in anderen Studiengängen

Optische Technologien M.Sc.;

Modul: Photogrammetric Computer Vision

Module: Photogrammetric Computer Vision

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Oral exam	3	15 min	graded
SL	Academic achievement	2	Various home exercises	ungraded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. habil. Christian Heipke
Lecturer	Prof. Dr.-Ing. habil. Christian Heipke
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module		
Title and form of the course	Semester hours	Ep / Aa
Photogrammetric Computer Vision - Vorlesung	2	Oral exam
Photogrammetric Computer Vision - Übung	1	Academic achievement

Requirements for participation:	Recommended for participation:
none	Bachelorabschluss in einem Ingenieurfach empfohlen.

Qualification goals

After studying the module the students have a good overview and detailed knowledge of some exemplary methods of 3D reconstruction from images and image sequences (structure from motion, sfm). They understand the geometric transformations between image and object space, the usual procedures for pose estimation of moving sensors and basics of signal theory as applied to image matching. Students can thus evaluate pros and cons of sfm. In the lab part, carried out in small groups, image sequences are captured using flying robots; these image sequences are being exploited using available software. In this way the students come to gain practical experience of digital image capture and geometric 3D reconstruction and can evaluate the obtained results.

Contents

Short introduction into aims, commonalities and differences of photogrammetry and computer vision, 3D image processing, projective geometry: transformation between image and object space, in linear models. Robust estimation (RANSAC). Different methods to represent 3D rotations (Euler angles axis-angle representation, quaternions). Structure from motion (sfm) from stereoscopic images and image sequences: interest operators (SIFT, SURF), sliding pose estimation, dense image matching, determination of object geometries. Methods for evaluation of results of image based approaches.

Special features

No information

Literature

David A. Forsyth and Jean Ponce (2003). Computer Vision, A Modern Approach. Prentice Hall. Richard Hartley and Andrew Zisserman (2003).

Applicability in other degree programs

AI Driven Mechatronics and Robotics M. Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Optische Technologien M.Sc.;

Modul: Production of Optoelectronic Systems

Module: Production of Optoelectronic Systems

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	**Duration**	**Language**	**ECTS**	**Recommended from**			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Written exam	5	90 min	graded

Workload	150 h
Attendance study period	42 h
Self-study time	108 h
Module coordinator	Prof. Dr.-Ing. Ludger Overmeyer
Lecturer	Prof. Dr.-Ing. Ludger Overmeyer
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Production of Optoelectronic Systems - Vorlesung	2	Written exam
Production of Optoelectronic Systems - Übung	1	

Requirements for participation:	Recommended for participation:
none	none

Qualification goals

This module gives basic knowledge about processes and devices that are used in production of semiconductor packages and microsystems. The main focus is on the back-end-process that means the process thins wafer dicing.

After successfully completing the module, students will be able to
• correctly use the terms optoelectronic system, wafer production, front end and back end and to give an overview of production processes of semiconductor packages,
• explain the production processes beginning from crude material sand and to have an idea about process relevant parameters,
• visualize different packaging techniques and explain the corresponding basics of physics,
• choose and classify different package types for an application.

Contents

• Wafer production
• Mechanical Wafer treatment
• Mechanical connection methods (micro bonding, soldering, eutectic bonding)
• Electrical connection methods (wire bonding, flip chip bonding, TAB)
• Package types for semiconductors
• Testing and marking of packages
• Design and production of printed circuit boards
• Printed circuit board assembly and soldering techniques

Special features

Lecture, exercise and exam are offered in German and English.

Literature

Lau, John H.: Low cost flip chip technologies : for DCA, WLCSP, and PBGA assemblies. McGraw-Hill, New York 2000.

Modul: Production of Optoelectronic Systems

Module: Production of Optoelectronic Systems

Pecht, Michael: Integrated circuit, hybrid, and multichip module package design guidelines : a focus on reliability. Wiley, New York 1994. Bei vielen Titeln des Springer-Verlages gibt es im W-Lan der LUH unter www.springer.com eine Gratis Online-Version.
Applicability in other degree programs
Maschinenbau M.Sc.; Mechatronik und Robotik M. Sc. PO 2025; Mechatronik und Robotik M.Sc. PO 2017; Nanotechnologie M.Sc.; Produktion und Logistik M.Sc.; Wirtschaftsingenieur M.Sc.;

Modul: Proseminar Biophotonik

Module: Proseminar Biophotonics

<table>
<tr><th colspan="3">Modultyp</th><th colspan="5">Kompetenzbereich</th></tr>
<tr><td colspan="3">Wahl</td><td colspan="5">Photonics and Laser Technology</td></tr>
<tr><th>Angebot im</th><th>Dauer</th><th>Sprache</th><th>ECTS</th><th colspan="4">Empfohlen ab</th></tr>
<tr><td>WiSe/SoSe</td><td>1 Semester</td><td>Deutsch/Englisch</td><td>3</td><td>Zulassung WiSe:</td><td>1. Semester</td><td>Zulassung SoSe:</td><td>1. Semester</td></tr>
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<table>
<tr><th colspan="5">Prüfungsleistungen (PL) / Studienleistung (SL)</th></tr>
<tr><th colspan="2">Art</th><th>ECTS</th><th>Dauer / Umfang</th><th>Notenskala</th></tr>
<tr><td>SL</td><td>Academic achievement</td><td>3</td><td>Presentation</td><td>ungraded</td></tr>
</table>

Workload	90 h
Präsenzstudienzeit	28 h
Selbststudienzeit	62 h
Modulverantwortliche-r	Prof. Dr. Bernhard Roth
Dozent-in	Prof. Dr. Uwe Morgner
Institut	Hannoversches Zentrum für Optische Technologien
Fakultät	Fakultät für Maschinenbau

<table>
<tr><th colspan="3">Aufbau des Moduls</th></tr>
<tr><th>Veranstaltungstitel und Form</th><th>SWS</th><th>PL / SL</th></tr>
<tr><td>Proseminar Biophotonik - Vorlesung</td><td>2</td><td>Academic achievement</td></tr>
</table>

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	Basics of physics, Optical elements / Measurement techniques, Physical foundations of optics and laser technology, Basic knowledge in laser applications recommended

Qualifikationsziele

- Students are able to search autonomously for the literature to a given topic from modern biophotonics
-Students are able to work out independently an actual science field
-Students are able to structure ande make a presentation about a complex issue from the modern physics, which could be followed by physical competent audience. By presenting the layout they are able to interest the audience for a complex special topic.
-Students are able to develop an appealing presentation (e.g. PowerPoint)
-Students are able to conduct a scientific discussion (on topics of theirs own and theirs classmates as well)
-Students are able to communicate fluently in German and English

Inhalte

The focus of the proseminar lies on the applications of optical technologies, methods and processes in the life sciences. The students acquire knowledge on both basic concepts and their implementation into real applications. Typical fields of application are optical microscopy and imaging for medical diagnosis or precision laser spectroscopy for the investigation of the functionality of biomolecules and molecular analytics. Furthermore, emphasis will be placed on modern optical technology for lab-on-chip applications and integrated laser methods for medical screening, among others.

Besonderheiten

Graded performance: oral examination and presentation slides Type of examination: oral (marked or unmarked, as required) The courses name on Stud.IP is "Proseminar Grundlagen der Biophotonik"

Modul: Proseminar Biophotonik

Module: Proseminar Biophotonics

Literatur
keine
Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Quantum Information Processing

Module: Quantum Information Processing

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	Admission WiSe:	1/2. Semester	Admission SoSe:	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		ECTS	Duration / Scope	Grading scale
PL	Muendliche Pruefung	5	20 min	benotet

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Jun.-Prof. Christoph Hirche
Lecturer	Jun.-Prof. Christoph Hirche
Institute	Institut für Informationsverarbeitung
Faculty	Fakultät für Elektrotechnik und Informatik

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Quantum Information Processing - Übung	2	Muendliche Pruefung
Quantum Information Processing - Vorlesung	2	

Requirements for participation:	Recommended for participation:
none	Mathematik I+II+III

Qualification goals

Students will understand the basic concepts of quantum information processing. In particular, they will have a broad overview of the tools needed to dive deeper into topics such as quantum computing, quantum information theory and quantum machine learning. The focus will be on theoretical considerations ofwhat we can achieve with quantum computing hardware and understanding the differences to traditional information processing. To achieve this, students will also solidify and widen their knowledge in mathematical tools, in particular linear algebra. At the end of the course students will be able to understand and explain current research in the field and independently solve problems related to it.

Contents

Quantum states, quantum channels, density matrix formalism, measurements; no-cloning theorem; distance measures; quantum circuits; quantum algorithms: quantum teleportation, super dense coding, Fourier transform, Shor's factoring algorithm; Grover's search algorithm; noisy quantum circuits, bounds from information theory; Entanglement and non-Locality, uncertainty relations; quantum error-correction; quantum machine learning.

Special features

none

Literature

Quantum Computing: Lecture Notes, Ronald de Wolf, https://arxiv.org/abs/1907.09415; Quantum Information, Mark M. Wilde, https://arxiv.org/abs/1106.1445; Quantum Computation (Lecture Notes), John Preskill, http://theory.caltech.edu/

Modul: Quantum Information Processing

Module: Quantum Information Processing

preskill/ph229/
Applicability in other degree programs
Optische Technologien M.Sc.;

Modul: Radar Remote Sensing

Module: Radar Remote Sensing

Type of module	Area of competence
Wahl	Photonics and Laser Technology

Offer in	Duration	Language	ECTS	Recommended from			
WiSe	1 Semester	Englisch	5	**Admission WiSe:**	1. Semester	**Admission SoSe:**	1. Semester

Examination performance (Ep) / Academic achievement (Aa)

Kind		ECTS	Duration / Scope	Grading scale
PL	Oral exam	4	15 min	graded
SL	Academic achievement	1	Various home exercises	ungraded

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Madhi Motagh
Lecturer	Prof. Dr. Madhi Motagh
Institute	Institut für Photogrammetrie und Geoinformation
Faculty	Fakultät für Bauingenieurwesen und Geodäsie

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Radar Remote Sensing - Vorlesung	2	Oral exam
Radar Remote Sensing - Übung	2	Academic achievement

Requirements for participation:	Recommended for participation:
none	Some familiarity with a Linux operating system is beneficial for lab exercises

Qualification goals

The aim of this module is to provide an introduction to the technique of radar remote sensing with an emphasis on Synthetic Aperture Radar (SAR), Interferometry Synthetic Aperture Radar (InSAR), and multi-temporal interferometry (MTI) techniques. Given the increasing availability of SAR systems, the goal is to foster a better understanding of these systems and their applicability to various types of natural disasters and engineering tasks. At the end of the course the students have an overview of basic requirements of radar remote sensing methods, systems and applications and have an understanding of the fundamental concepts underlying radar remote sensing. They have gained the ability to implement different processing techniques in order to extract and evaluate information from SAR data in response to natural disasters and engineering applications.

Contents

Mathematical and physical principles of Radar remote sensing
Introduction to Side Looking Radar, Radar Image Formation and Synthetic Aperture Radar (SAR)
Radar Parameters (wavelength, polarization, incidence anagle)
Geometric characteristics of SAR images and their distortions
Backscattering mechanism and interpretation of SAR signatures
Airborne and space-borne SAR sensor systems
How to access SAR data sources?
SAR Image simulation with Matlab
SAR image processing with SNAP
SAR data analysis with Google Earth Engine: Flood mapping and land cover classification
SAR interferometry (InSAR) and Differential InSAR (DInSAR) to measure Earth’s surface topography and deformation
Fundamental equation of Interferometry: Height ambiguity, sensitivity analysis, selection of baseline, critical baseline
Typical processing chain: 2 and 3 pass Interferometry
Interferometric phase quality: Coherence, temporal and spatial decorrelation
Phase Unwrapping <font face=Wingdings>Ø Error sources: Residual topography; Tropospheric error, ionospheric error
Stripmap and TOPS InSAR analysis with SNAP
Along-track interferometry; pixel offset tracking and multiple-aperture SAR interferometry

Modul: Radar Remote Sensing

Module: Radar Remote Sensing

Multi-temporal InSAR (MTI) theory: Stacking, Permanent/Persistent Scatterer Interferometry (PSI) and Small BAseline Subset (SBAS) Satellite SAR Interferometry for geophysical and engineering applications Cloud-based platforms for rapid InSAR and MTI analysis Optional excursions will be offered to GFZ Potsdam, towards the end of the semester. Lab: lab assignments in Radar Remote Sensing.
Special features
This lecture is given in English.
Literature
• Massonnet, D., & Feigl, K. L. (1998). Radar interferometry and its application to changes in the earths surface. Reviews of Geophysics, 36, 441-500. • Bürgmann, R., Rosen, P., & Fielding, E. (2000). Synthetic Aperture Radar Interferometry to measure Earths surface topography and its deformation. Annual Review of Earth and Planetary Sciences, 28, 169-209. • Hanssen, Ramon F (2001). Radar interferometry: data interpretation and error analysis. Vol. 2. Springer Science & Business Media, 2001. • Ghiglia, D.C. and Pritt, M.D. (1998). Two-dimensional phase unwrapping: theory, algorithms, and software (Vol. 4). New York: Wiley • Dzurisin, D. (2007). Volcano Deformation: Geodetic Measuring Techniques. Berlin, Heidelberg: Springer-Verlag. ISBN 3540426426. • Simons, M. & Rosen, P. (2007). Interferometric Synthetic Aperture Radar Geodesy. In: Schubert, G. & Herring, T. (eds.). Treatise on Geophysics, Volume 3: Geodesy (pp. 391-446), New York: Elsevier Press. • Shimada, Masanobu, (2020), Imaging From Spaceborne And Airborne Aars, Calibration, And Applications, ISBN 9780367570798 • Crosetto, Michele et al. "Persistent scatterer interferometry: A review. ISPRS Jour¬nal of Photo¬gram¬metry and Remote Sensing 115 (2016): 78-89. • Berardino, Paolo, et al. "A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms." IEEE Transactions on geoscience and remote sensing 40, no. 11 (2002): 2375-2383.
Applicability in other degree programs
Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Seminar Extreme Optics

Module: Seminar Extreme Optics

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe/SoSe	1 Semester	Deutsch/Englisch	3	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
PL	Project-oriented form of examination	1	Presentation (40 min)	graded
SL	Academic achievement	2	Course work	ungraded

Workload	90 h
Präsenzstudienzeit	28 h
Selbststudienzeit	62 h
Modulverantwortliche-r	apl. Prof. Dr. Milutin Kovacev
Dozent-in	apl. Prof. Dr. Milutin Kovacev
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Seminar Extreme Optics - Seminar	2	Project-oriented form of examination Academic achievement

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	Lectures on Nonlinear Optics / Ultrafast Lasers / Solid State Lasers recommended.

Qualifikationsziele

-Students are able to research autonomously for a iterature to a given actual issue from systems -Students are able to work out independently an actual science field -Students are able to struture and make a presentation about a complex issue from the modern physical competent audience. By presenting the layout they are able to interest the audience for a complex special topic -Students are able to conduct a scientific discussion (on topics of theirs own and theirs classmates as well) -Students are able to communicate fluently in German and English

Inhalte

- Hochleistungs-Femtosekunden-Lasersysteme
- Wechselwirkung von Materie mit starken Feldern
- Filamentation
- Plasmakanäle
- Die absolute Trägerphase
- Quanten-Interferenz-Metrologie
- Modenkämme
- Relativistische Optik
- Laser-Teilchenbeschleunigung
- Erzeugung und Nachweis hoher Harmonischer
- Erzeugung und Nachweis von Attosekunden-Pulsen
- Atomare Fotografie
- Der Freie-Elektronen-Laser
- High-power femtosecond laser systems
- Interaction of matter with strong fields
- Filamentation

Englisch: - Plasma channels
- The absolute carrier phase
- Quantum interference metrology

Modul: Seminar Extreme Optics

Module: Seminar Extreme Optics

- mode combs / Relativistic optics - laser particle acceleration - Generation and detection of high harmonics - Generation and detection of attosecond pulses - Atomic photography - The free-electron laser
Besonderheiten
For optical technologies The courses name on Stud.IP is "Seminar Optik auf Femto- und Attosekunden-Zeitskalen". The students have to do a graded exam performance as well as a course work in the seminar.
Literatur
keine
Verwendbarkeit in anderen Studiengängen
Optische Technologien M.Sc.;

Modul: Seminar Numerische Optik

Module: Seminar Numerical Optics

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	**Dauer**	**Sprache**	**ECTS**	**Empfohlen ab**			
WiSe	1 Semester	Deutsch/Englisch	3	**Zulassung WiSe:**	1. Semester	**Zulassung SoSe:**	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		**ECTS**	**Dauer / Umfang**	**Notenskala**
SL	Project-oriented form of examination	3	60 min Presentation und Discussion	ungraded

Workload	90 h
Präsenzstudienzeit	28 h
Selbststudienzeit	62 h
Modulverantwortliche-r	apl. Prof. Dr. Ayhan Demircan
Dozent-in	apl. Prof. Dr. Ayhan Demircan
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Seminar Numerische Optik - Seminar	2	Project-oriented form of examination

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
none	Computational Photonics

Qualifikationsziele

The students get introduced into numerical methods for the investigation of light matter interaction for weak and strong fields in optical media. A special topic has to be presented by the student with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Inhalte

Seminar covering selected topics for the calculation of light distributions in optical media
Contents:

- Spectral- and pseudospectral methods
- Runge-Kutta- and Split-Step-Integration
- Fast-Fourier Transform (FFT)
- Monte Carlo (MC) simulation
- Finite Difference Time Domain (FDTD)
- Finite Element Methods
- Ray Tracing
- Beam-propagation methods (BPM)
- Parallelization using MPI

Besonderheiten

-

Literatur

-

Verwendbarkeit in anderen Studiengängen

Optische Technologien M.Sc.;

Modul: Simulations in photonics (wave-optics)

Module: Simulations in photonics (wave-optics)

Type of module				Area of competence			
Wahl				Photonics and Laser Technology			
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	5	**Admission WiSe:**	1/2. Semester	**Admission SoSe:**	1/2. Semester

Examination performance (Ep) / Academic achievement (Aa)				
Kind		**ECTS**	**Duration / Scope**	**Grading scale**
PL	Project-oriented form of examination	5	225 min	graded

Workload	150 h
Attendance study period	56 h
Self-study time	94 h
Module coordinator	Prof. Dr. Antonio Calà Lesina
Lecturer	Dr. Izzatjon Allayarov Prof. Dr. Antonio Calà Lesina
Institute	Institut für Transport- und Automatisierungstechnik
Faculty	Fakultät für Maschinenbau

Structure of the module

Title and form of the course	Semester hours	Ep / Aa
Simulations in photonics (wave-optics) - Vorlesung Simulations in photonics (wave-optics) - Übung	2 2	Project-oriented form of examination

Requirements for participation:	Recommended for participation:
none	Knowledge of electrodynamics and theoretical optics (Grundlagen der Optik I und II).

Qualification goals

This moduleis the advanced version of the B.Sc. course "Programming and Software for Optics". It aims at presenting current software solutions for the simulation and design of photonic devices based on wave optics.

After successfully completing of the course, students are able to:

- Understand the basics of wave optics simulation and identify the most appropriate solutions for specific problems.
- Perform simulations on many relevant problems in the field of optics and photonics using current commercial software.
- Implement scripts in Python/Matlab for pre- and post-processing.
- Present and discuss simulation results.

Contents

This module is the advanced version of the B.Sc. course "Programming and Software for Optics". It aims at presenting current software solutions for the simulation and design of photonic devices based on wave optics. Simulation tools from the commercial packages Ansys Lumerical (FDTD, FDFD, EME, varFDTD, CHARGE, DGTD, FEEM, HEAT, LumOpt, Interconnect) and Comsol Multiphysics (wave optics module) will be demonstrated for applications in integrated optics, nanophotonics, optical fibers and waveguides, including multiphysics scenarios and optimization techniques. Integration with Matlab/Python will also be demonstrated, as well as solutions for pre-/post-processing.

Special features

A project will be assigned. This requires simulations on a given topic with a final presentation and discussion.

Literature

none

Applicability in other degree programs

Optische Technologien M.Sc.;

Modul: Strong Field Physics

Module: Strong Field Physics

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	**Dauer**	**Sprache**	**ECTS**	**Empfohlen ab**			
WiSe	1 Semester	Deutsch/Englisch	3	**Zulassung WiSe:**	1. Semester	**Zulassung SoSe:**	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		**ECTS**	**Dauer / Umfang**	**Notenskala**
PL	Written exam / Oral exam	2	60 min	graded
SL	Academic achievement	1	Exercise	ungraded

Workload	90 h
Präsenzstudienzeit	56 h
Selbststudienzeit	34 h
Modulverantwortliche-r	apl. Prof. Dr. Milutin Kovacev
Dozent-in	apl. Prof. Dr. Milutin Kovacev
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls		
Veranstaltungstitel und Form	**SWS**	**PL / SL**
Strong Field Physics - Vorlesung	2	Written exam / Oral exam
Strong Field Physics - Übung	2	Academic achievement

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
none	Basic knowledge of physics and coherent optics recommended.

Qualifikationsziele

Students understand the basic concepts of strong optical fields and their interaction with matter. In the lecture, they learn to apply these independently to selected problems.

Inhalte

-coherent and incoherent radiation sources
-X-ray optics
-Detection of X-ray radiation
-Laser-matter interaction
-Generation of higher order harmonics / attosecond pulses

Besonderheiten

In order to pass the module, both the examination and the coursework must be successfully completed.

Literatur

Z. Chang, „Fundamentals of Attosecond Optics“, CRC Press 2011 D. Attwood, “Soft x-rays and extreme ultraviolet radiation”, Cambridge University Press 1999 T. Brabec, “Strong Field Laser Physics”, 2008 Springer

Verwendbarkeit in anderen Studiengängen

Optische Technologien M.Sc.;

Modul: Ultrakurze Laserpulse
Module: Ultrashort laser pulses

Modultyp				Kompetenzbereich			
Wahl				Photonics and Laser Technology			
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
SoSe	1 Semester	Deutsch/Englisch	2	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester

Prüfungsleistungen (PL) / Studienleistung (SL)				
Art		ECTS	Dauer / Umfang	Notenskala
PL	Written exam	2	90 min	graded

Workload	60 h
Präsenzstudienzeit	28 h
Selbststudienzeit	32 h
Modulverantwortliche-r	Priv.-Doz. Dr. Ihar Babushkin
Dozent-in	Priv.-Doz. Dr. Ihar Babushkin
Institut	Institut für Quantenoptik
Fakultät	Fakultät für Mathematik und Physik

Aufbau des Moduls

Veranstaltungstitel und Form	SWS	PL / SL
Ultrakurze Laserpulse - Vorlesung	2	Written exam

Voraussetzungen für die Teilnahme:	Empfohlen für die Teilnahme:
keine	Optik, Atomphysik und Quantenphänomene; Empfohlen: Kohärente Optik

Qualifikationsziele

In this course, students shall gain an understanding for the generation of ultrashort laser pulses, including ist properties and areas of application.

Inhalte

Representation of ultrashort light pulses Propagation equations, Causality and dispersion, Origin of the refractive index Propagation in dispersive media, Pulse front distortions, Chirp management: Angular dispersion, Chirped mirrors, Pulse shapers Ultrafast nonlinear optics: Second-order effects, Phase matching, Broadband frequency conversion, OPA; Third-order effects: SPM, Self-focusing, Propagation in waveguides, Solitons, Filamentation Pulse characterization Ultrashort pulse generation: Resonators, Laser dynamics, Relaxation oscillations, Q-switching, Mode locking Short pulse amplification, High-energy laser systems

Besonderheiten

The courses name on Stud.IP is "Ultrakurze Laserpulse"

Literatur

D. Meschede: Optik, Licht und Laser, Vieweg+Teubner, 3. Aufl. 2008.

Verwendbarkeit in anderen Studiengängen

Optische Technologien B.Sc.; Optische Technologien M.Sc.;