

Fakultät für Maschinenbau

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Leibniz
Universität
Hannover

**COURSE CATALOGUE M.SC.
OPTICAL TECHNOLOGIES**
Summer Semester 2024

Course and Module Catalogue

for Examination Regulations 2017

Optical Technologies:
Photonics and Laser Technology

Master of Science

Summer Semester 2024

<http://www.maschinenbau.uni-hannover.de/>

Impressum

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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. M. Becker

- Dean of studies -

*European Credit Transfer System

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Master of Science

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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.

Initial Internship

The Initial Internship enables students to gain their first experience of industry. Within a working environment of experts, students, teachers and technical personnel, the student is able to develop practical knowledge of varied manufacturing processes and facilities.

The Initial Internship lasts 8 weeks and may be combined with the Advanced Internship.

If applicable, internships already completed or previous vocational training or activity may be credited. Further details are defined by the Internship Regulations and the Internship Office of the Faculty.

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 <u>ONLY</u> for VbP*	Timeperiod for all form of examination (<u>EXCEPT</u> VbP*)
Registration period	15.10. - 31.10.	15.11. - 30.11.
Examination Period	01.11 - 28.02.	15.12. - 14.04.
Summersemester		
	Timeperiod <u>ONLY</u> for VbP*	Timeperiod for all form of examination (<u>EXCEPT</u> VbP*)
Registration 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

	1./2. Semester WS	1./2. Semester SS	3. Semester	4. Semester
1	Optical Measurement Technology (5 CP) K / MP	Design and Simulation of optomechatronic Systems (5 CP) K / MP	Advanced Internship (12 Weeks) (15 CP) PB	Master Thesis (29 CP) MA + Presentation (1 CP) SL
2				
3				
4				
5				
6	Photonics (5 CP) K / MP	Master Lab Tutorial (5 CP) SL		
7				
8				
9	Laser Spectroscopy in Life Science (5 CP) K / MP	Optional (20 CP) K / MP	Student Research Project (10 CP) SA	
10				
11				
12	Optional (15 CP) K / MP		Optional (20 CP) K / MP	Oral Presentation of the Student Research Project (1 CP) SL
13				
14				
15		Studium Generale / Tutorials (4 CP) K / MP / SL		
16				
17				
18	Optional (15 CP) K / MP	Optional (20 CP) K / MP	Studium Generale / Tutorials (4 CP) K / MP / SL	
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				

CP	30	30	30	30
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Areas of competence		
Photonics and Laser-Technology (54-55 CP)	Optional (35 CP)	Master Thesis (30 CP)

Legend			
K = Exam	MA = Master Thesis	MP = Oral Exam	PB = Internship Report
SA = Student Project Report	SL = Course Credit Activity		

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	Applied Wave Optics	4
Applied Wave Optics	4	Atomic Optics	4
Fundamentals and Configuration of Laser Beam Sources	5	Biophotonics – Imaging Physics and Manipulation of Biological Cells	4
Fundamentals of Laser Medicine and Biophotonics	4	Computational Photonics	6
Image Sequence Analysis	5	Laser Material Processing	5
Introduction to Nanophotonics	5	Laser Measurement Technology	5
Introductory Biophysics for Physics	3	Non-linear Optics	5
Laserscanning – Modelling and Interpretation	5	Optical Radiometry	5
Optical Coatings and Layers for Engineering	5	Optical Clocks	2
Optik, Atomphysik und Quantenphänomene	8	Proseminar Biophotonics	3
Photogrammetric Computer Vision	5	Proseminar – Grundlagen der Mikroskopie	3
Production of Optoelectronic Systems	5	Seminar Optics at Femto- and Attoscond Scales	3
Radar Remote Sensing	5	Simulations in photonics (wave-optics)	5
Seminar Numerical Optics	3	Ultrashort Laser Pulses	2
Seminar Optics at Femto- and Attoscond Scales	3		
Strong Field Physics	3		

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							
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		Prof. Dr.-Ing. Roland Lachmayer					
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							
<p>If completed successfully, the students are capable of</p> <ul style="list-style-type: none"> defining fundamentals of lighting technology describing the physiology of the human visual system differentiating individual advantages in optical materials (glasses and polymers) and their according processing technologies analytically calculating basic optical elements such as mirrors and lenses setting up concepts for optical systems understanding and using an optical simulation software knowing the working principle of light measurement devices analyzing existing optical systems 							
Contents							
<ul style="list-style-type: none"> - Fundamentals of light propagation and distribution - Optical components and systems - Optical simulation software - Physiology of the human visual system - Light sources, manipulators and sensors 							
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.							
Literature							
Umdruck zur Vorlesung							
Applicability in other degree programs							
Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;							

Modul: Laser Spectroscopy in Life Sciences

Module: Laser Spectroscopy in Life Sciences

Type of module		Area of competence					
Pflicht							
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							
<p>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.</p>							
Contents							
<p>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.</p>							
Special features							
Recommended for second semester and higher (Master course).							
Literature							
<p>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.</p>							
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. Matthias Becker					
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 + 20 Wochen Praktikum (8 Wochen Vorpraktikum + 12 Wochen Fachpraktikum)				keine			
Qualifikationsziele							
<p>Nach dem erfolgreichen Absolvieren des Moduls sind Studierende in der Lage an einer wissenschaftlichen Problemstellung aus den Themenfeldern des Master-Studiums mitzuarbeiten, Teilprobleme in bestehende Theorien einzuordnen und im Studium erlernte Methoden geeignete Methoden zu identifizieren. Sie können erreichte Ergebnisse wissenschaftlich formulieren und dabei übliche Zitierregeln und Recherchemethoden anwenden.</p>							
Inhalte							
<p>Durch die Teilnahme am Modul Masterarbeit üben Studierende gängige Tätigkeiten von Ingenieurinnen und Ingenieuren aus, die in der Forschung, der Industrie oder dem Entrepreneurwesen tätig sind.</p>							
Besonderheiten							
<p>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.</p>							
Literatur							
Diverse							
Verwendbarkeit in anderen Studiengängen							
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;							

Modul: Masterlabor: Optische Technologien

Module: Practical Lessons Optical Technologies

Modultyp		Kompetenzbereich					
Pflicht							
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe/SoSe	1 Semester	Deutsch	5	Zulassung WiSe:	1. Semester	Zulassung SoSe:	2. Semester
Prüfungsleistungen (PL) / Studienleistung (SL)							
Art			ECTS	Dauer / Umfang		Notenskala	
SL	Studienleistung		5	Laborversuche und Auswertung		unbenotet	
Workload			150 h				
Präsenzstudienzeit			28 h				
Selbststudienzeit			122 h				
Modulverantwortliche-r			Prof. Dr. Bernhard Roth				
Dozent-in			Prof. Dr. Bernhard Roth				
Institut			Hannoversches Zentrum für Optische Technologien				
Fakultät			Fakultät für Maschinenbau				
Aufbau des Moduls							
Veranstaltungstitel und Form				SWS	PL / SL		
Masterlabor: Optische Technologien - Labor				2	Studienleistung		
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
keine				Keine			
Qualifikationsziele							
<p>The module imparts knowledge in the practical application and deepening of the theoretical basics taught in the lectures and theoretical exercises. After successfully completing the module, students are able to</p> <ul style="list-style-type: none"> • competently carry out demanding experiments in the fields of mechanical engineering, physics, computer science and electrical engineering, • to work out the necessary basics independently in a group, • to discuss and evaluate the results obtained and to present them to a group in a scientifically sound manner. 							
Inhalte							
<ul style="list-style-type: none"> • Laboratory courses from key areas of mechanical engineering, physics, computer science and electrical engineering • Methods of data analysis and interpretation • Approach to literature research • Development of concepts for experiments based on theoretical knowledge and information from the literature. 							
Besonderheiten							
Students who are requested mandatory courses as part of the master’s admission process need to pass these before starting with the master’s laboratory.							
Literatur							
Keine							
Verwendbarkeit in anderen Studiengängen							
Optische Technologien M.Sc.;							

Modul: Optische Messtechnik

Module: Optical Measurement Technology

Modultyp		Kompetenzbereich					
Pflicht							
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe	1 Semester	Deutsch/Englisch	5	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester
Prüfungsleistungen (PL) / Studienleistung (SL)							
Art			ECTS	Dauer / Umfang		Notenskala	
PL	Written exam / Oral exam		5	90 min/20 min		graded	
Workload			150 h				
Präsenzstudienzeit			56 h				
Selbststudienzeit			94 h				
Modulverantwortliche-r			Prof Dr.-Ing. Eduard Reithmeier				
Dozent-in			Prof Dr.-Ing. Eduard Reithmeier				
Institut			Institut für Mess- und Regelungstechnik				
Fakultät			Fakultät für Maschinenbau				
Aufbau des Moduls							
Veranstaltungstitel und Form				SWS	PL / SL		
Optische Messtechnik - Vorlesung				2	Written exam / Oral exam		
Optische Messtechnik - Hörsaalübung				2			
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
keine				Messtechnik I / Measurement Technology I empfohlen			
Qualifikationsziele							
<p>After successful completion of the module, students are able</p> <ul style="list-style-type: none"> * 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. 							
Inhalte							
<p>The lecture gives an overview on theory, methods and devices in optical metrology. 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.</p>							
Besonderheiten							
Examination depending on the number of participants: Individual examination 20 minutes orally or 90 minutes in writing.							
Literatur							
<p>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; Huguenschmidt: Lasermesstechnik; These and other sources are available as free download from www.springer.com in German and English.</p>							
Verwendbarkeit in anderen Studiengängen							
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Nanotechnologie M.Sc.; Optische Technologien M.Sc.;							

Modul: Photonics

Module: Photonics

Type of module		Area of competence					
Pflicht							
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 - Übung				1	Oral exam		
Photonics - Seminar				2	Project-oriented form of examination		
Photonics - Vorlesung				2	examination		
Requirements for participation:				Recommended for participation:			
none				Kohärente Optik, Nichtlineare Optik			
Qualification goals							
<p>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.</p>							
Contents							
<ul style="list-style-type: none"> •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. Matthias Becker					
Dozent-in		Dozenten der Fakultät für Maschinenbau					
Institut		Institut für Berufswissenschaften der Metalltechnik					
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							
<p>Mit der Studienarbeit schärfen Studierende ihre wissenschaftliche Arbeitsweise und -kompetenz und arbeiten selbständig an einem wissenschaftlichen Thema unter Betreuung eines der am Studiengang beteiligten Institute. Students sharpen their scientific skills and their scientific Mode of operation and work independently on a scientific topic under supervision of one of the institutes involved in the course of studies.</p>							
Inhalte							
<p>Neben der Herausarbeitung einer wissenschaftlichen Fragestellung gibt die Studienarbeit Platz geeignete wissenschaftliche Methoden auszuwählen, um in Test- und Laborreihen zu wissenschaftlichen Ergebnissen zu erlangen, die es zu hinterfragen gilt. Die Ergebnisse der Studienarbeit werden zudem vor dem Betreuungspersonal präsentiert und dargelegt. Die Studienarbeit bereitet auf die sich anschließende Masterarbeit vor. Ihr Workload beläuft sich auf 330 Stunden. In addition to the elaboration of a scientific question, the Project Work gives space to select suitable scientific methods in order to obtain scientific results in test and laboratory series, which have to be questioned. The results of the Project Work will presented to the Support personnel. The Project work prepared for the following Master Thesis. The Workload amounts to 330 hours.</p>							
Besonderheiten							
<p>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</p>							
Literatur							
Verwendbarkeit in anderen Studiengängen							
Biomedizintechnik M.Sc.; Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.; Produktion und Logistik M.Sc.;							

Modul: Advanced Nonlinear Optics

Module: Advanced Nonlinear Optics

Type of module		Area of competence					
Wahl							
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		4	60 min		graded	
Workload		120 h					
Attendance study period		56 h					
Self-study time		64 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				4	Oral exam		
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							
<ul style="list-style-type: none"> • 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: Applied Wave Optics

Module: Applied Wave Optics

Type of module		Area of competence					
Wahl							
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							
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							
<p>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.</p>							
Contents							
<ul style="list-style-type: none"> - 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
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: Atomic Optics

Module: Atomic Optics

Type of module		Area of competence					
Wahl							
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		3	90 min		graded	
SL	Academic achievement		1	Exercise sheet >50%		ungraded	
Workload		120 h					
Attendance study period		42 h					
Self-study time		78 h					
Module coordinator		Prof. Dr. Silke Ospelkaus-Schwarzer					
Lecturer		Prof. Dr. Silke Ospelkaus-Schwarzer					
Institute		Institut für Quantenoptik					
Faculty		Fakultät für Mathematik und Physik					
Structure of the module							
Title and form of the course				Semester hours	Ep / Aa		
Atomic Optics - Vorlesung				2	Written exam		
Atomic Optics - Übung				1	Academic achievement		
Requirements for participation:				Recommended for participation:			
keine				Atom and Molecular Physics, Quantumoptics recommended			
Qualification goals							
Students will gain insight in recent developments in the field of atomic physics.							
Contents							
Recent experimental procedures to investigate the physics of ultracold gases, laser manipulation of single atoms and quantum engineering are discussed experimentally and theoretically.							
<ul style="list-style-type: none"> •Matter-light interaction •Radiation pressure •Atom- and ion traps •Cooling by evaporation •Bose-Einstein condensation •Ultracold Fermi gases •Experiments based on ultracold and degenerated gases •Atoms in periodic optical gratings •ATOMICS and modern atomic physics experiments 							
Special features							
The courses name on Stud.IP is "Atomoptik"							
Literature							
B. Bransden, C. Joachain, „Physics of Atoms and Molecules“, Longman 1983 R. Loudon, “The Quantum Theory of Light”, OUP 1973 Van der Straaten							
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

Modultyp		Kompetenzbereich					
Wahl							
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
SoSe	1 Semester	Deutsch/Englisch	4	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester
Prüfungsleistungen (PL) / Studienleistung (SL)							
Art			ECTS	Dauer / Umfang		Notenskala	
PL	Written exam		4	90 min		graded	
Workload			120 h				
Präsenzstudienzeit			28 h				
Selbststudienzeit			92 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		
Biophotonics - Imaging Physics and Manipulation of Biological Cells - Vorlesung				2	Written exam		
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
keine				Basic knowledge in coherent optics, Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics			
Qualifikationsziele							
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							
Inhalte							
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.							
Besonderheiten							
keine							
Literatur							
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**Verwendbarkeit in anderen Studiengängen**

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

Modul: Computational Photonics

Module: Computational Photonics

Type of module		Area of competence					
Wahl							
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		apl. Prof. Dr. Ayhan Demircan					
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 - Hörsaalübung				2	Written exam		
Computational Photonics - Vorlesung				2	Academic achievement		
Requirements for participation:			Recommended for participation:				
none			Nonlinear Optics				
Qualification goals							
<p>The lecture explains various main numerical methods and techniques to solve scientific problems in linear and nonlinear optics. The students 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.</p>							
Contents							
<p>The lecture is organized in two parallel-running tracks: Photonics Fundamentals, and Numerical Methods.</p> <p>The course has a practical exercise component providing the student with basic computer simulation experience.</p> <p>Topics:</p> <ul style="list-style-type: none"> •Light-matter interaction (Chromatic and geometric dispersion, second and third-order susceptibility, Raman scattering, supercontinuum generation, multiphoton and 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							
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.-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		
Fundamentals and Configuration of Laser Beam Sources - Vorlesung				2	Written exam		
Fundamentals and Configuration of Laser Beam Sources - Übung				1			
Requirements for participation:			Recommended for participation:				
none							
Qualification goals							
<p>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.</p>							
Contents							
<p>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.</p>							
Special features							
<p>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.</p>							
Literature							
Applicability in other degree programs							

Modul: Fundamentals of Laser Medicine and Biophotonics

Module: Fundamentals of Laser Medicine and Biophotonics

Modultyp		Kompetenzbereich					
Wahl							
Angebot im	Dauer	Sprache	ECTS	Empfohlen ab			
WiSe	1 Semester	Deutsch/Englisch	5	Zulassung WiSe:	1. Semester	Zulassung SoSe:	1. Semester
Prüfungsleistungen (PL) / Studienleistung (SL)							
Art			ECTS	Dauer / Umfang		Notenskala	
PL	Written exam		4	90 min		graded	
SL	Academic achievement		1	Online Tests		ungraded	
Workload		150 h					
Präsenzstudienzeit		28 h					
Selbststudienzeit		122 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		
Fundamentals of Laser Medicine and Biophotonics - Vorlesung				2	Written exam Academic achievement		
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
keine				Coherent Optics, Photonics or Nonlinear Optics recommended			
Qualifikationsziele							
<p>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.</p>							
Inhalte							
<ul style="list-style-type: none"> • 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 							
Besonderheiten							
Possible separate module: Block seminar with topics from Laser in Medicine (has to be selected separately).							
Literatur							
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: Fundamentals of Laser Medicine and Biophotonics**Module:** Fundamentals of Laser Medicine and Biophotonics

"Applied Laser Medicine"; Springer-Verlag Berns, Greulich: "Laser Manipulation of Cells and Tissues"; Academic Press
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Verwendbarkeit in anderen Studiengängen
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Biomedizintechnik M.Sc.; Mechatronik und Robotik M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.;

Modul: Image Sequence Analysis

Module: Image Sequence Analysis

Type of module		Area of competence					
Wahl							
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	Student research project		1	Laboratory experiment		ungraded	
Workload		150 h					
Attendance study period		56 h					
Self-study time		94 h					
Module coordinator		Prof. Dr.-Ing. habil. Christian Heipke					
Lecturer		Dr.-Ing. Max Mehlretter					
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	Student research project		
Requirements for participation:				Recommended for participation:			
keine				Photogrammetric Computer Vision . Prior knowledge on image processing			
Qualification goals							
<p>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.</p>							
Contents							
<ul style="list-style-type: none"> - 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 							
Special features							
To achieve the 5 ETCS, the lab must be successfully completed. The course is taught in English							
Literature							
<ul style="list-style-type: none"> - 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**

Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;

Modul: Introduction to Nanophotonics

Module: Introduction to Nanophotonics

Type of module		Area of competence					
Wahl							
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 - Übung				1	Written exam		
Introduction to Nanophotonics - Vorlesung				2			
Requirements for participation:				Recommended for participation:			
none				Knowledge of electromagnetic theory (Maxwells equations, wave propagation, etc).			
Qualification goals							
<p>After successfully completing the module, students are able to:</p> <ul style="list-style-type: none"> - Understand the optical properties of dielectric/metals and the theory of surface plasmons. - Understand the theory of the scattering of light by a sphere (Mie theory) and multipoles and apply it to generic nanostructures. - Understand metasurfaces/metamaterials/photonic crystals and design such systems for light manipulation. - Understand some numerical techniques and use simulation software for nanophotonics modelling. 							
Contents							
<p>Nanophotonics studies how light behaves at the nanoscale, and how to engineer the properties of light by exploiting its exotic interaction with nanostructures. 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.</p> <p>Module content:</p> <ul style="list-style-type: none"> - Optical properties of matter, fundamentals of plasmonics. - Light scattering by metallic and dielectric nanostructures. - Metasurfaces, metamaterials and photonic crystals. - Numerical techniques and simulation software for nanophotonic systems. - Selected topics of current research. 							
Special features							
Literature							
<p>Novotny, L., & Hecht, B. (2012). Principles of Nano-Optics (2nd ed.). Cambridge: Cambridge University Press. Gaponenko, S. (2010). Introduction to Nanophotonics. Cambridge: Cambridge University Press. Maier, S. (2007). Plasmonics: Fundamentals and Applications. Springer, New York.</p>							
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							
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
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			
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
none				-			
Qualifikationsziele							
<p>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.</p>							
Inhalte							
<ul style="list-style-type: none"> • 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							
<p>Grundlegende Literatur:</p> <ul style="list-style-type: none"> • 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: Laser Material Processing

Module: Laser Material Processing

Type of module		Area of competence					
Wahl							
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							
<p>After successful completion of the module, the students are able</p> <ul style="list-style-type: none"> •to classify the scientific and technical basics for the use of laser systems and the interaction of the beam with different materials, •to recognize the necessary physical requirements for laser processing and to select specific process, handling and control technology for this purpose, •to explain the basic and current requirements for laser technology in production technology •to estimate the process variables that can be realized by means of laser material processing. 							
Contents							
<ul style="list-style-type: none"> - 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 <p>The module provides basic knowledge about the spectrum of laser technology in production as well as the potential of laser technology in future applications.</p>							
Special features							
Lectures and exercises in the rooms of the Laser Zentrum Hannover e.V. (laboratories / experimental field). Lecture und examination are offered in English and German. The courses name on Stud.IP is Lasermaterialbearbeitung							

Modul: Laser Material Processing**Module:** Laser Material Processing

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							
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							
<p>The aim of this lecture course 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.</p>							
Contents							
<ul style="list-style-type: none"> •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: Laserscanning - Modelling and Interpretation

Module: Laserscanning - Modelling and Interpretation

Type of module		Area of competence					
Wahl							
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	Exercise		ungraded	
Workload		150 h					
Attendance study period		42 h					
Self-study time		108 h					
Module coordinator		apl. Prof. Dr.-Ing. Claus Brenner					
Lecturer		apl. Prof. Dr.-Ing. Claus Brenner					
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		
Laserscanning - Modelling and Interpretation - Vorlesung				2	Oral exam		
Laserscanning - Modelling and Interpretation - Hörsaalübung				1	Academic achievement		
Requirements for participation:			Recommended for participation:				
keine			Programming Skills				
Qualification goals							
<p>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-level processing of laser scanning data</p>							
Contents							
<p>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, scanline grouping. Scanning and segmentation in robotics applications. Decision trees and random forests for point cloud classification. 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.</p>							
Special features							
Lecture is given in English							
Literature							
Skript							
Applicability in other degree programs							
Mechatronik und Robotik M.Sc.; Optische Technologien B.Sc.; Optische Technologien M.Sc.;							

Modul: Non-linear Optics

Module: Non-linear Optics

Type of module		Area of competence					
Wahl							
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. Silke Ospelkaus-Schwarzer					
Lecturer		Prof. Dr. Silke Ospelkaus-Schwarzer					
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 - Übung				1	Studienleistung		
Non-linear Optics - Vorlesung				3			
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							
<ul style="list-style-type: none"> •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;							
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							
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	2	Admission WiSe:	1. Semester	Admission SoSe:	1. Semester
Examination performance (Ep) / Academic achievement (Aa)							
Kind			ECTS	Duration / Scope		Grading scale	
PL	Oral exam		2	30 min		graded	
Workload		60 h					
Attendance study period		28 h					
Self-study time		32 h					
Module coordinator		Prof. Dr. Piet Schmidt					
Lecturer		Prof. Dr. Piet Schmidt					
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		
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							
<ul style="list-style-type: none"> -Introduction to optical clocks -Atom-light interaction -Trapped-ion physics -Atoms in optical lattices -Statistical uncertainty -Clock laser -Clock feedback loop -Systematic effects& mitigation I - Neutrals -Systematic 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							
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		Prof. Dr. Detlev Ristau					
Lecturer		Prof. Dr. Detlev Ristau					
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							
<ul style="list-style-type: none"> •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							
Offer in	Duration	Language	ECTS	Recommended from			
SoSe	1 Semester	Englisch	3	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		1	60 min		graded	
SL	Academic achievement		2	Exercise		ungraded	
Workload		90 h					
Attendance study period		28 h					
Self-study time		62 h					
Module coordinator		Prof. Dr. Andrea Trabattoni					
Lecturer		apl. Prof. Dr. Milutin Kovacev					
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				none			
Qualification goals							
<p>A new teaching concept will give the students the possibility to build their knowledge from hands-on projects. This concept aims to provide training for students in basic research skills like presenting, evaluating and analysing experimental research.</p>							
Contents							
<ul style="list-style-type: none"> •Radiometry •Photometry •Optical devices for light measurement •Laser safety <p>Example projects: Build up of a Power-Meter, Spectroscopy, Radiometry measurements of hazardous light sources, Light pulse detection, Coherent diffraction imaging, UV microscopy</p>							
Special features							
none							
Literature							
none							
Applicability in other degree programs							
Optische Technologien B.Sc.; Optische Technologien M.Sc.;							

Modul: Optik, Atomphysik und Quantenphänomene

Module: Optics, Atoms and Quantum Phenomena

Modultyp		Kompetenzbereich					
Wahl							
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. 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		
Optik, Atomphysik und Quantenphänomene - Übung				1	Klausur		
Optik, Atomphysik und Quantenphänomene - Labor				3	Studienleistung		
Optik, Atomphysik und Quantenphänomene - Vorlesung				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							
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 - Übung				1	Oral exam		
Photogrammetric Computer Vision - Vorlesung				2	Academic achievement		
Requirements for participation:			Recommended for participation:				
none			Bachelorabschluss in einem Ingenieurfach empfohlen.				
Qualification goals							
<p>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.</p>							
Contents							
<p>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.</p>							
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							
Mechatronik und Robotik M.Sc.; Optische Technologien M.Sc.;							

Modul: Production of Optoelectronic Systems

Module: Production of Optoelectronic Systems

Type of module		Area of competence					
Wahl							
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							
<p>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 successful examination in this module the students are able to</p> <ul style="list-style-type: none"> •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							
<ul style="list-style-type: none"> •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							
<p>Lau, John H.: Low cost flip chip technologies : for DCA, WLCSP, and PBGA assemblies. McGraw-Hill, New York 2000. 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.</p>							

Modul: Production of Optoelectronic Systems**Module:** Production of Optoelectronic Systems**Applicability in other degree programs**

Maschinenbau M.Sc.; Mechatronik und Robotik M.Sc.; Nanotechnologie M.Sc.; Produktion und Logistik M.Sc.;
Wirtschaftsingenieur M.Sc.;

Modul: Proseminar - Grundlagen der Mikroskopie

Module: Proseminar - Introduction to Microscopy

Modultyp		Kompetenzbereich					
Wahl							
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		
Proseminar - Grundlagen der Mikroskopie - Seminar				3	Project-oriented form of examination		
Voraussetzungen für die Teilnahme:				Empfohlen für die Teilnahme:			
keine				keine			
Qualifikationsziele							
<p>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.</p> <p>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.</p>							
Inhalte							
<ul style="list-style-type: none"> • Grundlagen der Bildgebung • Aberrationen und Beleuchtung • Abbe-Theorie in der Bildgebung • Kontrastmethoden • Fluorescence Mikroskopie • Das Spektrum des Lichts • Moderne Mikroskopietechniken • Introduction to optical Imaging • Aberrations and Illumination • Abbe theory of image formation • Fluorescence microscopy • Spectra and Filters • Recent developments in microscopy 							

Modul: Proseminar - Grundlagen der Mikroskopie**Module:** Proseminar - Introduction to Microscopy

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

Modul: Proseminar Biophotonik

Module: Proseminar Biophotonics

Modultyp		Kompetenzbereich					
Wahl							
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	
SL	Academic achievement		3	Presentation		ungraded	
Workload		90 h					
Präsenzstudienzeit		28 h					
Selbststudienzeit		62 h					
Modulverantwortliche-r		Prof. Dr. Uwe Morgner					
Dozent-in		Prof. Dr. Bernhard Roth					
Institut		Hannoversches Zentrum für Optische Technologien					
Fakultät		Fakultät für Maschinenbau					
Aufbau des Moduls							
Veranstaltungstitel und Form				SWS	PL / SL		
Proseminar Biophotonik - Vorlesung				2	Academic achievement		
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							
<ul style="list-style-type: none"> - 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 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 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"							
Literatur							
Verwendbarkeit in anderen Studiengängen							
Optische Technologien M.Sc.;							

Modul: Radar Remote Sensing

Module: Radar Remote Sensing

Type of module		Area of competence					
Wahl							
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 Prof. Dr. Madhi Motagh					
Lecturer							
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							
<p>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.</p>							
Contents							
<p>Lecture content:</p> <ul style="list-style-type: none"> ➤ 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 angle) ➤ 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 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 ➤ Error sources: Residual topography; Tropospheric error, ionospheric error ➤ Stripmap and TOPS InSAR analysis with SNAP 							

Modul: Radar Remote Sensing

Module: Radar Remote Sensing

- Along-track interferometry; pixel offset tracking and multiple-aperture SAR interferometry
- 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 earth's surface. *Reviews of Geophysics*, 36, 441-500.
- Bürgmann, R., Rosen, P., & Fielding, E. (2000). Synthetic Aperture Radar Interferometry to measure Earth's 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 Journal 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 Numerische Optik

Module: Seminar Numerical Optics

Modultyp		Kompetenzbereich					
Wahl							
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: <ul style="list-style-type: none"> • 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: Seminar Optik auf Femto- und Attosekunden-Zeitskalen

Module: Seminar Optics at Femto- and Attoscond Scales

Modultyp		Kompetenzbereich					
Wahl							
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	Preparation, Presence		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 Optik auf Femto- und Attosekunden-Zeitskalen - 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 literature 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							
<ul style="list-style-type: none"> - 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 - Plasma channels - The absolute carrier phase - Quantum interference metrology 							

Modul: Seminar Optik auf Femto- und Attosekunden-Zeitskalen**Module:** Seminar Optics at Femto- and Attoscond Scales

- 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

Für optische Technologien. The courses name on Stud.IP is "Seminar Optik auf Femto- und Attosekunden-Zeitskalen". Die Studierenden haben in dem Seminar sowohl eine benotete Prüfungsleistung als auch eine Studienleistung zu absolvieren.

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							
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		Prof. Dr. Antonio Calà Lesina					
Institute		Institut für Quantenoptik					
Faculty		Fakultät für Mathematik und Physik					
Structure of the module							
Title and form of the course				Semester hours	Ep / Aa		
Simulations in photonics (wave-optics) - Vorlesung				2	Project-oriented form of examination		
Simulations in photonics (wave-optics) - Übung				2			
Requirements for participation:			Recommended for participation:				
none			Knowledge of electrodynamics and theoretical optics (Grundlagen der Optik I und II).				
Qualification goals							
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 course 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							
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	Laboratory 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				Grundkenntnisse in Physik und Kohärenter Optik empfohlen.			
Qualifikationsziele							
Die Studierenden verstehen die grundlegenden Konzepte von starken optischen Feldern und deren Wechselwirkung mit Materie. Sie lernen in der Vorlesung diese eigenständig auf ausgewählte Probleme anzuwenden. Sie kennen fortgeschrittene experimentelle Methoden des Gebietes und können diese unter Anleitung anwenden.							
Inhalte							
Die Vorlesung beinhaltet auch eine Laborübung zur Förderung der Forschungskompetenz von Studierenden durch projektorientierte Lernformate. Das Erreichen der Kompetenzziele der Laborübung erfordert eine kontinuierliche Teilnahme							
<ul style="list-style-type: none"> •Kohärente und inkohärente Strahlungsquellen •Röntgen-Optik •Detektion von Röntgen-Strahlung •Laser-Materie-Wechselwirkung •Erzeugung von Harmonischen höherer Ordnung / Attosekundenpulse •Anwendungen in Atom-, Molekül- und Festkörperphysik 							
Students understand the basic concepts of strong optical fields and their interaction with matter. They learn to apply these independently to selected problems in the lecture. They know advanced experimental methods of the field and can apply them under guidance. The lecture also includes a laboratory exercise to enhance students research skills through project-based learning formats. Achieving the competency objectives of the laboratory exercise requires continuous participation							
-Coherent and incoherent radiation sources-X-ray optics -detection of X-ray radiation -Laser-matter interaction -Generation of higher order harmonics / attosecond pulses -Applications in atomic, molecular and solid state physics							
Besonderheiten							
Um das Modul zu bestehen, muss sowohl die Prüfungsleistung als auch die Studienleistung erfolgreich bestanden sein.							
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							

Modul: Strong Field Physics**Module:** Strong Field Physics**Verwendbarkeit in anderen Studiengängen**

Optische Technologien M.Sc.;

Modul: Ultrakurze Laserpulse

Module: Ultrashort laser pulses

Modultyp		Kompetenzbereich					
Wahl							
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.;							