Module Catalog for PO 2017

Study Guide for the study program
Optical Technologies
Bachelor of Science
Master of Science

academic year 17/18
Impressum
Hannover Centre for Optical Technologies of the Leibniz Universität Hannover
www.hot.uni-hannover.de

Valid for the winter semester 2017/2018
Hannover, 27.09.2017

Responsible: Prof. Dr. habil. Bernhard Roth

Contacts: Jonas Kanngießer, M.Sc.

Address:
Nienburger Straße 17
D-30167 Hannover

Telephone / Fax:
+49 (0)511 762-17908 / +49 (0)511-17909

E-Mail:
lehre@hot.uni-hannover.de
## Contents

- **Contents** .................................................................................................................. 1
- **Introduction** .................................................................................................................. 3
- Master's degree program Optical Technologies .............................................................. 4
- **Study profile** .................................................................................................................. 4
- Educational goals of the master's degree course optical technologies – Knowledge, Skills, Competence ................................................................................................................................. 4
- Didactic results ..................................................................................................................... 4
- **Master Lab** ....................................................................................................................... 4
- **Tutorial** .................................................................................................................................. 5
- **Student Project** ................................................................................................................. 5
- **Initial Internship** ............................................................................................................... 5
- **Advanced Internship** ........................................................................................................ 5
- Master Thesis ....................................................................................................................... 5
- **Master's degree plan** ......................................................................................................... 6
- **Program Description** ....................................................................................................... 7
- **Personal Prerequisites** ..................................................................................................... 7
- Compulsory and Optional Modules ..................................................................................... 7
- Course Descriptions ............................................................................................................ 9
- Atomic Optics ....................................................................................................................... 10
- **Augmented Reality Apps for Mechatronics and Medical Technology** ....................... 11
- **Automotive Lighting** ....................................................................................................... 12
- Biophotonics – Imaging and Manipulation of Biological Cells .......................................... 13
- **Computational Photonics** ............................................................................................... 14
- **Design and Simulation of Optomechatronic Systems** ...................................................... 15
- **Detection and Quantification of Optical Radiation** ........................................................ 16
- **Digital Image Processing** ................................................................................................ 17
- **Fundamentals and Configuration of Laser Beam Sources** .............................................. 18
- **Fundamentals of Laser Medicine and Biophotonics** ....................................................... 19
- Laser Interferometry ............................................................................................................. 20
- Laser Material Processing II ................................................................................................ 21
- Laser Measurement Technology .......................................................................................... 22
- Laser Spectroscopy in Life Sciences .................................................................................... 23
- **Nonlinear Optics** ............................................................................................................ 24
- Optical Coatings and Layers ............................................................................................... 25
- Optical Measurement Technology ....................................................................................... 26
- Optical properties of micro and nanostructures .................................................................. 27
- **Optics, atomic and quantum physics (additional module)** .............................................. 28
- Photogrammetric Computer Vision ..................................................................................... 29
- **Photonics** ....................................................................................................................... 30
- Physics of Solar Cells ........................................................................................................... 31
- Production of Optoelectronic Systems ............................................................................... 32
- Proseminar Biophotonics ..................................................................................................... 33
- Proseminar Nonlinear Fiber Optics ....................................................................................... 34
- Radar Remote Sensing ......................................................................................................... 35
- **Satellite Remote Sensing I** ............................................................................................. 36
Satellite Remote Sensing II .................................................................37
Seminar Numerical Optics ................................................................38
Seminar Theory and practice of optical functional layers ..................39
Solid State Lasers .............................................................................40
Ultrashort Laser Pulses .................................................................41
XUV Laser Physics .........................................................................42
Addresses and Contact Persons ......................................................43
Facilities of the Faculty of Mechanical Engineering .......................45
Institutes and Professors of the Faculty of Mechanical Engineering ......46
Institutes and Professors of the Faculty of Mathematics and Physics ........47
Institutes and Professors of the Faculties of Electrical Engineering and Computer Science ..........47
Facilities of the Leibniz Universität Hannover ..................................47
Other Institutes and Centers of the Leibniz University Hannover ........48
Associated Members of the HOT ....................................................49
Appendix .......................................................................................51
Objectives table of the master program Optical Technologies ............51
Diploma Supplement ......................................................................52
Dear Students,

Hereby, you receive the current module catalogue of the Master Course “Optical Technologies”. This course was established by the Faculty of Mechanical Engineering as well as the Faculty of Mathematics and Physics in cooperation with the Laser Zentrum Hannover e.V. in order to strengthen and promote the field of optical technologies in science and research in Hannover. With this new master course you receive an education, which combines cutting edge basic and applied research in the fields of optics and photonics, physics and engineering and thus qualifies you for both the optics industries and academic research. In combination with your educational background - Bachelor of Science or Bachelor of Engineering – you acquire skills to apply scientific theory in research practice.

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

We wish you the best for your studies,

Prof. Dr.-Ing. Stephan Kabelac
Dean of studies of the faculty of mechanical engineering.

Prof. Dr. habil. Bernhard Roth
Scientific and managing director, Hannover Centre for Optical Technologies (HOT).
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:

<table>
<thead>
<tr>
<th>Basic courses</th>
<th>20 CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional courses</td>
<td>35 CP</td>
</tr>
<tr>
<td>Master Lab</td>
<td>5 CP</td>
</tr>
<tr>
<td>Studium Generale and Tutorials</td>
<td>4 CP</td>
</tr>
<tr>
<td>Student Project</td>
<td>10 CP</td>
</tr>
<tr>
<td>Internship (12 weeks)</td>
<td>15 CP</td>
</tr>
<tr>
<td>Master Thesis</td>
<td>30 CP</td>
</tr>
</tbody>
</table>

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 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
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. For organization and further information please contact lehre@hot.uni-hannover.de.

**Tutorial**

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. This corresponds to approximately 7.5 40-hour-weeks.

**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.
Master’s degree plan

This section shows the attribution of the courses to the four semesters of the master’s degree program in Optical Technologies.

<table>
<thead>
<tr>
<th>CP</th>
<th>1st term</th>
<th>2nd term</th>
<th>3rd term</th>
<th>4th term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Photonics Compulsory Module (5 CP)</td>
<td>Design and Simulation of optomechatronic Systems Compulsory Module (5 CP)</td>
<td>Student Project (10 CP)</td>
<td>Master Thesis (30 CP)</td>
</tr>
<tr>
<td>2</td>
<td>Optical Measurement Technology Compulsory Module (5 CP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Laser Spectroscopy in Life Sciences Compulsory Module (5 CP)</td>
<td>Optional Modules (20 CP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Advanced Internship (15 CP)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Optional Modules (15 CP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>Project Pres. (1 CP)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Master Lab Tutorial (5 CP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>Studium Generale / Tutorials (4 CP)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Σ</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
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 Hannover Centre for Optical Technologies (HOT) 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.

Compulsory and Optional Modules

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

### Compulsory Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Measurement Technology</td>
<td>Rahlves</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Laser Spectroscopy in Life Sciences</td>
<td>Roth</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Design and Simulation of Optomechatronic Systems</td>
<td>Lachmayer</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Photonics</td>
<td>Chichkov</td>
<td>WS</td>
<td>5</td>
</tr>
</tbody>
</table>

### Optional Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic Optics</td>
<td>Ospelkau</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>Augmented Reality Apps for Mechatronics and Medical Engineering</td>
<td>Kahrs</td>
<td>SS/WS</td>
<td>4</td>
</tr>
<tr>
<td>Automotive Lighting</td>
<td>Wallaschek</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Biophotonics – Imaging Physics and Manipulation of Biological Cells</td>
<td>Heisterkamp</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>Computational Photonics</td>
<td>Demircan</td>
<td>SS</td>
<td>6</td>
</tr>
<tr>
<td>Detection and Quantification of Optical Radiation</td>
<td>Kovacev</td>
<td>SS</td>
<td>--</td>
</tr>
<tr>
<td>Digital Image Processing</td>
<td>Gigengack</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Fundamentals and Configuration of Laser Beam Sources</td>
<td>Overmeyer Kracht</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Course</td>
<td>Responsible</td>
<td>Sem.</td>
<td>Credits</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Fundamentals of Laser Medicine and Biophotonics</td>
<td>Lubatschowski</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Krüger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser Interferometry</td>
<td>Heinzel</td>
<td>WS/SS</td>
<td>3</td>
</tr>
<tr>
<td>Laser Material Processing II</td>
<td>Overmeyer</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Laser Measurement Technology</td>
<td>Roth</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Nonlinear Optics</td>
<td>Demircan</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Optical Coatings and Layers</td>
<td>Ristau</td>
<td>WS</td>
<td>4</td>
</tr>
<tr>
<td>Optical properties of micro and nano structures</td>
<td>Wolfer</td>
<td>WS</td>
<td>4</td>
</tr>
<tr>
<td>Photogrammetric Computer Vision</td>
<td>Heipke</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Physics of Solar Cells</td>
<td>Brendel, Altermatt</td>
<td>SS</td>
<td>6</td>
</tr>
<tr>
<td>Production of Optoelectronic Systems</td>
<td>Overmeyer</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Proseminar Biophotonics</td>
<td>Roth</td>
<td>WS/SS</td>
<td>3</td>
</tr>
<tr>
<td>Proseminar Nonlinear Fiber Optics</td>
<td>Demircan</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Radar Remote Sensing</td>
<td>Motagh</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Satellite Remote Sensing I</td>
<td>Melsheimer</td>
<td>WS</td>
<td>4</td>
</tr>
<tr>
<td>Satellite Remote Sensing II</td>
<td>Melsheimer</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>Seminar Numerical Optics</td>
<td>Roth</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Seminar Theory and practice of optical functional layers</td>
<td>Ristau</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Solid State Lasers</td>
<td>Weßels</td>
<td>SS</td>
<td>2</td>
</tr>
<tr>
<td>Ultrashort Laser Pulses</td>
<td>Babushkin</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>XUV Laser Physics</td>
<td>Kovacev</td>
<td>WS</td>
<td>5</td>
</tr>
</tbody>
</table>

### Additional Mandatory Modules

For all students who require additional mandatory modules. There are two modules available which replace the mandatory lectures as follows:

<table>
<thead>
<tr>
<th>Module</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid State Lasers</td>
<td>Weßels</td>
<td>SS</td>
<td>/</td>
</tr>
<tr>
<td>Replaces the mandatory modules:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Einführung in die Festkörperphysik</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This module can only acknowledged once! Students who are affected have to attend an additional course to match their ECTS-goal!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optics, atomic and quantum physics</td>
<td>Morgner</td>
<td>WS</td>
<td>/</td>
</tr>
<tr>
<td>Replaces the mandatory modules:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optik, Atomphysik, Quantenphänomene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atom- und Molekülphysik</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moleküle, Kerne, Teilchen, Festkörper</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

Type of Examination

Written or oral exams are administered by the teaching professor.
**Atomic Optics**

<table>
<thead>
<tr>
<th>Title:</th>
<th>Atomoptik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>13084</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Silke Ospelkaus, Prof. Dr. Christian Ospelkaus</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik</td>
</tr>
<tr>
<td>Email:</td>
<td></td>
</tr>
</tbody>
</table>

**Event description:**

Recent experimental procedures to investigate the physics of ultracold gases, laser manipulation of single atoms and quantum engineering are discussed experimentally and theoretically. Students will gain insight in recent developments in the field of atomic physics.

**Contents:**

- 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

**Prior knowledge**

Atom and Molecular Physics, Quantumoptics

**Recommended literature**

Van der Straaten

**Additional Information**

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>--</th>
<th>Type of exam</th>
<th>--</th>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>--</td>
<td>ECTS-CP:</td>
<td>4</td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
Augmented Reality Apps for Mechatronics and Medical Technology

Augmented Reality Apps für Mechatronik und Medizintechnik

<table>
<thead>
<tr>
<th>Title:</th>
<th>Augmented Reality Apps für Mechatronik und Medizintechnik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>--</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Dr.-Ing. Lüder A. Kahrs</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Mechatronische Systeme, <a href="http://www.imes.uni-hannover.de">www.imes.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:lueder.kahrs@imes.uni-hannover.de">lueder.kahrs@imes.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

Event description:
The course comprises development of apps for mobile devices in the field of mechatronics and medical technology. The target operating system is Android. A special focus is the usage of display and camera for augmented reality scenarios. Image processing and visualization techniques are important side aspects. The students will get insights of the IDE Android Studio and the library Vuforia. Further topics of the course are visualization concepts, mixed reality, object recognition, navigation, etc.

Prior knowledge
Required knowledge: Programming under Java, C or C++

Recommended literature
Slides, Online tutorials for Android Programming

Additional Information
The course is limited to 10 teams of 2 students each.

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>88h</td>
<td>ECTS-CP:</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Course content</td>
<td>L2/E1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Semester</td>
<td>WS/SS</td>
</tr>
</tbody>
</table>
Automotive Lighting
Kraftfahrzeug - Lichttechnik

Title: Automotive Lighting
Type: Lecture
Number: 33378
Lecturer: Prof. Dr.-Ing. Jörg Wallaschek, Prof. Dr.-Ing Roland Lachmeyer
Institute: Institut für Dynamik und Schwingungen, www.ids.uni-hannover.de
Email: wallaschek@ids.uni-hannover.de

Event description:
The course offers an introduction into automotive lighting technology and teaches the technological and physiological fundamentals which are necessary to understand and evaluate lighting systems. In addition to the required optical variables the state of the art and future trends of automotive lighting will be presented. Important technologies like for example new light sources and their application in automotive front and signal lights as well as in further optical systems will be considered. One main aspect of the lecture focusses on light-based driver assistance systems (e.g. glare free high beam, marking light) which are one core aspect of today’s technological development. Physiological and psychological basics like the structure of the human eye and the visual sense complete the course.

Contents:
- Basics of lighting
- Light sources, headlights, rear lights
- Mechanical and electronical components
- Light-based driving assistance systems
- Basics of human vision
- Structure of the human eye
- Photopic, mesopic and scotopic vision
- Disability and discomfort glare
- Environment sensor systems
- Image processing
- Active lighting systems

Prior knowledge
---

Recommended literature

Additional Information
The course consists of three parts: 1) a series of 6 introductive lectures as well as a practical training in light measurement technology, 2) preparation of lectures and the according presentation by the students their selves, 3) an excursion to a company or research facility in the field of vehicle lighting, e.g. Volkswagen AG in Wolfsburg, Hella or the L-LAB in Lippstadt.

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>oral</th>
<th>Course content</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>88h</td>
<td>ECTS-CP:</td>
<td>5</td>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
Biophotonics – Imaging and Manipulation of Biological Cells

Biophotonik – Bildgebung und Manipulation von biologischen Zellen

**Title:** Biophotonik – Bildgebung und Manipulation von biologischen Zellen

**Type:** Lecture

**Number:** 13144

**Lecturer:** Prof. Dr. Alexander Heisterkamp

**Institute:** Laser Zentrum Hannover e.V. and Institut für Quantenoptik

**Email:** a.heisterkamp@lzh.de

**Event description:**

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, as well as optical coherence tomography, and laser scanning microscopy and super resolution approaches. Furthermore, application within biotechnology, such as biochips, cell sorting and cell surgery and interaction with nanoparticles and nanostructures will be discussed.

The students will acquire knowledge within this interdisciplinary field of physics, engineering, life science and medicine. The covered areas will be exemplarily discussed using examples of current research themes investigated at joint projects with the MHH and the excellence cluster REBIRTH (From Regenerative Biology to Reconstructive Therapy).

Aside from teaching the fundamentals and facts of biophotonics, the lecture introduces the students to the search and understanding of original research articles. With each topic covered within the lecture, recent articles from research journals will be discussed in monthly tutorials. In one of these tutorials the article search using internet search engines will be covered (at the RRZN). The other tutorials will take place at the seminar room of the IQ, in which the relevant article will be discussed.

**Prior knowledge**

Basic knowledge in coherent optics
Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics

**Recommended literature**

Basic Methods in Microscopy, Spector, Goldman
Introduction to Biophotonics, P.N. Prasad
Laser Manipulation of Cells and Tissues, M.W. Berns, K. O. Greulich
Atala, Lanza, Thomson, Nerem: Principles of Regenerative Medicine
Original literature

**Additional Information**

Limited places in tutorial (30) (PC workstations at the RRZN)

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>45h</th>
<th>Type of exam:</th>
<th>written /oral</th>
<th>Course content</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>30h</td>
<td>ECTS-CP:</td>
<td>4</td>
<td>L2</td>
<td>SS</td>
</tr>
</tbody>
</table>
### Computational Photonics

**Title:** Computational Photonics  
**Type:** Lecture  
**Number:** 13149  
**Lecturer:** Ihar Babushkin, Ayhan Demircan, Oliver Melchert, Uwe Morgner  
**Institute:** Institut für Quantenoptik, www.iqo.uni-hannover.de  
**Email:** demircan@iqo.uni-hannover.de

**Event description:**

The lecture is organized in two parallel-running tracks: Photonics Fundamentals, and Numerical Methods. The course has a practical exercise component providing the student with basic computer simulation experience.

**Inhalt:**

- Light-matter interaction (Chromatic and geometric dispersion, second- and third-order susceptibility, Raman scattering, supercontinuum generation, multiphoton und tunneling ionization, low-order harmonic radiation)
- Laserdynamics (Mode-locking, Rate equation, Q-switching)
- 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
- Optimization algorithms
- Spectral and Pseudospectral methods
- Runge-Kutta and operator splitting approach
- Parallel computing (openMP, openMPI)

**Prior knowledge**

--

**Recommended literature**

Obayya, „Computational Photonics“, Wiley

**Additional Information**

--

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>60h</th>
<th>Type of exam:</th>
<th>written/oral</th>
<th>Course content</th>
<th>L2/E2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>90h</td>
<td>ECTS-CP:</td>
<td>6</td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
**Design and Simulation of Optomechatronic Systems**

Konstruktion Optischer Systeme / Optischer Gerätebau

<table>
<thead>
<tr>
<th>Title:</th>
<th>Konstruktion Optischer Systeme / Optischer Gerätebau</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>31308</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Lachmayer, Dr.-Ing. Alexander Wolf</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Produktentwicklung und Gerätebau, <a href="http://www.ipeg.uni-hannover.de">www.ipeg.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:wolf@ipeg.uni-hannover.de">wolf@ipeg.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

The course Design of Optical Systems provides knowledge about the specific design and manufacturing process of optical devices. The path of the light is considered from various light sources over different light shaping and modifying optical elements to the perception by the human eye. The course focuses on the methodological construction process, product development and optimization. Practical examples arise from vehicle lighting and connections to manufacturing technology and metrology. Exercises with optical simulation software complete the event.

**Prior knowledge**

Lecture Technical Mechanics III

**Recommended literature**

Lecture script

**Additional Information**

---

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118 h</td>
</tr>
<tr>
<td>Type of exam:</td>
<td>written/oral</td>
</tr>
<tr>
<td>ECTS-CP:</td>
<td>5</td>
</tr>
<tr>
<td>Course content</td>
<td>L2/E1</td>
</tr>
<tr>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
Detection and Quantification of Optical Radiation

Title: Detection and Quantification of Optical Radiation
Type: Lecture + Lab
Number: 12532 (Lecture), 12413 (Lab)
Lecturer: Prof. Milutin Kovacev
Institute: Institut für Quantenoptik

Event Description:

Contents:
- Radiometry
- Photometry
- Optical devices for light measurement
- Laser safety

Example projects:
Build up of a Power-Meter, Spectroscopy, Radiometry measurements of hazardous light sources, Light pulse detection, Coherent diffraction imaging, UV microscopy

Prior knowledge
---

Recommended Literature
---

Additional Information
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.

Presence studies time:
Self-Study
Type of exam:
ECTS-CP:
Course content
Semester
SS
Digital Image Processing

The students are familiar with two-dimensional discrete systems, scanning, the basics of visual perception, discrete geometry, image restoration, image processing and image analysis.

### Contents:
- Fundamentals
- Linear System Theory
- Image Description
- Discrete geometry
- Color and texture
- Transformations
- Image Editing
- Image restoration
- Image Coding
- Image analysis

### Prior knowledge
Engineering mathematics, digital signal processing (recommended)

### Recommended literature
- Jähne, Bernd: Digitale Bildverarbeitung, Springer Verlag, 1997
- Haberäcker, Peter: Praxis der Digitalen Bildverarbeitung und Mustererkennung, Carl Hanser Verlag, 1995
- Abmayr, Wolfgang: Einführung in die digitale Bildverarbeitung, Teubner Verlag, 1994
- Pinz, Axel: Bildverstehen, Springer Verlag, 1994
- Ohm, Jens-Rainer: Digitale Bildcodierung, Springer Verlag, 1995
- Girod, Rabenstein, Stenger: Einführung in die Systemtheorie, Teubner Verlag, 1997

### Additional information
Short testat

<table>
<thead>
<tr>
<th>Presence studies</th>
<th>Type of exam:</th>
<th>Course cont.</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>written</td>
<td>L2/E1/ Lab</td>
</tr>
<tr>
<td>Self-study:</td>
<td>ECTS-CP: 5</td>
<td>Semester SS</td>
</tr>
</tbody>
</table>
Fundamentals and Configuration of Laser Beam Sources
Grundlagen und Aufbau von Laserstrahlquellen

Title: Grundlagen und Aufbau von Laserstrahlquellen
Type: Lecture
Number: 30275
Lecturer: Prof. Dr.-Ing. Ludger Overmeyer, Dr. Dietmar Kracht
Institute: Institut für Transport- und Automatisierungstechnik, www.ita.uni-hannover.de
Laserzentrum Hannover, www.lzh.de
Email: d.kracht@lzh.de

Event description:

Contents:
- Fundamentals of laser beam sources
- Operation regime of lasers
- Characterization of lasers
- Laser diodes
- Optical resonators
- CO2-lasers
- Excimer lasers
- Concepts and materials for lasers
- Rod and disk lasers
- Fiber lasers and amplifiers
- Frequency conversion
- Ultrashort pulse lasers

Prior knowledge
Basic knowledge in coherent optics

Recommended literature
Lecture Script; Further recommendations in lecture

Additional Information
Multiple experimental demonstrations in the laboratories of Laser Zentrum Hannover e.V.

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>oral/written</th>
<th>Course</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
<td>ECTS-CP:</td>
<td>5</td>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
**Fundamentals of Laser Medicine and Biophotonics**

Grundlagen der Lasermedizin und Biophotonik

**Title:** Grundlagen der Lasermedizin und Biophotonik  
**Type:** Lecture  
**Number:** 12130  
**Lecturer:** apl. Prof. Dr. Holger Lubaschowski, Prof. Dr. Alexander Heisterkamp  
**Institute:** Institut für Quantenoptik, www.iqo.uni-hannover.de  
**Email:** a.krueger@lzh.de

**Event description:**

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

**Contents:**

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

**Prior knowledge**

Coherent Optics, Photonics or Nonlinear Optics

**Recommended literature**

Eichler, Seiler: "Lasertechnik in der Medizin"; Springer-Verlag  
Berlien, Müller: "Angewandte Lasermedizin"; Bd. 1,2, eco med Verlag  
Berlien, Müller: "Applied Laser Medicine"; Springer-Verlag  

**Additional Information**

5 ECTS-CP for lecture + seminar, limited places for talks in block seminar (20 talks), participation in lecture and seminar not limited (4 ECTS)

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>22h</th>
<th>Type of exam:</th>
<th>written/oral</th>
<th>Course content</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>128h</td>
<td>ECTS-CP:</td>
<td>4+1</td>
<td>L2</td>
<td>WS</td>
</tr>
</tbody>
</table>
Laser Interferometry
Laserinterferometrie

<table>
<thead>
<tr>
<th>Title:</th>
<th>Laserinterferometrie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>12412</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>apl. Prof. Gerhard Heinzel</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Gravitationsphysik, <a href="http://www.aei.mpg.de">www.aei.mpg.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:gerhard.heinzel@aei.mpg.de">gerhard.heinzel@aei.mpg.de</a></td>
</tr>
</tbody>
</table>

Event description:
Students acquire knowledge of modern laser interferometry. The emphasis of the lecture is laid in laser interferometers for gravitational wave detection such as well as in laser interferometry on satellites (LISA Pathfinder, GRACE Follow-On, LISA).

Contents:
- Michelson-, Mach-Zehnder- and Fabry-Perot interferometer
- Thermal noise
- Mechanical quality of hanging lenses
- Applications for measurement of Gravitational waves and the gravity field of the earth
- Description Gaussian rays and higher methods
- Transformation of Gaussian rays
- Selection procedures: internal, external and Schnuppmodulation; Pound-Drever Hall procedure
- Polarization
- Transfer function and control loops

Applications: GEO600, LISA, GRACE Follow-On

Prior knowledge
Coherent Optics, nonlinear Optics

Recommended literature

Additional Information

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>exam</th>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>58h</td>
<td>ECTS-CP:</td>
<td>3</td>
<td>Semester</td>
<td>WS/SS</td>
</tr>
</tbody>
</table>
# Laser Material Processing II

<table>
<thead>
<tr>
<th>Title:</th>
<th>Laser Material Processing II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>32236</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Ludger Overmeyer, Yixiao Wang</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Transport- und Automatisierungstechnik, <a href="http://www.ita.uni-hannover.de">www.ita.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:Yixiao.wang@ita.uni-hannover.de">Yixiao.wang@ita.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

### Event description:

The course covers the spectrum of laser technology in the production as well as the potential of laser technology for future applications. We explain the scientific and technical basic knowledge, which is used in the laser systems as well as in the interaction of the beam with different materials. On the basis of applications in subject areas such as micromachining, the required physical conditions for laser processing such as wavelength, fluence, pulse peak power, are worked out and described in connection with the specific process, handling and control technology. The purpose is to develop an understanding of the basics and the current demands for laser technology to provide an access for the participants into laser technology in industry.

### Prior knowledge

Basic optics, Light sources II

### Recommended literature

Recommendation made in the lecture; lecture script

### Additional Information

Lectures and exercises seminars in the rooms of Laser Zentrum Hannover e.V. (Laboratory/test areas)

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118 h</td>
</tr>
<tr>
<td>Type of exam:</td>
<td>oral</td>
</tr>
<tr>
<td>ECTS-CP:</td>
<td>5</td>
</tr>
<tr>
<td>Course content:</td>
<td>L2/E1</td>
</tr>
<tr>
<td>Semester:</td>
<td>SS</td>
</tr>
</tbody>
</table>
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.

Content:
- Basic physics
- Optical elements/detection techniques
- Lasers for measurement applications
- Laser triangulation and interferometry
- Distance and velocity measurement
- Laser spectrometry
- Holographic measurement techniques
- Ultra-short laser pulse measurement techniques
- Application in measurement, monitoring, and sensing

Prior knowledge
Fundamentals of measurement technology, Basics of laser physics and laser technology

Recommended literature

Additional Information
Recommended for second semester and higher (Master course)
# Laser Spectroscopy in Life Sciences

<table>
<thead>
<tr>
<th>Title:</th>
<th>Laserspektroskopie in Life Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>13501</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Bernhard Roth</td>
</tr>
<tr>
<td>Institute:</td>
<td>Hanover Centre for Optical Technologies, HOT, <a href="http://www.hot.uni-hannover.de">www.hot.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:bernhard.roth@hot.uni-hannover.de">bernhard.roth@hot.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

## Event description:

The aim of this lecture course is the introduction to the fundamentals and methods in laser spectroscopy for application in the life sciences. Apart from the basic principles of laser spectroscopic techniques and methods applied in various up-to-date areas of fundamental research also 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 exercise course aims at consolidating the understanding of the basic principles given as well as at their application for practical examples.

## Prior knowledge

- Basic physics
- Optical elements and measurement techniques
- Lasers for spectroscopic applications
- Laser interferometry
- Laser spectrometry and spectroscopy
- Applications of (ultra)short pulse lasers

## Recommended literature

- Jürgen Eichler, Hans Joachim Eichler: Laser - Bauformen Strahlführung Anwendungen (Springer), 2010
- Thomas Engel: Quantum Chemistry and Spectroscopy (Pearson), 2013

## Additional Information

Recommended for second semester and higher (Master course)

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of exam:</th>
<th>written/oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-CP:</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
Nonlinear Optics

Event description:
- 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

Prior knowledge
Atom and molecular physics

Recommended literature
Dmitriev, *Handbook of nonlinear crystals*, Springer

Original literature

Additional Information

<table>
<thead>
<tr>
<th>Presence studies</th>
<th>Type of exam:</th>
<th>Course content</th>
</tr>
</thead>
<tbody>
<tr>
<td>time: 42h</td>
<td>written/oral</td>
<td>L3/E1</td>
</tr>
<tr>
<td>Self-study:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>108h</td>
<td>ECTS-CP:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
**Optical Coatings and Layers**

Optische Schichten

<table>
<thead>
<tr>
<th>Title:</th>
<th>Optische Schichten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>12140</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Detlev Ristau</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik, <a href="http://www.iqo.uni-hannover.de/">http://www.iqo.uni-hannover.de/</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:d.ristau@lzh.de">d.ristau@lzh.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

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

**Contents:**

- General basis (applications, impact, and functional principle of optical coatings, state of the art in coatings for laser technology)
- Theoretical fundamentals (compilation of formulae and consideration of fundamental phenomena, calculation of single layers and layer systems)
- Production of optical components (substrates, coating materials and techniques, control of coating processes)
- Optics characterization (measurement of optical transfer properties, optical losses: Total Scattering and absorption, laser induced damage thresholds of laser components, non-optical properties)

**Prior knowledge**

Fundamentals of optics and physics

**Recommended literature**

Will be announced during the course, for an introduction:

**Additional Information**

Three exercise sheets for homework, solution of exercises discussed during the course, major course assessment alternatively by colloquium, oral examination, or by written test

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>written/oral</th>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
<td>ECTS-CP:</td>
<td>4</td>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>

ECTS-CP: 4 Semester WS
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.

Prior knowledge
Fundamentals of Measurement

Recommended literature
Born, Wolf: Principles of Optics;
Hecht: Optics;
Saleh, Teich: Fundamentals of Photonics;
Lauterborn, Kurz: Coherent Optics;
Goodman: Introduction to Fourier Optics;
Hugenschmidt: Lasermesstechnik;
Demtröder: Experimentalphysik

Additional Information

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
<td>ECTS-CP:</td>
<td>5</td>
</tr>
<tr>
<td>Course content</td>
<td>L2/E1</td>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
Optical properties of micro and nanostructures

Event description:
The module teaches the basics of the optical properties of micro- and nanostructures.

After successful completion of the module, students are able to

- understand the fundamentals of geometric optics, to understand physical light / matter interactions at sub-wavelength-scale structures
- design optical grating structures
- to assess spectroscopic measurement principles and diffractive elements
- classify the production technologies of optical micro- and nanostructures
- understand the basics of photovoltaics

Contents:

- Introduction to the topic
- Fundamentals: Geometrical Optics, Calculating with complex amplitudes, Energy transfer at boundaries, Two beam interference
- Huygens’ principle, Fresnel zone construction, Introduction to Fourier Optics
- Kirchhoff-Fresnel diffraction integral, Fresnel diffraction, Fraunhofer diffraction, Introduction to diffraction gratings
- Theory and applications of subwavelength gratings
- Spectroscopic gratings, Thick and thin gratings, Grating regimes
- Photonic crystals
- Imaging with diffractive optical elements
- Production technologies for micro structures with optical functions
- Photonmanagement in solar cells

Prior knowledge
--

Recommended literature
Recommendation made in the lecture; lecture script

Additional Information

Presence studies time: 32h  Type of exam: oral/written  Course content: L2/E1
Self-study: 88h  ECTS-CP: 4  Semester: WS
Optics, atomic and quantum physics (additional module)

Optik, Atomphysik und Quantenphänomene

| Title: | Optik, Atomphysik und Quantenphänomene |
| Type: | Lecture |
| Number: | 12454 |
| Lecturer: | Prof. Dr. Alexander Heisterkamp |
| Institute: | Institut für Quantenoptik, www.iqo.uni-hannover.de |
| Email: | dekan@maphy.uni-hannover.de |

Event description:

Topics:
- Geometrical optics
- Wavelike properties of light: Interference, refraction, polarization, birefringence
- Optics, optical instruments
- Matter waves, wave-particle dualism
- Composition of atoms
- Energy states, angular momentum, magnetic moment
- Pauli principle
- Spectroscopy, spontaneous and stimulated emission

Prior knowledge

- 

Recommended literature

Born, Wolf: Principles of Optics
Saleh, Teich: Fundamentals of Photonics;
Lauterborn, Kurz: Coherent Optics

Additional Information

Additional module for students who are imposed with some or all of the following German lectures:
- Optik, Atomphysik, Quantenphänomene
- Moleküle, Kerne, Teilchen, Festkörper
- Atom- und Molekülphysik

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>written/oral</th>
<th>Course content</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>88h</td>
<td>ECTS-CP:</td>
<td>-</td>
<td>L3/E1</td>
<td>WS</td>
</tr>
</tbody>
</table>

Note: The presence study time includes lectures, seminars, and tutorials, and the self-study time includes reading and homework.
Photogrammetric Computer Vision

Event description:
After attending this 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.

Prior knowledge
- 

Recommended literature
http://www.cs.cmu.edu/~cil/vision.html

Additional Information
Lab work, oral exam

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>oral</th>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
<td>ECTS-CP:</td>
<td>5</td>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
Event description:
The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents:

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

Prior knowledge
Basic knowledge in coherent optics, Nonlinear Optics Lecture

Recommended literature
Saleh, Teich: Photonics, Wiley;
Boyd: Nonlinear Optics, Academic Press

Additional Information
---

<table>
<thead>
<tr>
<th>Presence studies time</th>
<th>Type of exam:</th>
<th>Course content</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>60h</td>
<td>written/oral</td>
<td>L2/E1</td>
<td>WS</td>
</tr>
<tr>
<td>Self-study:</td>
<td>ECTS-CP:</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>90h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Event description:

Semiconductor equations, optical properties of semiconductors, transport of electrons and holes, carrier recombination mechanisms, current-voltage curves, manufacturing process of solar cells, characterization methods for solar cells, physical limitations for efficiency improvements, new concepts.

### Prior knowledge

Basic knowledge in Solid State Physics is helpful but not mandatory

### Recommended literature


### Additional Information

The slides presented during the course will be available for the students.

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>Type of exam:</th>
<th>Course content</th>
</tr>
</thead>
<tbody>
<tr>
<td>60h</td>
<td>written</td>
<td>L2/E2</td>
</tr>
<tr>
<td>Self-study:</td>
<td>ECTS-CP:</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
# Production of Optoelectronic Systems

<table>
<thead>
<tr>
<th>Title:</th>
<th>Production of Optoelectronic Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>--</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Ludger Overmeyer</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Transport- und Automatisierungstechnik, <a href="http://www.ita.uni-hannover.de">www.ita.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:Ludger.overmeyer@ita.uni-hannover.de">Ludger.overmeyer@ita.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

## Event description:
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:

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

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

## Prior knowledge
---

## Recommended literature


Lecture script

## Additional Information

Distinct English- and German taught lectures available

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of exam:</th>
<th>written</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-CP:</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course content</th>
<th>L2/E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
**Proseminar Biophotonics**

**Title:** Proseminar Biophotonik  
**Type:** Proseminar  
**Number:** 12137e  
**Lecturer:** Dr. Merve Wollweber, Dr.-Ing. habil. Maik Rahlves, Prof. Dr. Bernhard Roth, Prof. Dr. Uwe Morgner  
**Institute:** Hannoversches Zentrum für Optische Technologien  
**Email:** bernhard.roth@hot.uni-hannover.de  
merve.wollweber@hot.uni-hannover.de  
maik.rahlves@hot.uni-hannover.de

**Event description:**

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.

**Prior knowledge**

- Basics of physics  
- Optical elements / Measurement techniques  
- Physical foundations of optics and laser technology  
- Basic knowledge in laser applications

**Additional Information**

Graded performance: oral examination and presentation slides  
Type of examination: oral (marked or unmarked, as required)

| Presence studies time: | 30h | Type of exam: | seminar | Course content | S2  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>60h</td>
<td>ECTS-CP:</td>
<td>3</td>
<td>Semester</td>
<td>WS/SS</td>
</tr>
</tbody>
</table>
**Proseminar Nonlinear Fiber Optics**

**Title:** Proseminar Nichtlinear Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher

**Type:** Proseminar

**Number:** 12137f

**Dozent:** PD Dr. Ayhan Demircan, Dr. Ihar Babushkin, Prof. Dr. Uwe Morgner

**Institute:** Institut für Quantenoptik

**Event description:**
Fiber-optical analogies to extremal phenomena from various fields of physics.

**Prior knowledge**
--

**Recommended literature**
--

**Additional Information**
--

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>Type of exam</th>
<th>Course Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seminar</td>
<td>S2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-study:</th>
<th>ECTS-CP:</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>SS</td>
</tr>
</tbody>
</table>
Radar Remote Sensing

Event description:
This course is intended to provide an introduction to the technique of Interferometry Synthetic Aperture Radar (InSAR) and its application for monitoring aspects of Earth’s surface including its topography and deformation. With the increasing availability of SAR systems it is becoming more crucial and important than ever to learn about these systems and to better understand what can be gained from SAR data for various types of natural disasters and engineering applications. The course covers mainly the underlying principle of InSAR measurement technique and time-series approaches of Permanent Scatterer (PS) and Small Baseline Subset (SBAS). The module will be accompanied by lab exercises that provide hands-on experience with classical processing techniques. At the end of the course the students will acquire knowledge and understanding of the fundamental concepts underlying radar remote sensing and will gain the ability to implement processing techniques to extract information from radar data. The lecture is complemented by reading and discussion of textbooks and journal papers, and a 1-day excursion to GeoForschungsZentrum (GFZ) Potsdam towards the end of the semester.

Content:
- Introduction to two-dimensional radar imaging and Synthetic Aperture Radar (SAR)
- Image resolution and SAR geometric distortions
- SAR interferometry to measure Earth’s surface topography and deformation
- Airborne and space-borne SAR sensor systems
- How to access SAR data?
- Fundamental equation of Interferometry: Height ambiguity, sensitivity analysis, selection of baseline, critical baseline
- Typical processing chain: 2 and 3 pass Interferometry
- Application of radar remote sensing in geodesy, geophysics and environmental sciences
- Interferometric phase quality: Coherence
- Error sources: Residual topography; atmospheric error, phase unwrapping, decorrelation
- Time-series methods: Permanent/Persistent Scatterer Interferometry (PSI) and Small Baseline Subset (SBAS)
- Latest development in SAR systems
- Lab: Interferometry exercise using public domain software DORIS

Prior knowledge
Some familiarity with a Linux operating system is beneficial for lab exercises

Recommended literature

Additional Information
- Presence studies time: --
- Type of exam: Oral+Lab
- Course Content: L1/E1/L
- a1
- Self-study: --
- ECTS-CP: 3
- Semester: SS
Satellite Remote Sensing I

Fernerkundung I

<table>
<thead>
<tr>
<th>Title:</th>
<th>Fernerkundung I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>--</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Dr. Christian Melsheimer</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Meteorologie und Klimatologie, <a href="http://www.muk.uni-hannover.de">www.muk.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:melsheimer@uni-bremen.de">melsheimer@uni-bremen.de</a></td>
</tr>
</tbody>
</table>

Event description

The students are learning the basics of remote sensing with emphasis on satellite meteorology, i.e. the measurement of meteorological parameters with satellites. Apart from boosting expert knowledge, the theoretical exercises also train communication skills and methodological competence.

Contents:

- Basics: Satellite orbits, electromagnetic radiation and radiative transfer
- Remote sensing with satellite instruments
- Deduction of temperature, clouds, trace gases, rainfall with remote sensing instruments of satellites
- Overview over current operative meteorological satellites and satellite instruments

Prior knowledge

Electromagnetic radiation, basics of electrical engineering, optics, nuclear physics.

Recommended literature


Additional information

---

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>45h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of exam:</td>
<td>oral</td>
</tr>
<tr>
<td>Course cont.</td>
<td>L2/E1</td>
</tr>
<tr>
<td>Self-study:</td>
<td>75h</td>
</tr>
<tr>
<td>ECTS-CP</td>
<td>4</td>
</tr>
<tr>
<td>Semester</td>
<td>WS</td>
</tr>
</tbody>
</table>
Event description
The students are learning the basics of remote sensing of the land masses, the oceans and the atmosphere. Apart from boosting expert knowledge, the theoretical exercises also train communication skills and methodological competence.

Contents:
- Basics: Electromagnetic radiation, generation and measurement of radiation, radiative transfer
- Retrieval-methods, inverse methods
- Remote sensing (active and passive) of the land masses with visible light, infrared and microwaves
- Remote sensing (active and passive) of the oceans with visible light, infrared and microwaves
- Remote sensing (active and passive) of the atmosphere with visible light, infrared and microwaves, atmospheric probing
- Overview over important satellites and satellite instruments, current and historical

Prior knowledge
Electromagnetic radiation, basics of electrical engineering, optics, nuclear physics, satellite remote sensing I.

Recommended literature

Additional information
--

Presence studies time: 45h  Type of exam: oral  Course cont. L2/
Self-study: 75h  ECTS-CP  4  E1 Semester WS
Seminar Numerical Optics

Seminar Numerische Optik

<table>
<thead>
<tr>
<th>Title:</th>
<th>Seminar Numerische Optik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Seminar</td>
</tr>
<tr>
<td>Number:</td>
<td>12076</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Bernhard Roth, PD Dr. Ayhan Demircan, Prof. Dr. Uwe Morgner</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik</td>
</tr>
<tr>
<td>Email:</td>
<td></td>
</tr>
</tbody>
</table>

Event description:
Seminar covering selected topics for the calculation of light distributions in optical media.

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

Prior knowledge
--

Recommended literature
--

Additional Information
--

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>Type of exam</th>
<th>Course Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seminar</td>
<td>S2</td>
</tr>
<tr>
<td>Self-study:</td>
<td>ECTS-CP:</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
Seminar Theory and practice of optical functional layers
Seminar Theorie und Praxis optischer Funktionsschichten

Title: Theorie und Praxis optischer Funktionsschichten
Type: Seminar
Number: --
Lecturer: Dr. Holger Badorreck, Dr. Marco Jupé, Prof. Dr. Detlev Ristau
Institute: Laser Zentrum Hannover e.V., www.lzh.de
Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: d.ristau@lzh.de

Event description
The major objective of the seminar is to acquire advanced skills concerning the characterization, calculation, and simulation of optical functional layers. After an introduction by the lecturers, defined tasks shall be studied in small groups (up to 3 persons, also of varying composition, all groups work in parallel on one issue, also for several days according to the specific task). The results obtained by the groups for the tasks will be briefly presented in a synopsis and jointly evaluated. The corresponding tasks include practical as well as theoretical aspects, however calculations and simulations will be in the foreground of the studies. The necessary equipment will be available at the Laser Zentrum Hannover. Work on own computers will be also possible and supported by granting the necessary software packages (licenses with limited usage time). The following tasks can be considered as a preliminary selection addressed by the seminar:

- theoretical foundations: thin-film technology
- introduction to the thin film software
- internship: (preparation and characterization of a single-layer)
- determination of optical parameters by means of the “Spektrum Software”
- anti-reflective coatings and highly reflective mirror calculated with thin film software
- complex systems: broad band mirrors and broadband anti-reflective coatings
- complex systems: Mirrors with defined phase gradients and/or Rugate structures
- considerations on layer simulation
- atomistic simulation: kMC, MD, structure formation
- atomistic simulation: structure analysis
- non-linear excitation and laser damage

Prior knowledge
Lecture “Optical coatings”

Recommended literature
---

Additional information
---

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>seminar</th>
<th>Course cont.</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>64h</td>
<td>ECTS-CP</td>
<td>3</td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>


**Solid State Lasers**

Festkörperlaser

<table>
<thead>
<tr>
<th>Title:</th>
<th>Festkörperlaser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>13083</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Dr. Peter Weßels, Dr. Stefan Spiekermann</td>
</tr>
<tr>
<td>Institute:</td>
<td>Laser Zentrum Hannover e.V.; <a href="http://www.lzh.de">www.lzh.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:p.wessels@lzh.de">p.wessels@lzh.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

Within this lecture the fundamentals needed for the understanding of modern solid state lasers will be developed. In particular, the optical properties and typical parameters of different solid state laser designs will be developed. Furthermore, the application potential of the various solid laser designs will be treated.

**Contents:**

- Solid state laser media
- optical resonators
- laser modes of operation
- diode pumped solid state lasers
- laser designs: fiber, rod, disc; tunable lasers
- single-frequency lasers
- ultrashort-pulse lasers
- frequency conversion

**Prior knowledge**

Basic knowledge in physics and coherent optics

**Recommended literature**

W. Koechner, Solid-State Laser Engineering  
A. E. Siegman, Lasers; O. Svelto, Principles of Lasers.

**Additional Information**

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>24h</th>
<th>Type of exam:</th>
<th>oral</th>
<th>Course content</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>36h</td>
<td>ECTS-CP:</td>
<td>2</td>
<td>Semester</td>
<td>SS</td>
</tr>
</tbody>
</table>
Ultrashort Laser Pulses

Title: Ultrakurze Laserpulse
Type: Lecture
Number: 13082
Lecturer: Prof. Dr. Uwe Morgner, Dr. Ihar Babushkin
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: babushkin@iqo.uni-hannover.de

Event description:

Contents:
- General basics of the linear and nonlinear interaction of light and matter.
- Nonlinear propagation of short optical pulses.
- Dynamics of lasers, mode-locking in lasers.
- Types of contemporary short pulse lasers.
- Applications of ultrashort pulses in physics, chemistry and biology.
- High energy laser systems.
- Generation of high harmonics and attosecond pulses.
- Relativistic optics.

Prior knowledge
Basic knowledge in physics and coherent optics

Recommended literature

Additional Information

Presence studies time: 24h  Type of exam: oral  Course content: L2
Self-study: 24h  ECTS-CP: 2  Semester: SS
XUV Laser Physics

XUV-Laserphysik

<table>
<thead>
<tr>
<th>Title:</th>
<th>XUV-Laserphysik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Lecture</td>
</tr>
<tr>
<td>Number:</td>
<td>13088 (Lecture), 13250 (Lab)</td>
</tr>
<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Milutin Kovacev</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik, <a href="http://www.iqo.uni-hannover.de">www.iqo.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:kovacev@iqo.uni-hannover.de">kovacev@iqo.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

Event description:

- Introduction to coherent sources of XUV radiation
- XUV optics, detection
- XUV applications in atomic, molecular and solid-state physics

A new teaching concept will give the students the possibility to build their knowledge from hands-on projects.

Projects:

- High-power femtosecond laser systems
- Interaction of matter with strong fields
- Filamentation / plasma channels
- Absolute carrier phase
- Quantum Interference Metrology / Mode Combs
- Relativistic optics / laser particle acceleration
- Generation and detection of high harmonics
- Generation and detection of attosecond pulses
- Atomic photography
- Free-electron lasers

Prior knowledge

Basic knowledge in physics and coherent optics

Recommended literature

P. Jaeglé, Coherent Sources of XUV Radiation

Additional Information

Presence studies: 
Type of exam: oral
Course content: L2/La2
Self-study: 
ECTS-CP: 5
Semester: WS
Facilities of the Faculty of Mechanical Engineering

Student Counselling
Jonas Kanngießer
Hannover Centre for Optical Technologies, Nienburger Straße 17, 30167 Hannover
Tel.: +49 (0)511 762-17943
E-Mail: lehre@hot.uni-hannover.de
Office hours: by appointment

Student association of the faculty of mechanical engineering
Student representatetives
Otto- Klüsener-Haus
Im Moore 11 B
30167 Hannover
E-Mail: fsr@fsr-mb.uni-hannover.de
Internet: www.maschinenbau.uni-hannover.de

AG Study information
Ivo Cichon
Michael Köhrmann
Phil Demter
Tel.: +49 (0)511 762-4178
E-Mail: agstud@maschinenbau.uni-hannover.de
https://www.maschinenbau.uni-hannover.de/ag-studieninformation.html
Office hours: by appointment

Examination board
Chair-man:
Prof. Dr.-Ing. B.-A. Behrens
Contact Person:
Laura Lacatena
Im Moore 11 B (OK-Haus)
Tel.: +49 (0)511 762-4279
Fax.: +49 (0)511 762-3814
E-Mail: pa@maschinenbau.uni-hannover.de
Office hours:
Thu: 1000 – 1200 h

Threshold Workers Office
Chair-man:
Prof. Dr.-Ing. B.-A. Behrens
Secretary:
Laura Lacatena
Im Moore 11 B // Raum 504
30167 Hannover
Tel. +49 (0)511 762-2271
E-Mail: praktikum@maschinenbau.uni-hannover.de
Office hours:
Mo: 900 – 1200 h
Wed: 1300 – 1600 h
Thu: 1400 – 1600 h
and by appointment

Dean’s Office
Dean:
Prof. Dr.-Ing. S. Kabelac
Secretary:
Gabriele Schnaidt
Im Moore 11 B
30167 Hannover
Tel.: +49 (0)511 762-4165
Fax: +49 (0)511 762-2763
E-Mail: studiendekan@maschinenbau.uni-hannover.de
Office hours:
Mo – Fr: 900 – 1300 h
by appointment
### Institutes and Professors of the Faculty of Mechanical Engineering

#### Institute of Product Development

Prof. Dr.-Ing. R. Lachmayer  
Welfengarten 1 A  
30167 Hannover  
Tel.: +49 (0) 511 762-3472  
Fax: +49 (0) 511 762-4506  
E-Mail: ipeg@ipeg.uni-hannover.de  
Internet: www.ipeg.uni-hannover.de

#### Institute for Multiphase Processes

Prof. Dr.-Ing. B. Glasmacher  
Callinstraße 36  
30167 Hannover  
Tel.: +49 (0) 511 762-3828  
Fax: +49 (0) 511 762-3031  
E-Mail: sekretariat@imp.uni-hannover.de  
Internet: www.imp.uni-hannover.de

#### Institute of Measurement and Automatic Control

Prof. Dr.-Ing. E. Reithmeier  
Nienburger Straße 17  
30167 Hannover  
Tel.: +49 (0) 511 762-3334  
Fax: +49 (0) 511 762-3234  
E-Mail: sekretariat@imr.uni-hannover.de  
Internet: www.imr.uni-hannover.de

#### Institute of Micro Production Technology

Prof. Dr.-Ing. habil. H.-J. Maier  
Produktionstechnisches Zentrum  
Hannover  
An der Universität 2  
30823 Garbsen  
Tel.: +49 (0) 511 762-5104  
Fax: +49 (0) 511 762-2867  
E-Mail: impt@impt.uni-hannover.de  
Internet: www.impt.uni-hannover.de

#### Institute of Transport- and Automation Technology

Prof. Dr.-Ing. L. Overmeyer  
Produktionstechnisches Zentrum  
Hannover  
An der Universität 2  
30823 Garbsen  
Tel.: +49 (0) 511 762-3524  
Fax: +49 (0) 511 762-4007  
E-Mail: ita@ita.uni-hannover.de  
Internet: www.ita.uni-hannover.de

#### Institute of Turbomachinery and Fluid Dynamics

Prof. Dr.-Ing. J. Seume  
Appelstraße 9  
30167 Hannover  
Tel.: +49 (0) 511 762-2732  
Fax: +49 (0) 511 762-3997  
E-Mail: info@tfd.uni-hannover.de  
Internet: www.tfd.uni-hannover.de

#### Institute of Materials Science

Prof. Dr.-Ing. habil. H.-J. Maier  
Produktionstechnisches Zentrum  
Hannover  
An der Universität 2  
30823 Garbsen  
Tel.: +49 (0) 511 762-4312  
Fax: +49 (0) 511 762-5245  
E-Mail: office@iw.uni-hannover.de  
Internet: www.iw.uni-hannover.de
Institutes and Professors of the Faculty of Mathematics and Physics

Institut für Festkörperphysik
Prof. Dr. rer. nat. M. Oestreich
Appelstraße 2
30167 Hannover
Tel: +49 (0)511 762-2902
Fax: +49(0)511 762-2904
E-Mail: oest@nano.uni-hannover.de
Internet: http://www.fkp.uni-hannover.de

Institut für Quantenoptik
Prof. Dr. rer. nat. U. Morgner
Welfengarten 1
30167 Hannover
Tel.: +49 (0)511 762-2452
Fax: +49 (0)511 762-2211
E-Mail: morgner@iqo.uni-hannover.de
Internet: http://www.iqo.uni-hannover.de

Max-Planck-Institute for Gravitational Physics
Prof. Dr. rer. nat. K. Danzmann
Callinstraße 38
30167 Hannover
Tel.: +49 (0)511 762-2229
Fax: +49 (0)511 762-2784
E-Mail: karsten.danzmann@aei.mpg.de
Internet: http://www.aei.mpg.de

Institutes and Professors of the Faculties of Electrical Engineering and Computer Science

Institut für Informationsverarbeitung
Prof. Dr.-Ing. J. Ostermann
Appelstraße 9 A
30167 Hannover
Tel: +49 (0)511 762-5316
Fax: +49(0)511 762-5333
E-Mail: ostermann@tnt.uni-hannover.de
Internet: http://www.tnt.uni-hannover.de

Facilities of the Leibniz Universität Hannover

Examination Office
Welfengarten 1
30167 Hannover
Tel: +49 (0)511 762-2020
(Servicehotline)
Fax: +49 (0)511 762-2137
E-Mail: studium@uni-hannover.de
Internet: www.uni-hannover.de/pruefungsamt
Contact person: Arne Sindermann
E-Mail: arne.sindermann@zuv.uni-hannover.de
Office hours:
Mo – Do: 1000 – 1230 h
Do: 1400 – 1600 h
Tel.:
Mo – Do: 900 – 1700 h
Fr: 900 – 1500 h
Apart from office hours:
(at ServiceCenter)
Mo – Mi: 1230 – 1700 h
Do: 1230 – 1400 h and 1600 – 1700 h
Fr: 1000 – 1500 h

International Office
Wilhelm-Grunwald-Haus
Welfengarten 1 A
30167 Hannover
Tel: +49 (0)511 762-2548
Tel: +49 (0)511 762-2020
(Servicehotline)
Fax: +49 (0)511 762-4090
E-Mail: internationaloffice@uni-hannover.de
Internet: www.international.uni-hannover.de
Office hours:
Mo – Do: 1000 – 1200 h
Di und Do: 1400 – 1600 h
At ServiceCenter:
Mo – Do: 1000 – 1700 Uhr
Fr: 1000 – 1500 Uhr
International office:
(at ServiceCenter)
Advice for Foreign Students at the Service Center:

Mo: 10:00 – 13:00 Guidance and advice of foreign students, postgraduates and visiting scientist
Th: 14:00 – 16:00 Registration for Events and excursions
Tu: 14:00 – 16:00 ERASMUS Incomings, exchange students
Th: 10:00 – 13:00

Matriculations Office

Welfengarten 1
30167 Hannover
Tel: +49 (0)511 762-2020
(Service hotline)
E-Mail: studium@uni-hannover.de
Internet: www.uni-hannover.de/i-amt

Office hours (at ServiceCenter):
Mo – Do: 10:00 – 17:00 h
Fr: 10:00 – 15:00 h
Tel.
Mo – Do: 9:00 – 17:00 h
Fr: 9:00 – 15:00 h

Service Center

Welfengarten 1 (Main building)
30167 Hannover
Tel: +49 (0)511 762-2020
(Service hotline)
Fax: +49 (0)511 762-19385
E-Mail: studium@uni-hannover.de
Internet: www.uni-hannover.de/servicecenter/

Office hours:
Mo – Do: 10:00 – 17:00 h
Fr: 10:00 – 15:00 h
Tel.
Mo – Do: 9:00 – 17:00 h
Fr: 9:00 – 15:00 h

Student Advisory Office (ZSB)

Welfengarten 1 (Main building)
30167 Hannover
Tel. +49 (0)511 762-2020
(Service hotline)
E-Mail: studienberatung@uni-hannover.de
Internet: www.zsb.uni-hannover.de

Individual Counseling:
by appointment only:
+49 (0)511 762-2020 (service hotline)

Open consultation
(Registeration at the info desk)
Th: 14:00 – 17:00

Brief counseling (at the info desk, max. 10 minutes)
Mo – Fr: 10:00 – 14:00

Infothek (Materials for self information)
Mo – Th: 10:00 – 17:00 Uhr
Fr: 10:00 – 15:00 Uhr

Telefonische Anfragen: (Service hotline: +49 511 762 2020)
Mo – Fr: 9:00 – 15:00 Uhr

Other Institutes and Centers of the Leibniz University Hannover

Hannover Centre for Optical Technologies (HOT)
Prof. Dr. habil. Bernhard Roth
Nienburger Straße 17
30167 Hannover
Tel.: +49 (0)511 762-17908
Fax: +49 (0)511 762-17909
E-Mail: info@hot.uni-hannover.de
Internet: www.hot.uni-hannover.de

Institut für Integrierte Produktion Hannover gGmbH (IPH)
Managing Directors:
Prof. Dr.-Ing. B.-A. Behrens
Prof. Dr.-Ing. L. Overmeyer
Prof. Dr.-Ing. P. Nyhuis
Dr.-Ing. Georg Ullmann
Hollerithallee 6
30419 Hannover
Tel.: +49 (0)511 27976-0
Fax: +49 (0)511 27976-888
Laboratory of Nano and Quantum Engineering

Dr. F. Schulze Wischeler
Schneiderberg 39
30167 Hannover
Tel.: +49 (0)511 762-16014
Fax: +49 (0)511 762-16099
E-Mail: schulze-wischeler@lnqe.uni-hannover.de

Speaker of the board of directors:
Prof. Dr. R. Haug
Appelstraße 2
30167 Hannover
Tel.: +49 (0)511 762-2902
Fax: +49 (0)511 762-2904
E-Mail: haug@nano.uni-hannover.de
Internet: www.lnqe.uni-hannover.de

Laser Zentrum Hannover e.V. (LZH), Leibniz Universität Hannover

Speaker of the board of directors:
Prof. Dr. Wolfgang Ertmer
Hollerithallee 8
30419 Hannover
Telefon : +49 (0)511 2788-0
Fax : +49 (0)511 2788-100
E-Mail: info@lzh.de
Internet: www.lzh.de

Hannover Center of Mechatronics, Leibniz Universität Hannover

Dr.-Ing. Wolfgang Bartsch
Appelstraße 11
30167 Hannover
Tel.: +49 (0)511 762-4464
Fax: +49 (0)511 762-4536
E-Mail: mailbox@mzh.uni-hannover.de
Internet: www.mzh.uni-hannover.de

Speaker of the board of directors:
Prof. Dr.-Ing. B. Ponick
Tel.: +49 (0)511 762-2571
Fax: +49 (0)511 762-3040
E-Mail: ponick@ial.uni-hannover.de
Internet: www.mzh.uni-hannover.de

Zentrum für Biomedizintechnik (zbm) of the Leibniz Universität Hannover

Speaker of the board of directors:
Prof. Dr.-Ing. B. Glasmacher
Managing director:
Dipl.-Ing. G. Hohenhoff, M.Sc.
Callinstraße 36
30167 Hannover
Tel.: +49 (0)511 762-2786
Fax: +49 (0)511 762-3031
E-Mail: sekretariat@imp.uni-hannover.de
Internet: www.zbm.uni-hannover.de

Centre for the Didactics of Engineering

Prof. Dr.-Ing. B. Wagner
Appelstraße 9A
30167 Hannover
Tel.: +49 (0)511/762-5515
Fax: +49 (0)511/762-4012
E-Mail: wilke@rts.uni-hannover.de
Internet: www.zdt.uni-hannover.de

Associated Members of the HOT

National Metrology Institute of Germany
Dr. rer. nat. Erik Benkler
Bundesallee 100
38116 Braunschweig
Telefon : +49 (0)531 592-0
Fax : +49 (0)531 592-694530
E-Mail: erik.benkler@ptb.de
Internet: http://www.ptb.de/

Fraunhofer Heinrich-Hertz-Institute
Prof. Dr. rer. nat. W. Schade
Am Stollen 19
38640 Goslar
Tel.: +49 (0)5321 6855-153
Fax: +49 (0)5321 6855-179
E-Mail: astrid.stueber@hhi.fraunhofer.de
Internet: http://www.hhi.fraunhofer.de/

Institut für Hochfrequenztechnik der TU Braunschweig
Prof. Dr. W. Kowalsky
Schleinitzstraße 22
38106 Braunschweig
# Appendix

## Objectives table of the master program Optical Technologies

<table>
<thead>
<tr>
<th>Important study goals</th>
<th>Competency goals in the sense of learning outcomes</th>
<th>Corresponding modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic knowledge of physics</td>
<td>Basic principles (engineers) and further education (physicist) in the field of optics and related fields</td>
<td>Biophotonics, Laser Spectroscopy in Life Sciences, Optical Coatings, Photonics</td>
</tr>
<tr>
<td>Basic knowledge of engineering sciences</td>
<td>Basics (physicists) or specialization (engineers) in engineering sciences</td>
<td>Design of Optical Systems, Automotive Lighting, Optical Metrology, Augmented Reality Apps for Mechatronics and Medical Technology</td>
</tr>
<tr>
<td>Immersion or specialization in Optical Technologies</td>
<td>Getting detailed knowledge about modern optical technologies provided by a wide range of optic concerning lectures.</td>
<td>Compare selective module descriptions.</td>
</tr>
</tbody>
</table>
This Diploma Supplement model was developed by the European Commission, Council of Europe and UNESCO/CEPES. The purpose of the supplement is to provide sufficient independent data to improve the international 'transparency' and fair academic and professional recognition of qualifications (diplomas, degrees, certificates etc.). It is designed to provide a description of the nature, level, context, content and status of the studies that were pursued and successfully completed by the individual named on the original qualification to which this supplement is appended. It should be free from any value judgements, equivalence statements or suggestions about recognition. Information in all eight sections should be provided. Where information is not provided, an explanation should give the reason why.

### Diploma Supplement

#### 1. HOLDER OF THE QUALIFICATION

1.1 Family Name / 1.2 First Name

1.3 Date, Place of Birth

1.4 Student ID Number or Code

#### 2. QUALIFICATION

2.1 Name of Qualification (full, abbreviated; in original language)
   Master of Science in Optical Technologies, MSc
   Master of Science in Optische Technologien
   Title Conferred (full, abbreviated; in original language)
   Master of Science, MSc

2.2 Main Field(s) of Study
   Mechanical Engineering, Physics

2.3 Institution Awarding the Qualification (in original language)
   Gottfried Wilhelm Leibniz Universität Hannover
   Fakultät für Maschinenbau
   Status (Type / Control)
   University / State Institution

2.4 Institution Administering Studies (in original language)
   [same]
   Status (Type / Control)
   [same]

2.5 Language(s) of Instruction/Examination
   German
3. LEVEL OF THE QUALIFICATION

3.1 Level
Second degree, research-oriented, including Master’s thesis

3.2 Official Length of Programme
Two years, 120 ECTS Credit Points

3.3 Access Requirements
Bachelor degree in Mechanical Engineering, Physics, Electrical Engineering or an equivalent first degree or foreign equivalent (see Sec. 8.4)

4. CONTENTS AND RESULTS GAINED

4.1 Mode of Study
Full-time programme

4.2 Programme Requirements/Qualification Profile of the Graduate
4.2.1 Qualification targets Master’s in Optical Technologies — Knowledge, Skills, Competencies
The degree course enables graduates to solve problems and to address issues in the field of optical technologies. In compulsory subjects, students on the programme learn not only engineering methods for solving problems and addressing issues, but also important principles of physics relevant to optical technologies. Elective competence areas round off the theoretical physics training with topics specific to engineering.

Practical training in the form of laboratory experiments and work experience in industry prepare students for their professional life in research firms in the optical industry. By writing a project report and a Master’s thesis, students acquire the skills required for conducting independent project work. The primary goals of this work include gaining experience in the planning and implementation of projects as well as learning how to draw up correct project documentation and presenting project results.

4.2.2 Learning results
Graduates of the Master’s programme are expected to have broad knowledge of optical technologies. To this end, students are taught knowledge, skills and methods that represent the state of the art, due to the high level of research conducted by the faculties involved. Industry internships, laboratory and project work, and the Master’s thesis enable students to gain experience in managing their own projects, working in a team, and exercising scientific responsibility within research activities.
In order to achieve these goals, the Master’s programme is divided into a basic field and several advanced optional fields. The basic field consists of field A “Physics” and field B “Engineering”.

4.4 Grading Scheme
See grading scheme in Sec. 8.6
4.5 Overall Classification (in original language)
«MPO_Gesamtnote_eng»

Based on weighted average of grades in examination fields.

\[
\text{Overall grade} = \frac{(\text{Grade for the examination} \times \text{respective CP}) + (\text{grade for the project work} \times 10 \text{ CP}) + (\text{grade for the Master's thesis} \times 30 \text{ CP})}{\text{Sum of CP for all graded examinations}}
\]
5. FUNCTION OF THE QUALIFICATION

5.1 Access to Further Study
The Master’s degree qualifies the graduate to apply for admission to doctoral studies.

5.2 Professional Status
The Master’s degree is the second degree in Mechanical Engineering that qualifies for a professional and scientific career.

6. ADDITIONAL INFORMATION

6.1 Additional Information
The Master of Science in Optical Technologies was accredited in 2014 by ASIIN (Accreditation Agency for Programmes in Engineering, Computer Science, Natural Sciences and Mathematics, www.asiin-ev.de).

6.2 Further Information Sources
About the university: www.uni-hannover.de
About the faculty: http://www.maschinenbau.uni-hannover.de/
About the study programme: http://www.maschinenbau.uni-hannover.de/480.html
Student Advice Service: http://www.uni-hannover.de/de/studium/studienfuehrer/optische-tech/

Contact:
Der Dekan der Fakultät für Maschinenbau
der Leibniz Universität Hannover
Im Moore 11b
30167 Hannover
Tel. ++49-511-762-2779
Fax ++49-511-762-2763

7. CERTIFICATION

This Diploma Supplement refers to the following original documents:
Urkunde über die Verleihung des Grades vom [Date]
Prüfungszeugnis vom [Date]

Certification Date: ____________________________
(Official Stamp/Seal)
Chairman Examination Committee

8. NATIONAL HIGHER EDUCATION SYSTEM

The information on the national higher education system on the following pages provides a context for the qualification and the type of higher education that awarded it.
8. INFORMATION ON THE GERMAN HIGHER EDUCATION SYSTEM

8.1 Types of Institutions and Institutional Status

Higher education (HE) studies in Germany are offered at three types of Higher Education Institutions (HEI):

- **Universitäten** (Universities) including various specialized institutions, offer the whole range of academic disciplines. In the German tradition, universities focus in particular on basic research so that advanced stages of study have mainly theoretical orientation and research-oriented components.

- **Fachhochschulen** (Universities of Applied Sciences) concentrate their study programmes in engineering and other technical disciplines, business-related studies, social work, and design areas. The common mission of applied research and development implies a distinct application-oriented focus and professional character of studies, which include integrated and supervised work assignments in industry, enterprises or other relevant institutions.

- **Kunst- und Musikhochschulen** (Universities of Art/Music) offer studies for artistic careers in fine arts, performing arts and music; in such fields as directing, production, writing in theatre, film, and other media; and in a variety of design areas, architecture, media and communication.

Higher Education Institutions are either state or state-recognized institutions. In their operations, including the organization of studies and the designation and award of degrees, they are both subject to higher education legislation.

8.2 Types of Programmes and Degrees Awarded

Studies in all three types of institutions have traditionally been offered in integrated "long" (one-tier) programmes leading to Diplom- or Magister Artium degrees or completed by a Staatsprüfung (State Examination).

Within the framework of the Bologna-Process one-tier study programmes are successively being replaced by a two-tier study system. Since 1998, a scheme of first- and second-level degree programmes (Bachelor and Master) was introduced to be offered parallel to or instead of integrated "long" programmes. These programmes are designed to provide enlarged variety and flexibility to students in planning and pursuing educational objectives, they also enhance international compatibility of studies.

The German Qualification Framework for Higher Education Degrees\(^5\) describes the degrees of the German Higher Education System. It contains the classification of the qualification levels as well as the resulting qualifications and competencies of the graduates.

For details cf. Sec. 8.4.1, 8.4.2, and 8.4.3 respectively. Table 1 provides a synoptic summary.

8.3 Approval/Accreditation of Programmes and Degrees

To ensure quality and comparability of qualifications, the organization of studies and general degree requirements have to conform to principles and regulations established by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK). \(^4\) In 1999, a system of accreditation for programmes of study has become operational under the control of an Accreditation Council at national level. All new programmes have to be accredited under this scheme; after a successful accreditation they receive the quality-label of the Accreditation Council.\(^5\)

Table 1: Institutions, Programmes and Degrees in German Higher Education

---

\(^1\) The German Higher Education System.
\(^2\) Link to the document.
\(^3\) Link to the document.
\(^4\) Link to the document.
\(^5\) Link to the document.
Integrated/long (One-Tier) Programmes

**UNIVERSITIES (Universitäten) & SPECIALISED INSTITUTIONS of university standing (Theologische und Pädagogische Hochschulen)**

- Bachelor (B.A.,B.Sc.,B.Eng.,LL.B.,B.Ed.) [3-4 years]
- Master (M.A.,M.Sc.,M.Eng.,LL.M.,M.Ed.) [1-2 years]
- Diplom & Magister Artium (M.A.) degree [4-5 years]
- Staatsprüfung (State Examination) [3-6.5 years]

**UNIVERSITIES OF APPLIED SCIENCES (UAS) (Fachhochschulen)**

- Bachelor (B.A.,B.Sc.,B.Eng.,LL.B.) [3-4 years]
- Master (M.A.,M.Sc.,M.Eng.,LL.M.) [1-2 years]
- Diplom (FH) degree [4 years]

**UNIVERSITIES OF ART/MUSIC (Kunst- / Musikhochschulen)**

- Bachelor (B.A.,B.F.A.,B.Mus.,B.Ed.) [3-4 years]
- Master (M.A.,M.F.A.,M.Mus.,M.Ed.) [1-2 years]
- Diplom & M.A. degree, Certificates, certified examinations [4.5 years]

Transfer Procedures

Doctorate (Dr.)

(Thesis research; may include formal course work)

Integrated/long (One-Tier) Programmes

Programmes/ Degrees

First degree

Second degree

Transfer Procedures

Doctorate