Module Handbook
Physics Master (Master of Science)

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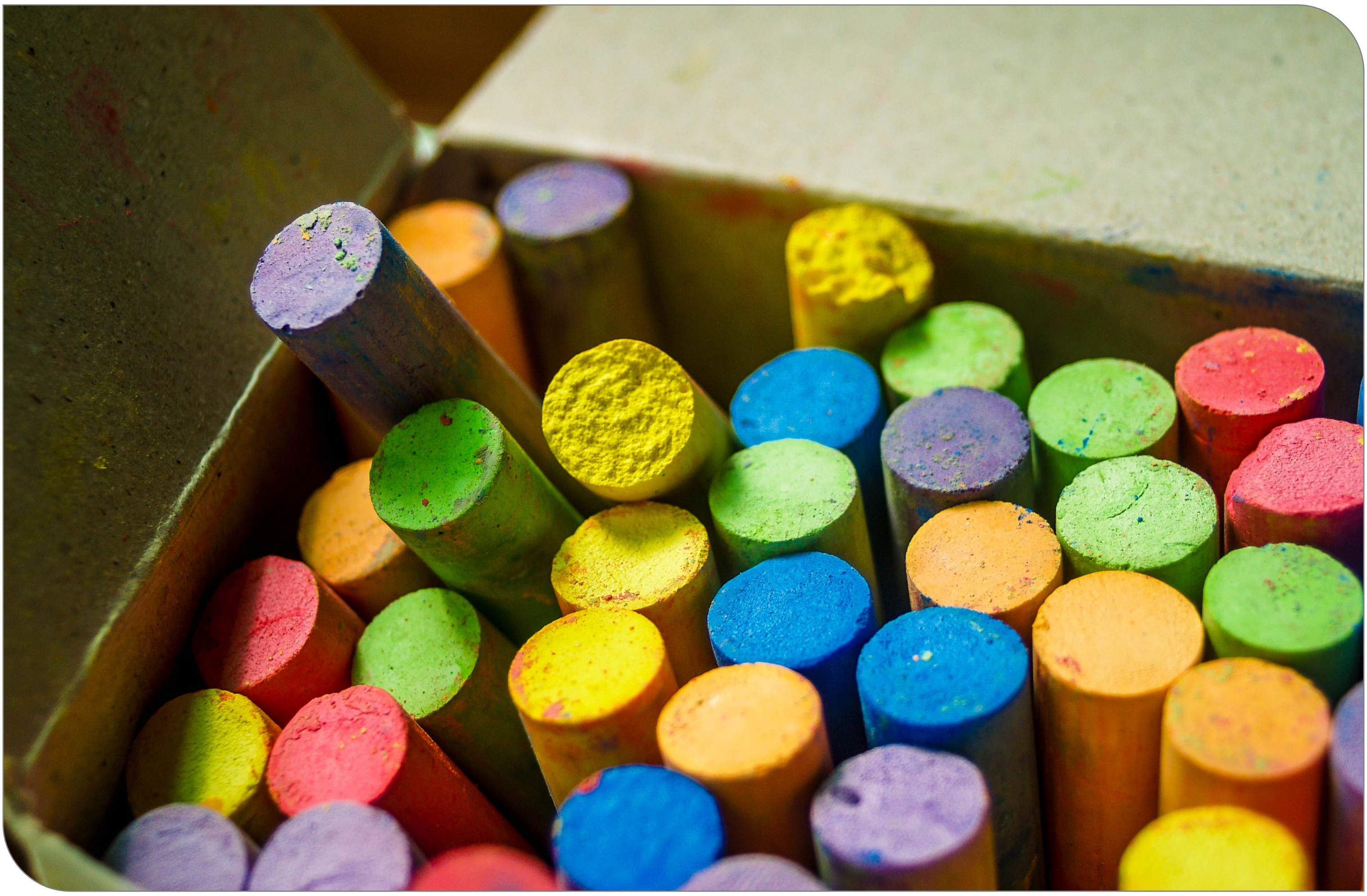
KIT DEPARTMENT OF PHYSICS



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1 Master’s Program in Physics

Physics is one of the classical natural sciences. Studies of physics are geared towards scientific work as a physicist at universities and non-university research institutions as well as in industry. Our Master's program in physics is focused on research-oriented teaching, with lectures that are centered around modern research topics and the Master's thesis offering the opportunity for students to participate in state-of-the-art research work as central part of their education. However, the future field of work of physicists is not limited to scientific research. Physicists are in high demand by a broad variety of employers, both in industry and in the public sector. This is mainly due to their competences in analyzing, modeling, and solving problems in accordance with scientific standards. These competences can be used widely and represent the focus of education.

The Master’s program of physics builds on a Bachelor’s program of physics in which the foundations of the field are acquired. The consecutive Master’s program of physics covers a wide range of topics, but also imparts in-depth and specialized knowledge. These topics are divided into:

A. Experimental Physics:

- Condensed Matter
- Nanophysics
- Optics and Photonics
- Experimental Particle Physics
- Experimental Astroparticle Physics

B. Theoretical Physics:

- Theoretical Particle Physics
- Theoretical Cosmology and Astroparticle Physics
- Condensed Matter Theory

Students are given a variety of options to choose these topics; they are modeled as major, second major, and minor subjects in physics in the Master's program. In addition, courses from meteorology, climate physics, and geophysics may be chosen as second major or minor subjects. The program concludes with the Master’s thesis, which includes an introduction to independent scientific work and a specialization phase. Master’s studies can be aligned largely to the students’ individual preferences and skills and allows a wide range of profiles, ranging from theory-focused work over instrumentation for physics experiment to data science.

To meet the requirements for admission to the Master’s program in physics, a solid university education in physics is required, as conveyed in the Bachelor’s program of physics at KIT or other German universities. The KIT Department of Physics has adopted corresponding regulations for admission to the Master’s program.

1.1 Qualification Goals

1.1.1 Qualification Goals of the Master’s Program

Graduates of the Master’s program in physics know the scientific foundations of experimental and theoretical physics and have obtained in-depth knowledge of the state-of-the-art in their major, second major, and minor subjects in physics, which can be selected from a large range of subjects in experimental and theoretical physics as well as meteorology and geophysics (see above). They possess advanced knowledge in an additional subject outside of physics that can be selected from a large range of options. They know how to apply concepts of theoretical or experimental physics to research-related problems and how to search for solution strategies. In experimental physics, they are able to perform sophisticated physics experiments, to determine physics observables from measured data, to formulate models describing the data, and to derive predictions. Graduates specialized in theoretical physics know how to carry out complex calculations and to interpret the results within the framework of the theory studied. Based on the acquired knowledge, they are able to classify facts and subject areas professionally. Moreover, graduates can summarize scientific findings and research results in both written and oral form and present them in a didactically appealing way. Successful completion of the program allows for work in a variety of fields, including university and industrial research and development, data science and process optimization, or programming and hardware application. Graduates also are qualified to start doctoral studies in physics. KIT attaches particular value to research-oriented teaching. Master’s students can choose from a large range of options to specialize according to their interests, in close contact to research within KIT's university mission or using the unique large-scale research facilities of KIT's Helmholtz mission.

The Bachelor's and Master's programs in physics at KIT are in line with the Bologna Process, offering full compatibility with corresponding programs at other universities within the European Higher Education Area. The combination of the Bachelor’s program with the Master’s program at KIT is equivalent to the former Diplom program. General qualification goals of Bachelor’s and Master’s programs in physics are defined by the Konferenz der Fachbereiche Physik (Association of Physics Departments of universities that are members of the German Rectors Conference) for all of Germany, taking into account international academic education and research. In this way, students can easily change their university in Germany and are guaranteed an internationally well-defined field of work.

1.1.2 Relevance for Sustainable Development Goals

The laws of physics are the fundamental basis of how the world around us functions. The understanding of physics principles is essential for reaching several of the UN sustainable development goals (SDGs, https://sdgs.un.org/goals). Examples of SDGs and their relation to the Master's program include

- #3 Good Health: Master's students are educated in physics technologies such as magnetic resonance imaging and particle detectors, which can be applied in medicine.
- #4 Quality Education: Graduates of the Master's program in physics are excellent educators and multiplicators of knowledge in basic science.
- #5 Gender Equality: Increasing the number of women in science, technology, engineering and mathematics (STEM) subjects is a key goal of the KIT Physics Department, with measures including female professors as role models and gender-neutral language in all study programs.
- #7 Affordable and Clean Energy, and #8 Decent Work and Economic Growth: The Master's curriculum includes courses geared towards research on the physics foundations of technologies that support both future products and the global transition to affordable and clean energy, e.g., high-efficiency solar cells.
- #13 Climate Action: Master's students can study advanced topics of meteorology and climate physics, as well as geophysics as part of their individual course selection.

In addition to these direct relations to the SDGs, all courses in the physics curriculum transmit knowledge and skills which are directly or indirectly essential for sustainable development: The students acquire in-depth knowledge about physics principles, the scientific approach to problem solving, and modern techniques in data analysis and computation.

1.1.3 Qualification Goals of Individual Subjects

1.1.3.1 Major, Second Major, and Minor Subjects in Physics

Students decide the focus of their Master's studies and deepen their knowledge in selected subjects. Thanks to research-oriented teaching, they obtain knowledge that enables them to independently work on latest research topics. The major, second major, and minor subjects must be chosen from different fields. This allows students to gain deeper insight into their area of interest, while keeping a broad education. Students learn to deal with research-related issues and to use latest literature when searching for solution approaches. They familiarize with modern measurement methods and computing techniques needed for work on their Master's thesis.

1.1.3.2 Non-Physics Elective Subject

The non-physics elective subject may be a subject of mathematics, natural sciences, or engineering and can be chosen from courses offered by other KIT Departments. Master's students acquire expert skills in neighboring disciplines, opening up a wide range of opportunities in the labor market.

1.1.3.3 Advanced Physics Laboratory Course

The advanced physics laboratory course conveys knowledge about latest experimental methods and techniques. Students have advanced skills in setting up experiments and measuring and evaluating experimental data.

1.1.3.4 Advanced Seminar

Students hone their presentation techniques by giving an own presentation and listening to presentations of the other participants. They learn how to gather scientific material beyond typical textbook knowledge, cite sources correctly, select and arrange the material from a didactic point of view, structure their presentation, use latest presentation media, make their own presentation, and answer the questions of the audience.

1.1.3.5 Interdisciplinary Qualifications

Students acquire competencies beyond their discipline. The House of Competence (HoC), Zentrum für Angewandte Kulturwissenschaft (ZAK) and the Language Center (Sprachenzentrum) regularly offer modules in the areas of scientific English, patent law, project management, tutor programs, scientific writing, and public science.

1.1.3.6 Introduction to Scientific Methods and Specialization Phase

The subject "Introduction to Scientific Methods" teaches basic working methods for successful scientific research. These methods are independent of the specialization area, but are trained and taught to cope with a defined task (subject of the Master's thesis). The students are instructed by the future supervisor of their Master's thesis. Parallel to their studies, students attend seminars and colloquia in physics to obtain an overview of latest research issues. They can extend their knowledge by attending special lectures on issues that are not covered by their area of specialization and by having their questions answered by the lecturer. In the subject "Specialization Phase", the students independently work on a concrete task relating to their future Master's thesis. This may be the execution of measurements, the setup of a program, or the development of a theoretical approach. In this way, students learn essential techniques for work on their Master's thesis, which are specific to their area of specialization. Again, students are instructed by the future supervisor of their Master's thesis. In addition, students attend the seminar offered by the research area in which they will write their Master's thesis. Here, they learn to present their work and results to other researchers for critical discussion and to respond to suggestions for further action.

1.1.3.7 Master's Thesis

In addition to the major, second major, and minor subject, the Master's thesis is the central component of specialization and acquisition of in-depth knowledge. While working on their Master's thesis, students learn to independently analyze a scientific problem, develop suitable solutions, interpret the findings, and present major results in writing. In addition, key competencies such as working in a planned and purposeful manner, measurement technology, documentation, team work, and team responsibility are acquired. The Master's thesis is prepared by the introduction to independent scientific work and a specialization phase.

1.1.4 Credits

Course credits are defined on the module level according to the European Credit Transfer System (ECTS). One ECTS credit point corresponds to a time expenditure of about 30 hours. This time is divided into time spent attending, preparing for, and following up on lectures, exercises, and tutorials, as well as for preparing for the corresponding exams.

According to the Studies and Examination Regulations of the Master's Program of Physics, 120 ECTS credit points must be achieved for the successful completion of the Master's program:

- Major in Physics: 20 ECTS credit points
- Second Major in Physics: 14 ECTS credit points
- Minor in Physics: 8 ECTS credit points
- Advanced Physics Laboratory Course: 6 ECTS credit points
- Non-Physics Elective: 8 ECTS credit points
- Interdisciplinary Qualifications: 4 ECTS credit points
- Specialization Phase: 15 ECTS credit points
- Introduction to Scientific Methods: 15 ECTS credit points
- Master's Thesis: 30 ECTS credit points

1.2 Study Plan for the Master's Program of Physics

1.2.1 Introduction

The Master's program is designed to specialize and deepen the basic and methodological knowledge acquired during Bachelor's program while maintaining its breadth. Master's studies may be aligned largely to individual preferences and skills. Quality is assured by a mandatory Master's thesis that is written within a period of six months (30 ECTS credit points). The standard period of study is four semesters, including work on the Master's thesis. When the Master's exam is passed, the academic degree of "Master of Science (M. Sc.)" is awarded by Karlsruhe Institute of Technology.

The sequence of the Master's program in physics at KIT is specified below. Detailed rules for the organization of the program and exams are outlined in the Studies and Examination Regulations for the Master's Program of Physics of March 9, 2023. The official document (in German) and a legally non-binding English translation can be found on the website of the KIT Department of Physics (**https://www.physik.kit.edu/english/studies/services/documents.php**). If you have any questions regarding the examination regulations, the recognition of coursework and examinations, content of studies, or the admission to and registration for examinations, please contact the persons listed on website of the KIT Department of Physics.

Detailed descriptions of the courses and rules for performance reviews ("controls of success", e.g., problem sheets, oral presentations) are given below.

1.2.2 Courses, Credits, and Grading

a) Major, Second Major, and Minor Subjects in Physics

Students can select their major, second major, and minor subjects from eight areas of physics that reflect the research activities of the KIT Department of Physics. The areas are divided into Experimental Physics (Field A: Condensed Matter, Nanophysics, Optics and Photonics, Experimental Particle Physics, Experimental Astroparticle Physics), and Theoretical Physics (Field B: Theoretical Particle Physics, Theoretical Cosmology and Astroparticle Physics, Condensed Matter Theory). For further information on the research pursued in the KIT institutes with lecturers associated to the KIT Department of Physics please visit the department's website (**https://www.physik.kit.edu/english/forschung/our_research.php**).

In the major subject, the grade is determined by an individual oral exam covering material from the corresponding courses. A total of at least 20 ECTS credit points are required for admission to the exam. These are acquired by passing the controls of the success defined in this document. The advanced seminar (4 ECTS credit points, see below) may be used to reach the 20 ECTS credit points, but will not be covered by the oral examination.

In the second major subject, the controls of success are graded. These are defined in this document and may be oral exams (individual or group exams), short presentations (concurrent with lecture or in blocks at the end of the semester), short written papers about a specific topic, or written examinations. A total of at least 14 ECTS credit points is required for admission to the exam. The advanced seminar may be used to reach the 14 ECTS credit points, but will not be graded. The final grade is obtained as the credit point-weighted average of the individual grades.

No grade is assigned in the minor subject. Students are only required to pass the control of success for the chosen course, e.g., successful participation in exercise sections accompanying the lecture, oral exams, short presentations, short written papers or written examinations. A total of at least 8 ECTS credit points is required, which may include the advanced seminar (4 ECTS credit points).

b) Advanced Physics Laboratory Course

The lecture program on experimental physics is complemented by a laboratory course (6 ECTS credit points, not graded) in which students perform advanced physics experiments, analyze the data and document the results.

c) Advanced Seminar

Students select an advanced seminar (4 ECTS credit points, not graded) in one of the three major, second major, and minor subjects. During the advanced seminar, expert knowledge is deepened in one of the fields and scientific presentation techniques are conveyed.

d) Non-Physics Elective Subject

The "Non-Physics Elective" may be chosen from courses offered by other KIT departments and requires at least 8 ECTS credit points. Courses in mathematics, natural sciences, or engineering are most often chosen. Course controls of success are graded.

e) Interdisciplinary Qualifications

In addition to integrative key competencies acquired as part of the Master's program, courses on interdisciplinary qualification that impart additive key competencies must be passed (4 ECTS credit points, not graded).

f) Introduction to Scientific Methods, Specialization Phase, and Master's Thesis

The Master's thesis in the fourth semester of the Master's program is prepared by a specialization phase (15 ECTS credit points, not graded) and an introduction to scientific work (15 ECTS credit points, not graded) in the third semester. Both subjects provide a sound basis and (in integrative form) key competencies for conducting research.

Calculation of the Overall Grade

The overall grade of the master's examination is calculated from the grade average weighted by credit points of the following subjects: Major in Physics (20 ECTS credit points), Second Major in Physics (14 ECTS credit points), Non-Physics Elective (8 ECTS credit points), and the Master's Thesis (30 ECTS credit points).

1.2.3 Organization of Subjects and Selection Rules

The Master's program in physics is designed to allow for curricula tailored to individual students within the framework of the subjects, research fields, and topics defined above. To provide additional flexibility, students only have to decide on the assignment of courses to the major, second major, and minor subjects in physics after completing the first year of their Master studies. Note however that the choice of courses is subject to additional selection rules to ensure scientific breadth and consistent curricula, as detailed below. Students are advised to contact the department's student advisor (**https://www.physik.kit.edu/english/studies/services/guidance.php**) or the examination committee to determine if their individual curriculum is compatible with these rules. Further independent counseling is provided by the student council.

Major, Second Major, and Minor Subjects in Physics

Students elect their major, second major, and minor subjects from courses offered by the KIT Department of Physics in the topics of experimental physics (Field A) and theoretical physics (Field B). The second major and minor subjects may also be chosen from a list of appropriate courses in meteorology or geophysics (Field C). The lists of courses below contain a few courses offerend by other departments; these are marked "extern" (external). Additional lectures on topics close to physics offered by other departments (e.g., on non-linear optics) may be combined in a subject upon approval by the examination committee.

- **Major:** A core curriculum is established for each topic with one or more required courses for the selection as a major subject. These courses are supplemented by other courses within the topic and optionally the advanced seminar for a total of at least 20 ECTS credit points.
- **Second Major:** Students elect a combination of courses from a different topic (and optionally the advanced seminar) as their second major subject for a total of at least 14 ECTS credit points. Some topics also contain required courses if elected as a second major subject.
- **Minor:** As a rule, the minor subject in physics consists of a single course on a third topic for at least 8 ECTS credit points, e.g. Semiconductor Physics, Particle Physics I, Theoretical Particle Physics I, etc.
- **Theory/Experiment:** At least one of the major, second major, and minor subjects must belong to the field of experimental physics (Field A) and theoretical physics (Field B), respectively. Some courses of the topics of experimental physics are marked with "(T)"; these are theoretical courses within an otherwise experimental curriculum. Students cannot choose only theoretical courses if they choose only one experimental topic.

Non-Physics Elective

The non-physics elective subject in the area of mathematics, natural or engineering sciences is chosen from the courses offered by KIT departments other than physics. The examination committee publishes a positive list of approved modules and module combinations. Further suitable courses may be approved by the examination committee upon request, these shall included at least six hours a week, four of which must be for lectures. Before taking a non-physics elective that is not on the positive list, students strongly encouraged to consult with the examination committee.

Specialization Phase, Introduction to Scientific Methods, Master Thesis

Students who have successfully passed module examinations in the subjects Major in Physics, Second Major in Physics, Minor in Physics, Advanced Physics Laboratory Course, and Non-Physics Elective can start their specialization phase and register for their Master's thesis.

Further Rules

- The examiners in the major, second major, minor, and non-physics elective subjects must be different.
- The rules for required courses in the individual topics must be fulfilled separately for the major and the second major subjects.
- All courses offered by the House of Competence (HoC), Zentrum für Angewandte Kulturwissenschaft (ZAK) and the Language Center are approved as part of the subject Interdisciplinary Qualifications. Any other modules must be approved by the examination committee.
- Results reached in the Bachelor's program as part of a non-physics elective subject may not be credited again in the Master's program.

1.2.4 Registration for Controls of Success, Subject Examinations, and Master's Thesis

The high flexibility of the Master's program in physics cannot currently be represented in the KIT's student portal "Campus"; therefore, online registration for controls of success and examinations is not possible. Students can register for examinations at the Examination Office (Prüfungssekretariat) of the KIT Department of Physics (Physics High-Rise, Building 30.23, room 9/13) instead. If necessary, successful participation in courses may be confirmed by paper certificates issued by the lecturer.

Since the specialization phase and introduction to scientific methods are carried out under the guidance of the supervisor of the Master's thesis, students register for all three modules before or during the first days of the specialization phase. Registration forms can be obtained from the Examination Office.

1.3 Use of generative artificial intelligence

Algorithms based on "artificial intelligence" (AI) are both a working tool in physics and the subject of active research. The aim is therefore to familiarize students with the responsible use of this technology, particularly with regard to the considerable potential for increasing productivity, but also for the problems that can arise in the quality assurance of scientific results. The use of so-called "generative artificial intelligence" for the creation of texts and texts and images or graphics in text documents such as theses or scientific publications is problematic with regard to the traceability of authorship and the quality of the sources used. In the case of study achievements and exams, the assessment of the author's learning objectives and personal, original contributions must not be impaired by the use of AI.

Rules on the use of artificial intelligence methods

- The use of AI as familiarization with new subject areas, as an aid to research and for structuring content is permitted.
- The use of AI for grammatical or stylistic improvement of texts is permitted, but the tools used must be specified.
- Any further use of AI for examinations and proof of performance (theses, seminar presentations, internship protocols or homework and exercise sheets, etc.) is not permitted.
- The use of generative AI may under no circumstances replace the achievement of the learning objectives and competences defined in a module.
- Responsibility for the text, its accuracy and the correct citation of primary sources lies with the author and cannot be transferred to an AI. The rules of good scientific practice of the KIT apply explicitly.
- The unauthorized use of AI methods or the lack of documentation of their use is considered an attempt to cheat.
- Deviating rules can be established by lecturers of the departement for special specific areas of the course of study.

1.4 Mobility

In the sequence of the Master's program, it is possible to study one semester at a university outside Germany (semester abroad). This semester abroad should be passed before starting work on the Master's thesis. Credits earned abroad will be recognized for the Master's program if they provide comparable competencies to the KIT program. It is recommended to ask the examination committee for the exact conditions of recognition, preferably before starting the courses abroad.

1.5 Internships

The Master's program in physics at KIT does not provide for mandatory internships; however, it is possible to complete a voluntary internship. The period suited best for internships is after the second master's semester or after the exams in the major, second major, minor, and non-physics elective subjects and before starting the module "Introduction to Scientific Methods". Students are responsible for finding suitable internships. It is possible to request a semester on leave during the internship.

1.6 Graphical Representation of the Plan of Study

Term	Major in Physics and Master's Thesis	Second Major in Physics	Minor in Physics	Lab Course	Non-Physics Elective	Interdisciplinary Qualifications	CP†
1	**Modules of the Major in Physics** 8	**Modules of the Second Major in Physics** 8	**Modules of the Minor in Phyiscs*** 8	**Advanced Physics Laboratory Course*** P4 6			30
2	**Modules of the Major in Physics** 12	**Modules of the Second Major in Physics** 6			**Modules of the Non-Physics Elective*** 8	**Interdisciplinary Qualifications*** 4	30
3	**Specialization Phase** 15 **Introduction to Scientific Methods** 15						30
4	**Master's Thesis** 30						30
							Sum: 120

† Credit Points according to the European Credit Transfer and Accumulation System

* Modules of the Minor in Physics, the Advanced Physics Laboratory Course, the Non-Physics Elective and the Interdisciplinary Qualifications are offered both in winter and summer terms and can be taken according to preference. Overload should be avoided.

Field A: Experimental Physics

Condensed Matter

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Electronic Properties of Solids I (with/without exercises) *Elektronische Eigenschaften von Festkörpern I (mit/ohne Übungen)*		WS	L4E1/L4	10/8	A	Ex
Electronic Properties of Solids II (with/without exercises) *Elektronische Eigenschaften von Festkörpern II (mit/ohne Übungen)*	✓	SS	L2E2/L2	8/4	B	Ex
Physics of Semiconductors (with/without exercises) *Halbleiterphysik (mit/ohne Übungen)*			L4E1/L4	10/8	C	Ex
Electron Microscopy I (with/without exercises) *Elektronenmikroskopie I (mit/ohne Übungen)*			L2E2/L2	8/4		Ex
Surface Science (with/without exercises) *Oberflächenphysik (mit/ohne Übungen)*	✓		L4E1/L4	10/8	D	Ex
Solid-State Optics *Solid-State Optics*		WS	L4	8	E	✓

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Solid State Quantum Technologies *Solid State Quantum Technologies*	✓		L2E2	8		✓
Superconducting Nanostructures *Supraleitende Nanostrukturen*			L2E1	6		✓
Spin Transport in Nanostructures *Spintransport in Nanostrkcturen*	✓		L2E1	6		✓
Electron Microscopy II (with/without exercises) *Elektronenmikroskopie II (mit/ohne Übungen)*	✓		L2E2/L2E	8/4		Ex
Accelerator Physics (with/without ext. Exercises) *Beschleunigerphysik (mit/ohne erw. Übungen)*		WS	L4E1/L4E	8/6		✓
X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (with/without exercises and Lab) *X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (mit/ohne Übungen und Praktikum)*		WS	L2E1P1/L2	8/4		Ex
Introduction to Neutron Scattering *Einführung in die Neutronenstreuung*			L2E1	6		✓
Fundamentals of Cryophysics (with/without exercises)			L2E1/L2	6/4		Ex
Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training*		WS	10 days block practical course	4		✓

* This module cannot be combined with an advanced seminar or any non-graded module in the major in physics or second major in physics.

Major in Physics (Maj):
Required courses are **A or C**: „Electronic Properties of Solids I " or „Physics of Semiconductors".

Second Major in Physics (Maj2):
Required courses: **minmum one** out of **A, B, C, D, E**

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with "**Ex**" in column ***Min***, can only be selected in the variant „with Exercises".

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Nanophysics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Basics of Nanotechnology I *Grundlagen der Nanotechnologie I*		WS	L2	4	A	✓
Basics of Nanotechnology II *Grundlagen der Nanotechnologie II*	✓	SS	L2	4	B	✓
Electronic Properties of Solids I (with/without exercises) *Elektronische Eigenschaften von Festkörpern I (mit/ohne Übungen)*		WS	L4E1/L4E	10/8	C	Ex
Electronic Properties of Solids II (with/without exercises) *Elektronische Eigenschaften von Festkörpern I (mit/ohne Übungen)*	✓	SS	L2E2/L2E	8/4		Ex
Physics of Semiconductors (with/without exercises) *Halbleiterphysik (mit/ohne Übungen)*			L4E1/L4E	10/8	D	Ex
Surface Science (with/without exercises) *Oberflächenphysik (mit/ohne Übungen)*	✓		L4E1/L4E	10/8	E	Ex
Electron Microscopy I (with/without exercises) *Elektronenmikroskopie I (mit/ohne Übungen)*			L2E2/L2E	8/4		Ex
Nano-Optics *Nano-Optics*		WS	L3E1	8		✓

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Experimental Biophysics II (with/without seminar) *Experimentelle Biophysik II (mit/ohne Seminar)*	✓	SS	L4E2S2/L4E2	14/12	F	✓
Electron Microscopy II (with/without exercises) *Elektronenmikroskopie II (mit/ohne Übungen)*	✓		L2E2/L2E	8/4		Ex
X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (with/without exercises and lab) *X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (mit/ohne Übungen und Praktikum)*		WS	L2E1P1/L2	8/4		Ex
Superconducting Nanostructures *Supraleiter-Nanostrukturen*			L2E1	6		✓
Theoretical Nanooptics *Theoretical Nanooptics*			L2E1	6 (**T**)		✓
Spin Transport in Nanostructures *Spintransport in Nanostrukturen*	✓		L2E1	6		✓
Theoretical Molecular Biophysics (with/without seminar) *Theoretische molekulare Biophysik (mit/ohne Seminar)*			L2E1S2/L2E1	8/6 (**T**)		✓
Theoretical Optics *Theoretical Optics*	✓	SS	L2E1	6 (**T**)		✓
Theoretical Quantum Optics *Theoretical Quantum Optics*			L2E1	6 (**T**)		✓
Quantum Optics at the Nano Scale (with/without exercises) *Quantenoptik auf der Nanoskala (mit/ohne Übungen)*	✓		L3E1/L3	8/6		Ex
Solid State Quantum Technologies *Solid State Quantum Technologies*	✓		L2E2	8		✓
Computational Photonics (with/without ext. exercises) *Computational Photonics (with/without ext. exercises)*			L2E2/L2E1	8/6 (**T**)		✓
Computational Condensed Matter Physics *Computational Condensed Matter Physics*	✓		L4E2	12 (**T**)		✓
Software Engeneering in Condensed Matter Physics			L2E1	6		✓
Fundamentals of Cryophysics (with/without exercises)			L2E1/L2	6/4		Ex
Microscale Fluid Mechanics (extern)		WS	L2	4		

(**T**) Lecture in Theory– not selectable if „Nanophysics“ is the only experimental subject.

Major in Physics (Maj):
Required courses are
- **A and B**: „Basics of Nanotechnology I“ and „Basics of Nanotechnology II“
- **as well as one** course out of **C, D, E, F**

Second Major in Physics (Maj2):
Required courses are **A and B**: „Basics of Nanotechnology I“ and „Basics of Nanotechnology II“

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Optics and Photonics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Solid-State Optics *Solid-State Optics*		WS	L4	8	A	✓
Nano-Optics *Nano-Optics*		WS	L3E1	8		✓
Theoretical Optics *Theoretical Optics*	✓	SS	L2E1	6 (**T**)	B	✓
Theoretical Nanooptics *Theoretical Nanooptics*			L2E1	6 (**T**)		✓
Molecular Spectroscopy (extern) *Molekülspektroskopie (extern)*		WS	L2E1	6	External	
Nonlinear Optics (extern) *Nonlinear Optics (extern)*	✓	SS	L2E2	6	External	
Photovoltaik (extern) *Photovoltaics (extern)*	✓	SS	L4E1	6	External	

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (with/without Exercises and Lab) *X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures (mit/ohne Übungen und Praktikum)*		WS	L2E1P1/L2	8/4	C	Ex
X-ray Physics II: Optical Coherence, Imaging and Computed Tomography (with/without Exercises and Lab) *X-ray Physics II: Optical Coherence, Imaging and Computed Tomography (mit/ohne Übungen und Parktikum)*	✓	SS	L2E1P1/L2	8/4	D	Ex
Experimental Biophysics II (with/without seminar) *Experimentelle Biophysik II (mit/ohne Seminar)*	✓	SS	L4E2S2/L4E2	14/12	E	✓
Theoretical Quantum Optics *Theoretical Quantum Optics*			L2E1	6 (**T**)	F	✓
Computational Photonics (with/without ext. exercises) *Computational Photonics (with/without ext. exercises)*			L2E2/L2E1	8/6 (**T**)	G	✓
Quantum Optics at the Nano Scale (with/without exercises) *Quantenoptik auf der Nanoskala (mit/ohne Übungen)*	✓		L3E1/L3	8/6	H	Ex
Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training*		WS	10 days block practical course	4		✓

* This module cannot be combined with an advanced seminar or any non-graded module in the major in physics or second major in physics.

(**T**) Lecture in Theory– not selectable if „Optics and Photonics“ is the only experimental subject.

Major in Physics (Maj):
Required courses are **A and B**: „Solid-State Optics“ and „Theoretical Optics“.

Second Major in Physics (Maj2):
- **At most one** course from an **external** provider **(„External“)**
- **At most one** course out of the **further courses (C-H)**

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Experimental Particle Physics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Particle Physics I *Teilchenphysik I*		WS	L3P2	8	A	✓
Modern Methods of Data Analysis (with/without ext. Exercises)* *Moderne Methoden der Datenanalyse (mit/ohne erw. Übungen)**	✓	SS	L2P4/L2P2	8/6	B	✓
Electronics for Physicists *Elektronik für Physiker*		WS	L4P4	10		✓
Accelerator Physics (with/without ext. Exercises) *Beschleunigerphysik (mit/ohne erw. Übungen)*		WS	L4E1/L4	8/6		✓
Measurement Methods and Techniques in Experimental Physics (with/without ext. Exercises) *Messmethoden und Techniken der Experimentalphysik (mit/ohne erw. Übungen)*			L2E1P2/L2E1	8/6		✓
Detectors for Particle and Astroparticle Physics (with/without ext. Exercises) *Detektoren für Teilchen- und Astroteilchenphysik (mit/ohne erw. Übungen)*		WS	L2P4/L2P2	8/6		✓

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Particle Physics II – Flavour Physics (with/without ext. Exercises) *Teilchenphysik II – Flavour-Physik (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	C	✓
Particle Physics II – W, Z, Higgs at Colliders (with/without ext. Exercises) *Teilchenphysik II – W, Z, Higgs am Collider (mit/ohne erw. Übungen)*		SS	L2E2/L2E1	8/6	D	✓
Particle Physics II – Top Quarks and Jets at the LHC (with/without ext. Exercises) *Teilchenphysik II – Top-Quarks und Jets am LHC (mit/ohne erw. Übungen)*		SS	L2E2/L2E1	8/6	E	✓
Particle Physics II – Physics Beyond the Standard Model (with/without ext. Exercises) *Teilchenphysik II – Physik jenseits des Standardmodells (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	F	✓
Computational Methods for Particle Physics and Cosmology *Computational Methods for Particle Physics and Cosmology*			L2E1	6 (**T**)	G	---
Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training**		WS	10 days block practical course	4		✓
Modern Methods of Spektroscopy: Applications in Astroparticle Physics** *Moderne Methoden der Spektroskopie: Anwendungen in der Astroteilchenphysik***		WS SS	5 days block practical course	2		✓
Block Practical Course: ETP Data Science** *Blockpraktiukum: ETP Data Science***		WS	5 days block practical course	2		✓
Quantum Detectors and Sensors *Quantum Detectors and Sensors*		WS	L3E1	8		✓
Plasma Physics I	✓		L3E1	8		✓

* only selectable if „Methods of Data Analysis“ from the field „Meteorology“ is not selected at the same time for the second Major or Minor „Meteorology“

** This module cannot be combined with an advanced seminar or any non-graded module in the major in physics or second major in physics.

(**T**) Lecture in Theory– not selectable if „Experimental Particle Physics“ is the only experimental subject.

Major in Physics (Maj):
Required courses are
- **A** („Particle Physics I“)
- **and one from C, D, E, F** („Particle Physics II“)

Second Major (Maj2):
Required course is **A** („Particle Physics I“)

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Additonal Constraints:
One can select **either B** („Modern Methods of Data Analysis“) **or G** („Computational Methods for Particle Physics and Cosmology“) als part of the Major in Physics or the Second Major in Physics.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Experimental Astroparticle Physics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Astroparticle Physics I *Astroteilchenphysik I*		WS	L3E1	8	A	✓
Introduction to Cosmology *Einführung in die Kosmologie*		WS	L2E1	6	B	✓
Modern Methods of Data Analysis (with/without ext. Exercises)* *Moderne Methoden der Datenanalyse (mit/ohne erw. Übungen)**	✓	SS	L2P4/L2P2	8/6	C	✓
Electronics for Physicists *Elektronik für Physiker*		WS	L4P4	10		✓
Accelerator Physics (with/without ext. Exercises) *Beschleunigerphysik (mit/ohne erw. Übungen)*		WS	L4E1/L4	8/6		✓
Measurement Methods and Techniques in Experimental Physics (with/without ext. Exercises) *Messmethoden und Techniken der Experimentalphysik (mit/ohne erw. Übungen)*			L2E1P2/L2E1	8/6		✓
Detectors for Particle and Astroparticle Physics (with/without ext. Exercises) *Detektoren für Teilchen- und Astroteilchenphysik (mit/ohne erw. Übungen)*		WS	L2P4/L2P2	8/6		✓

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Astroparticle Physics II – Cosmic Rays (with/without ext. Exercises) *Astroteilchenphysik II – Kosmische Strahlung (mit/ohne erw. Übungen)*		WS	L2E2/L2E1	8/6	D	✓
Astroparticle Physics II – Gamma Rays and Neutrinos (with/without ext. Exercises) *Astroteilchenphysik II – Gamma Rays and Neutrinos (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	E	✓
Astroparticle Physics II – Particles and Stars (with/without ext. Exercises) *Astroteilchenphysik II – Teilchen und Sterne (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	F	✓
Introduction to General Relativity** *Einführung in die allgemeine Relativitätstheorie***		WS	L3E1	8 (**T**)		✓
Computational Methods for Particle Physics and Cosmology *Computational Methods for Particle Physics and Cosmology*			L2E1	6 (**T**)	G	✓
Introduction to Theoretical Cosmology** *Einführung in die Theoretische Kosmologie***	✓		L3E1	8 (**T**)		✓
Modern Methods of Spektroscopy: Applications in Astroparticle Physics*** *Moderne Methoden der Spektroskopie: Anwendungen in der Astroteilchenphysik****		WS SS	5 days block practical course	2		✓
Block Practical Course: ETP Data Science*** *Blockpraktiukum: ETP Data Science****		WS	5 days block practical course	2		✓
Quantum Detectors and Sensors *Quantum Detectors and Sensors*		WS	L3E1	8		✓

* only selectable if „Methods of Data Analysis“ from the field „Meteorology“ is not selected at the same time for the second Major or Minor „Meteorology“

** can be used as part of „Experimental Astroparticle Physics“ till 30.09.25. After that it will be an exclusive part of „Theoretical Cosmology and Astroparticle Physics“

*** This module cannot be combined with an advanced seminar in the major in physics or second major in physics.

(**T**) Lecture in Theory– not selectable if „Experimental Particle Physics“ is the only experimental subject.

Major in Physics (Maj):
Required courses are
- **A or B**: „Astroparticle Physics I“ or „Introduction to Cosmology“
- **combined with one** course out of **D, E, F** („Astroparticle Physics II“)

Second Major in Physics (Maj2):
Required courses are **A or B**: „Astroparticle Physics I“ or „Introduction to Cosmology“.

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Additonal Constraints:
One can select **either C** („Modern Methods of Data Analysis“) **or G** („Computational Methods for Particle Physics and Cosmology“) als part of the Major in Physics or the Second Major in Physics.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Field B: Theoretical Physics

Theoretical Particle Physics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Theoretical Particle Physics I, Fundamentals and Advanced Topics (with/without exercises) *Theoretische Teilchenphysik I, Grundlagen und Vertiefungen (mit/ohne Übungen)*		WS	L4E2/L4	12/8	A	Ex
Theoretical Particle Physics I, Fundamentals (with/without exercises) *Theoretische Teilchenphysik I, Grundlagen (mit/ohne Übung)*		WS	L3E1/L3	8/6	B	Ex
Theoretical Particle Physics II (with/without exercises) *Theoretische Teilchenphysik II (mit/ohne Übungen)*	✓	SS	L4E2/L4	12/8		Ex

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Introduction to Theoretical Cosmology* *Einführung in die Theoretische Kosmologie**	✓		L3E1	8		✓
Computational Physics	✓		L2E2	8		✓
Computational Methods for Particle Physics and Cosmology			L2E1	6		✓
Mathematical Methods of Theoretical Physics** *Mathematische Methoden der Theoretischen Physik***			L4E2	12		✓
Introduction to Flavor Physics, Fundamentals and Advanced Topics *Einführung in die Flavourphysik, Grundlagen und Vertiefungen*			L4E2	12		✓
Introduction to Flavor Physics, Fundamentals *Einführung in die Flavourphysik, Grundlagen*			L3E2	10		✓
Particle Physics with Extra Dimensions *Particle Physics with Extra Dimensions*			L2	4		
New light Particles beyond the Standard Model (without Exercises) *Neue leichte Teilchen jenseits des Standardmodells (ohne Übungen)*			L2	4		
Physics beyond the Standard Model (with/without Exercises) *Physik jenseits des Standardmodells (mit/ohne Übungen)*			L2E1/L2	6/4		
Supersymmetry and Exotics at Colliders (with/without Exercises) *Supersymmetrie und Exotica an Collidern (mit/ohne Übungen)*			L4E2/L4	12/8		Ex
Symmetries, Groups and extended Gauge Theories *Symmetrien, Gruppen und erweiterte Eichtheorien*			L4E2	12		✓
Symmetries and Groups *Symmetrien und Gruppen*			L3E1	8		✓
Groups, Algebras and Representations *Gruppen, Algebren und Darstellungen*			L2E1	6		✓
Advanced Topics in Quantum Field Theory			L2	4		
Effective Field Theories	✓		L1E1	4		✓
Introduction to General Relativity* *Einführung in die allgemeine Relativitätstheorie**		WS	L3E1	8		✓
Non-supersymmetric Extension of the Standard Model *Non-supersymmetric Extension of the Standard Model*			L2	4	---	✓
Precision Phenomenology at Colliders and Computational Methods (with/without Exercises) *Präzisions-Phänomenologie an Beschleunigern und Berechnungsmethoden (mit/ohne Übungen)*			L2E2/L2	8/4		Ex

* can be used as part of „Theoretical Particle Physics“ till 30.09.25. After that it will be an exclusive part of „Theoretical Cosmology and Astroparticle Physics“

** only selectable for the Second Major in Physics if also „Introduction in Theoretical Particle Physics“ or „Theoretical Particle Physics I“ are selected.

Major in Physics (Maj):
Required courses are **A or B** („Theoretical Particle Physics I“) with **8 or 12** ECTS points.

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Theoretical Cosmology and Astroparticle Physics

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Introduction to Theoretical Cosmology (with exercises) *Einführung in die Theoretische Kosmologie (mit Übung)*	✓	SS	L3E1	8	A	✓
Theoretical Cosmology (with/without exercises) *Theoretische Kosmologie (mit/ohne Übungen)*	✓	SS	L4E2/ L4	12/8	A	Ex

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Introduction to General Relativity (with/without exercises) *Einführung in die Allgemeine Relativitätstheorie (mit/ohne Übungen)*		WS	L3E1/ L3	8/6	B	Ex
Theoretical Particle Physics I, Fundamentals (with/without exercises) *Theoretische Teilchenphysik I, Grundlagen (mit/ohne Übung)*		WS	L3E1/L3	8/6		
Theoretical Particle Physics I, Fundamentals and Advanced Topics (with/without exercises) *Theoretische Teilchenphysik I, Grundlagen und Vertiefungen (mit/ohne Übungen)*		WS	L4E2/L4	12/8		
Computational Methods for Particle Physics and Cosmology *Computational Methods for Particle Physics and Cosmology*			L2E1	6		
Mathematical Methods of Theoretical Physics** *Mathematische Methoden der Theoretischen Physik***			L4E2	12		
New light Particles beyond the Standard Model (without Exercises) *Neue leichte Teilchen jenseits des Standardmodells (ohne Übungen)*			L2	4		
Physics beyond the Standard Model (with/without Exercises) *Physik jenseits des Standardmodells (mit/ohne Übungen)*			L2E1/L2	6/4		
Astroparticle Physics II – Cosmic Rays (with/without ext. Exercises) *Astroteilchenphysik II – Kosmische Strahlung (mit/ohne erw. Übungen)*		WS	L2E2/L2E1	8/6	C	
Astroparticle Physics II – Gamma Rays and Neutrinos (with/without ext. Exercises) *Astroteilchenphysik II – Gamma Rays and Neutrinos (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	C	
Astroparticle Physics II – Particles and Stars (with/without ext. Exercises) *Astroteilchenphysik II – Teilchen und Sterne (mit/ohne erw. Übungen)*	✓	SS	L2E2/L2E1	8/6	C	

Major (Maj) and Second Major (Maj2) in Phyiscs:
Course **A** („(Introduction to) Theoretical Cosmology“) with at least **8** ECTS points is mandatory.

Minor in Physics (Min):
For the Minor in Physics, one of the courses A or B in the variant “with Exercises” (Ex) is required.

Use of experimental courses:
One of the courses **C** (“Astroparticle Physics II”) can be used for Major (Second Major) if “Experimental Astroparticle Physics” is not chosen for Second Major (Major)

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Condensed Matter Theory

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Condensed Matter Theory I, Fundamentals and Advanced Topics *Theorie der kondensierten Materie I, Grundlagen und Vertiefungen*		WS	L4E2	12	A	✓
Condensed Matter Theory I, Fundamentals *Theorie der kondensierten Materie I, Grundlagen*		WS	L3E1	8	B	✓
Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics *Theorie der kondensierten Materie II: Vielteilchentheorie, Grundlagen und Vertiefungen*	✓	SS	L4E2	12		✓
Condensed Matter Theory II: Many-Body Theory, Fundamentals *Theorie der kondensierten Materie II: Vielteilchentheorie, Grundlagen*	✓	SS	L3E1	8		✓
Condensed Matter Theory II: Many-Body Theory, selected topics* *Theorie der kondensierten Materie II: Vielteilchentheorie, ausgewählte Themen **	✓	SS	L1	2	**only Maj2**	

Further Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***	***Maj/ Maj2***	***Min***
Theory and Applications of Quantum Machines *Theorie und Anwendung von Quantenmaschinen*			L2E2	8		✓
Computational Condensed Matter Physics *Computational Condensed Matter Physics*	✓		L4E2	12		✓
Theoretical Molecular Biophysics (with/without seminar) *Theoretische molekulare Biophysik (mit/ohne Seminar)*			L2E1S2/L2E1	8/6		✓
Theoretical Nanooptics *Theoretical Nanooptics*			L2E1	6		✓
The ABC of DFT *The ABC of DFT*	✓		L2E1	6		
Theoretical Quantum Optics *Theoretical Quantum Optics*			L2E1	6		✓
Superconductivity, Josephson effect and applications, with/without Exercises *Superconductivitym Josephson effects and applications, ohne/mit Übungen*			L3E1/ L3	8/6		Ex
Superconductivity, Microscopic Theory and Macroscopic Phenomena			L2E2	8		✓
Software Engeneering in Condensed Matter Physics			L2E1	6		✓
Theory of Strongly Correlated Electron Systems *Theorie stark korrelierter Elektronensysteme*			L4E2	12	***only Maj***	
Topology in Condensed Matter Physics: Fundamentals and Advanced Topics			L3E1	8		✓
Topology in Condensed Matter Physics: Fundamentals and Selected Topics			L1	2		
Macroscopic Quantum Coherence and Dissipation, with/without Exercises			L3E1 / L3	8/6		✓
Quantum Fluctuations and Dissipation far from Equilibrium	✓		L4	8		
Theory of Magnetism *Theorie des Magnetismus*	✓		L2E2	8		✓

* Can only be selected as part of the second Major, e.g. to reach 14 ECTS points in combination with „Condensed Matter Theory I, Fundamentals and Advanced Topics“

Major in Physics (Maj):
Required courses are **A or B** („Condesed Matter Theory I“) with **8 or 12** ECTS points.

Minor in Physics (Min):
All courses for which the column ***Min*** is marked with ✓, can be selected (as part of) the Minor in Physics. Courses marked with “**Ex**” in column ***Min***, can only be selected in the variant „with Exercises“.

Semester Hours:
L: Lecture / E: Exercises / P: Practical Exercises

Field C: Meteorology and Geophysics

Suitable for the **Second Major in Physics (Maj2)** and the **Minor in Physics (Min)**

Meteorology

The following courses are part of the Master's program in Meteorology and are offered on an annual basis. Courses below can be combined in the module "Selected Topics in Meteorology (Second Major, graded)" for the Second Major in Physics (14 ECTS credits) and in the module "Selected Topics in Meteorology (Minor, ungraded)" for the Minor in Physics (8 ECTS credits). The criteria for earning the credit points are:

> **Minor (ungraded):** The examination is done via a coursework. Whether this is oral, written or of another kind depends on the respective course. Information about this can be found in the guide for all the moduls "Master Meteorology and Climate Physics". The credit points are acquired through the individual bricks (8 ECTS points).
>
> **Second Major in Physics (graded):** The examination is done by an oral examination ("Prüfung über meteorologische Spezialgebiete / Exam on Selected Topics in Meteorology"). The prerequisite for admission to the examination is passing the course work. Whether this is oral, written or of another kind depends on the respective course. Information about this can be found in the guide to all the modules „Master Meteorology and Climate Physics“. The credit points are acquired through the individual bricks (at least 10 ECTS points) and the oral examination (4 ECTS points).

Courses	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***
Remote Sensing of Atmosphere and Ocean	✓	SS	L2E1	4
Turbulent Diffusion	✓	SS	L2E1	4
Advanced Numerical Weather Prediction	✓	SS	L2E1	4
Energy Meteorology	✓	SS	L2	2
Methods of Data Analysis*	✓	SS	L2E1	4
Climate Modeling & Dynamics with ICON		WS	L2E1	4
Energetics		WS	L2	2
Cloud Physics		WS	L2E1	4
Atmospheric Radiation		WS	L2	2
Atmospheric Aerosols		WS	L2E1	4
Middle Atmosphere in the Climate System		WS	L2	2
Tropical Meteorology		WS	L2E1	4
Seminar on IPCC Assessment Report		WS	S2	2
Ocean-Atmosphere Interactions		WS	L2	2
Physics of Planetary Atmospheres		WS	L2E2	6
Arctic Climate System		WS	L2	2

* only selectable if „Modern Methods of Data Analysis“ from the ETP or ATP is not chosen at the same time for the second Major or Minor

Geophysics

Courses in Geophysics can be chosen as ungraded minor in physics (Minor) with a total of 8 ECTS credits or as the graded second major in physics (Maj2) with a total of 14 ECTS credits in the master's program in physics. All courses of the international master program "Geophysics" are held in English.

As a **minor** subject, individual courses among the compulsory courses in the Master's program "Geophysics" that cover 8 ECTS points are preferably suitable; however, several courses can also be combined if necessary. The examination is done within the framework of course achievements; the type of examination depends on the respective course. More detailed information on the individual courses can be found in the guide to all the modules "Geophysics Master (M.Sc.)".
The following courses are eligible for recognition as **a minor in physics**. Other courses can be approved by the examination board upon request.

Courses suitable as Minor in Physics	***SS 25***	***Reg.***	***Semester Hours***	***ECTS***
Seismology *Seismologie*		WS	L2E2	8
Seismics *Seismics*		WS	L2E2	8
Physics of Seismic Instruments *Physik seismischer Messinstrumente*		WS	L2E1	6
Inversion and Tomography *Inversion & Tomographie*	✓	SS	L2E2	8
Theory of Seismic Waves *Theorie seismischer Wellen*	✓	SS	L2E1	6
Seismic Modelling	✓	SS	L1E1	4
Full-waveform inversion			L2E1	6

Certain combinations of courses in Geophysics are suitable as second Major in Physics, which, when graded, add up to at least 14 ECTS points. For compulsory courses in the Master's program "Geophysics", i.e. the courses "Physics of Seismic Instruments", "Seismology" and "Seismics" in the winter semester and "Inversion and Tomography", "Theory of Seismic Waves" and "Seismic Modelling" in the summer semester, the examination is done by an oral examination for the respective semester. Students who choose Geophysics as a second major in physics are admitted to the oral examination if they pass the relevant course work(s). The way in which individual course achievements are assessed depends on the course in question. More detailed information on the individual courses can be found in the guide to all the modules "Geophysics Master (M.Sc.)". For students who choose Geophysics as the second Major in Physics, the examination material of the oral comprehensive examination covers only the respective course achievement(s) passed, not all three course achievements that are part of the respective module, as is the case for students of Geophysics. In the case of graded elective courses in the Master's program "Geophysics", the type of performance assessment and grading depends on the respective course; again, see the guide to all the modules "Geophysics Master (M.Sc.)" for details. The grades of the second Major in Physics are included in the overall grade of the master's examination as described in the section "Grade formation".

			Seismology (L2E2)	Seismics (L2E2)	Inversion and Tomography (L2E2)	Physics of Seismic Instruments (L2E1)	Theory of Seismic Waves (L2E1)	Geological Hazards and Risks (v2u2)	In Situ: Tectonics and Seismic Hazards in the Mediterranean Region (L1E2)	Array Techniques in Seismology (L1E1)	Seismic Modeling (L1E1)	Seismic Data Processing (L1E)
		SS 25			✓		✓				✓	✓
	SS 25	**Reg.**	WS	WS	SS	WS	SS				SS	
Seismology (v2u2)		WS		16 LP	16 LP	14 LP	14 LP	16 LP	14 LP	16 LP		
Seismics (v2u2)		WS	16 LP		16 LP	14 LP	14 LP					14 LP
Inversion and Tomograpy (v2u2)	✓	SS	16 LP	16 LP		14 LP	14 LP					

3 Field of study structure

Mandatory	
Master's Thesis	30 CR
Major in Physics (Election: 1 item)	
Major in Physics: Condensed Matter	20 CR
Major in Physics: Nanophysics	20 CR
Major in Physics: Optics and Photonics	20 CR
Major in Physics: Experimental Particle Physics	20 CR
Major in Physics: Experimental Astroparticle Physics	20 CR
Major in Physics: Theoretical Particle Physics	20 CR
Major in Physics: Theoretical Cosmology and Astroparticle Physics	20 CR
Major in Physics: Condensed Matter Theory	20 CR
Second Major in Physics (Election: 1 item)	
Second Major in Physics: Condensed Matter	14 CR
Second Major in Physics: Nanophysics	14 CR
Second Major in Physics: Optics and Photonics	14 CR
Second Major in Physics: Experimental Particle Physics	14 CR
Second Major in Physics: Experimental Astroparticle Physics	14 CR
Second Major in Physics: Theoretical Particle Physics	14 CR
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics	14 CR
Second Major in Physics: Condensed Matter Theory	14 CR
Second Major in Physics: Geophysics	14 CR
Second Major in Physics: Meteorology	14 CR
Minor in Physics (Election: 1 item)	
Minor in Physics: Condensed Matter	8 CR
Minor in Physics: Nanophysics	8 CR
Minor in Physics: Optics and Photonics	8 CR
Minor in Physics: Experimental Particle Physics	8 CR
Minor in Physics: Experimental Astroparticle Physics	8 CR
Minor in Physics: Theoretical Particle Physics	8 CR
Minor in Physics: Theoretical Cosmology and Astroparticle Physics	8 CR
Minor in Physics: Condensed Matter Theory	8 CR
Minor in Physics: Geophysics	8 CR
Minor in Physics: Meteorology	8 CR
Mandatory	
Non-Physics Elective	8 CR
Advanced Physics Laboratory Course	6 CR
Specialization Phase	15 CR
Introduction to Scientific Methods	15 CR
Interdisciplinary Qualifications	4 CR
Voluntary	

Additional Examinations *This field will not influence the calculated grade of its parent.*	

3.1 Master's Thesis

Credits
30

Mandatory		
M-PHYS-106481	Master's Thesis	30 CR

3.2 Major in Physics: Condensed Matter

Credits
20

Required Condensed Matter (Election: between 1 and 2 items)		
M-PHYS-102089	Electronic Properties of Solids I, with Exercises	10 CR
M-PHYS-102090	Electronic Properties of Solids I, without Exercises	8 CR
M-PHYS-102131	Physics of Semiconductors, with Exercises	10 CR
M-PHYS-102301	Physics of Semiconductors, without Exercises	8 CR
Elective Condensed Matter (Election:)		
M-PHYS-102109	Electronic Properties of Solids II, without Exercises	4 CR
M-PHYS-102108	Electronic Properties of Solids II, with Exercises	8 CR
M-PHYS-102990	Electron Microscopy I, without Exercises	4 CR
M-PHYS-102989	Electron Microscopy I, with Exercises	8 CR
M-PHYS-106483	Surface Science, without Exercises	8 CR
M-PHYS-106482	Surface Science, with Exercises	10 CR
M-PHYS-102408	Solid-State Optics	8 CR
M-PHYS-104857	Solid State Quantum Technologies	8 CR
M-PHYS-102191	Superconducting Nanostructures	6 CR
M-PHYS-102293	Spin Transport in Nanostructures	6 CR
M-PHYS-102844	Electron Microscopy II, without Exercises	4 CR
M-PHYS-102227	Electron Microscopy II, with Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-106323	Introduction to Neutron Scattering	6 CR
M-PHYS-106798	Fundamentals of Cryophysics, without Exercises	4 CR
M-PHYS-106799	Fundamentals of Cryophysics, with Exercises	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102203	Advanced Seminar in the Area Condensed Matter	4 CR

3.3 Major in Physics: Nanophysics

Credits
20

Mandatory		
M-PHYS-102097	Basics of Nanotechnology I	4 CR
M-PHYS-102100	Basics of Nanotechnology II	4 CR
Required Elective Nanophysics (Election: at least 1 item)		
M-PHYS-102089	Electronic Properties of Solids I, with Exercises	10 CR
M-PHYS-102090	Electronic Properties of Solids I, without Exercises	8 CR
M-PHYS-106482	Surface Science, with Exercises	10 CR
M-PHYS-106483	Surface Science, without Exercises	8 CR
M-PHYS-102131	Physics of Semiconductors, with Exercises	10 CR
M-PHYS-102301	Physics of Semiconductors, without Exercises	8 CR
M-PHYS-102165	Experimental Biophysics II, with Seminar	14 CR
M-PHYS-102167	Experimental Biophysics II, without Seminar	12 CR
Elective Nanophysics (Election:)		
M-PHYS-102108	Electronic Properties of Solids II, with Exercises	8 CR
M-PHYS-102109	Electronic Properties of Solids II, without Exercises	4 CR
M-PHYS-102990	Electron Microscopy I, without Exercises	4 CR
M-PHYS-102989	Electron Microscopy I, with Exercises	8 CR
M-PHYS-102146	Nano-Optics	8 CR
M-PHYS-102227	Electron Microscopy II, with Exercises	8 CR
M-PHYS-102844	Electron Microscopy II, without Exercises	4 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-102191	Superconducting Nanostructures	6 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102293	Spin Transport in Nanostructures	6 CR
M-PHYS-102171	Theoretical Molecular Biophysics, without Seminar	6 CR
M-PHYS-102169	Theoretical Molecular Biophysics, with Seminar	8 CR
M-PHYS-102277	Theoretical Optics	6 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-106508	Quantum Optics at the Nano Scale, with Exercises	8 CR
M-PHYS-106510	Quantum Optics at the Nano Scale, without Exercises	6 CR
M-PHYS-104857	Solid State Quantum Technologies	8 CR
M-PHYS-101933	Computational Photonics, with ext. Exercises	8 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises	6 CR
M-PHYS-104862	Computational Condensed Matter Physics	12 CR
M-PHYS-106833	Software Engineering in Condensed Matter Physics	6 CR
M-PHYS-106798	Fundamentals of Cryophysics, without Exercises	4 CR
M-PHYS-106799	Fundamentals of Cryophysics, with Exercises	6 CR
M-MACH-106539	Microscale Fluid Mechanics	4 CR
M-PHYS-102204	Advanced Seminar in the Area Nanophysics	4 CR

3.4 Major in Physics: Optics and Photonics

Credits
20

Mandatory		
M-PHYS-102408	Solid-State Optics	8 CR
M-PHYS-102277	Theoretical Optics	6 CR
Elective Optics and Photonics (Election: at least 6 credits)		
M-PHYS-102146	Nano-Optics	8 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102337	Molecular Spectroscopy	6 CR
M-ETIT-100430	Nonlinear Optics	6 CR
M-ETIT-100513	Photovoltaics	6 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-105558	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab	8 CR
M-PHYS-105559	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab	4 CR
M-PHYS-102165	Experimental Biophysics II, with Seminar	14 CR
M-PHYS-102167	Experimental Biophysics II, without Seminar	12 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises	6 CR
M-PHYS-101933	Computational Photonics, with ext. Exercises	8 CR
M-PHYS-106508	Quantum Optics at the Nano Scale, with Exercises	8 CR
M-PHYS-106510	Quantum Optics at the Nano Scale, without Exercises	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102205	Advanced Seminar in the Area Optics and Photonics	4 CR

3.5 Major in Physics: Experimental Particle Physics

Credits
20

Mandatory		
M-PHYS-102114	Particle Physics I	8 CR
Required Elective Experimental Particle Physics (Election: at least 1 item)		
M-PHYS-102422	Particle Physics II - Flavour Physics, with ext. Exercises	8 CR
M-PHYS-102154	Particle Physics II - Flavour Physics, without ext. Exercises	6 CR
M-PHYS-104081	Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises	6 CR
M-PHYS-104084	Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises	8 CR
M-PHYS-104086	Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises	6 CR
M-PHYS-104088	Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises	8 CR
M-PHYS-105937	Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises	6 CR
M-PHYS-105939	Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises	8 CR
Elective Experimental Particle Physics (Election:)		
M-PHYS-102125	Modern Methods of Data Analysis, without ext. Exercises	6 CR
M-PHYS-102127	Modern Methods of Data Analysis, with ext. Exercises	8 CR
M-PHYS-102184	Electronics for Physicists	10 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-102517	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises	8 CR
M-PHYS-102518	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises	6 CR
M-PHYS-102121	Detectors for Particle and Astroparticle Physics, with ext. Exercises	8 CR
M-PHYS-102119	Detectors for Particle and Astroparticle Physics, without ext. Exercises	6 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-106193	Quantum Detectors and Sensors	8 CR
M-PHYS-107114	Plasma Physics I *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102206	Advanced Seminar in the Area Experimental Particle Physics	4 CR

3.6 Major in Physics: Experimental Astroparticle Physics

Credits
20

Required Experimental Astroparticle Physics (Election: at least 1 item)		
M-PHYS-102075	Astroparticle Physics I	8 CR
M-PHYS-102175	Introduction to Cosmology	6 CR
Further Required Experimental Astroparticle Physics (Election: at least 1 item)		
M-PHYS-102525	Astroparticle Physics II - Cosmic Rays, with ext. Exercises	8 CR
M-PHYS-102078	Astroparticle Physics II - Cosmic Rays, without ext. Exercises	6 CR
M-PHYS-105683	Astroparticle Physics II - Gamma Rays and Neutrinos	6 CR
M-PHYS-105686	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises	8 CR
M-PHYS-102527	Astroparticle Physics II - Particles and Stars, with ext. Exercises	8 CR
M-PHYS-102081	Astroparticle Physics II - Particles and Stars, without ext. Exercises	6 CR
Elective Experimental Astroparticle Physics (Election:)		
M-PHYS-102127	Modern Methods of Data Analysis, with ext. Exercises	8 CR
M-PHYS-102125	Modern Methods of Data Analysis, without ext. Exercises	6 CR
M-PHYS-102184	Electronics for Physicists	10 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-102517	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises	8 CR
M-PHYS-102518	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises	6 CR
M-PHYS-102121	Detectors for Particle and Astroparticle Physics, with ext. Exercises	8 CR
M-PHYS-102119	Detectors for Particle and Astroparticle Physics, without ext. Exercises	6 CR
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-106193	Quantum Detectors and Sensors	8 CR
M-PHYS-102207	Advanced Seminar in the Area Experimental Astroparticle Physics	4 CR

3.7 Major in Physics: Theoretical Particle Physics

Credits
20

Required Theoretical Particle Physics (Election: 1 item)		
M-PHYS-102033	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR
M-PHYS-102035	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR
M-PHYS-102034	Theoretical Particle Physics I, Fundamentals, with Exercises	8 CR
Elective Theoretical Particle Physics (Election:)		
M-PHYS-102048	Theoretical Particle Physics II, without Exercises	8 CR
M-PHYS-102046	Theoretical Particle Physics II, with Exercises	12 CR
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-105535	Mathematical Methods of Theoretical Physics	12 CR
M-PHYS-102986	Introduction to Flavor Physics, Fundamentals and Advanced Topics	12 CR
M-PHYS-102987	Introduction to Flavor Physics, Fundamentals	10 CR
M-PHYS-106055	Particle Physics with Extra Dimensions	4 CR
M-PHYS-105833	New Light Particles Beyond the Standard Model, without Exercises	4 CR
M-PHYS-106727	Physics beyond the Standard Model, with Exercises	6 CR
M-PHYS-106728	Physics beyond the Standard Model, without Exercises	4 CR
M-PHYS-106850	Supersymmetry and Exotics at Colliders, without Exercises	8 CR
M-PHYS-106848	Supersymmetry and Exotics at Colliders, with Exercises	12 CR
M-PHYS-102315	Symmetries, Groups and Extended Gauge Theories	12 CR
M-PHYS-102317	Symmetries and Groups	8 CR
M-PHYS-106732	Groups, Algebras and Representations	6 CR
M-PHYS-106842	Advanced Topics in Quantum Field Theory	4 CR
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-105640	Precision Phenomenology at Colliders and Computational Methods, with Exercises	8 CR
M-PHYS-105641	Precision Phenomenology at Colliders and Computational Methods, without Exercises	4 CR
M-PHYS-107091	Effective Field Theories *First usage possible from Apr 01, 2025.*	4 CR
M-PHYS-107092	Computational Physics *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102208	Advanced Seminar in the Area Theoretical Particle Physics	4 CR

3.8 Major in Physics: Theoretical Cosmology and Astroparticle Physics

Credits
20

Required: Theoretical Cosmology and Astroparticle Physics (Election: 1 item)		
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106845	Theoretical Cosmology, with Exercises	12 CR
M-PHYS-106847	Theoretical Cosmology, without Exercises	8 CR
Elective: Theoretical Cosmology an Astroparticle Physics (Election: at least 8 credits)		
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-106843	Introduction to General Relativity, without Exercises	6 CR
M-PHYS-102034	Theoretical Particle Physics I, Fundamentals, with Exercises	8 CR
M-PHYS-102036	Theoretical Particle Physics I, Fundamentals, without Exercises	6 CR
M-PHYS-102033	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR
M-PHYS-102035	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-105535	Mathematical Methods of Theoretical Physics	12 CR
M-PHYS-105833	New Light Particles Beyond the Standard Model, without Exercises	4 CR
M-PHYS-106727	Physics beyond the Standard Model, with Exercises	6 CR
M-PHYS-106728	Physics beyond the Standard Model, without Exercises	4 CR
M-PHYS-102525	Astroparticle Physics II - Cosmic Rays, with ext. Exercises	8 CR
M-PHYS-102078	Astroparticle Physics II - Cosmic Rays, without ext. Exercises	6 CR
M-PHYS-105686	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises	8 CR
M-PHYS-105683	Astroparticle Physics II - Gamma Rays and Neutrinos	6 CR
M-PHYS-102527	Astroparticle Physics II - Particles and Stars, with ext. Exercises	8 CR
M-PHYS-102081	Astroparticle Physics II - Particles and Stars, without ext. Exercises	6 CR
M-PHYS-106829	Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics	4 CR

3.9 Major in Physics: Condensed Matter Theory

Credits
20

Required Condensed Matter Theory (Election: 1 item)		
M-PHYS-102053	Condensed Matter Theory I, Fundamentals and Advanced Topics	12 CR
M-PHYS-102054	Condensed Matter Theory I, Fundamentals	8 CR
Elective Condensed Matter Theory (Election:)		
M-PHYS-102308	Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics	12 CR
M-PHYS-102313	Condensed Matter Theory II: Many-Body Theory, Fundamentals	8 CR
M-PHYS-105942	Theory and Applications of Quantum Machines	8 CR
M-PHYS-104862	Computational Condensed Matter Physics	12 CR
M-PHYS-102171	Theoretical Molecular Biophysics, without Seminar	6 CR
M-PHYS-102169	Theoretical Molecular Biophysics, with Seminar	8 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102984	The ABC of DFT	6 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-105655	Superconductivity, Josephson Effect and Applications, with Exercises	8 CR
M-PHYS-106584	Superconductivity, Josephson Effect and Applications, without Exercises	6 CR
M-PHYS-106796	Superconductivity, Microscopic Theory and Macroscopic Phenomena	8 CR
M-PHYS-106833	Software Engineering in Condensed Matter Physics	6 CR
M-PHYS-105381	Theory of Magnetism, with Exercises	8 CR
M-PHYS-106056	Theory of Strongly Correlated Electron Systems	12 CR
M-PHYS-106586	Topology in Condensed Matter Physics: Fundamentals and Advanced Topics	8 CR
M-PHYS-106588	Topology in Condensed Matter Physics: Fundamentals and Selected Topics	2 CR
M-PHYS-106724	Macroscopic Quantum Coherence and Dissipation, with Exercises	8 CR
M-PHYS-106725	Macroscopic Quantum Coherence and Dissipation, without Exercises	6 CR
M-PHYS-107194	Quantum Fluctuations and Dissipation far from Equilibrium *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102209	Advanced Seminar in the Area Condensed Matter Theory	4 CR

3.10 Second Major in Physics: Condensed Matter

Credits
14

Required Elective Condensed Matter (Election: at least 1 item)		
M-PHYS-102089	Electronic Properties of Solids I, with Exercises	10 CR
M-PHYS-102090	Electronic Properties of Solids I, without Exercises	8 CR
M-PHYS-102108	Electronic Properties of Solids II, with Exercises	8 CR
M-PHYS-102109	Electronic Properties of Solids II, without Exercises	4 CR
M-PHYS-102131	Physics of Semiconductors, with Exercises	10 CR
M-PHYS-102301	Physics of Semiconductors, without Exercises	8 CR
M-PHYS-106482	Surface Science, with Exercises	10 CR
M-PHYS-106483	Surface Science, without Exercises	8 CR
M-PHYS-102408	Solid-State Optics	8 CR
Elective Condensed Matter (Election:)		
M-PHYS-102989	Electron Microscopy I, with Exercises	8 CR
M-PHYS-102990	Electron Microscopy I, without Exercises	4 CR
M-PHYS-104857	Solid State Quantum Technologies	8 CR
M-PHYS-102191	Superconducting Nanostructures	6 CR
M-PHYS-102293	Spin Transport in Nanostructures	6 CR
M-PHYS-102227	Electron Microscopy II, with Exercises	8 CR
M-PHYS-102844	Electron Microscopy II, without Exercises	4 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-106323	Introduction to Neutron Scattering	6 CR
M-PHYS-106798	Fundamentals of Cryophysics, without Exercises	4 CR
M-PHYS-106799	Fundamentals of Cryophysics, with Exercises	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102203	Advanced Seminar in the Area Condensed Matter	4 CR

3.11 Second Major in Physics: Nanophysics

Credits
14

Mandatory		
M-PHYS-102097	Basics of Nanotechnology I	4 CR
M-PHYS-102100	Basics of Nanotechnology II	4 CR
Elective Nanophysics (Election: at least 6 credits)		
M-PHYS-102089	Electronic Properties of Solids I, with Exercises	10 CR
M-PHYS-102090	Electronic Properties of Solids I, without Exercises	8 CR
M-PHYS-102108	Electronic Properties of Solids II, with Exercises	8 CR
M-PHYS-102109	Electronic Properties of Solids II, without Exercises	4 CR
M-PHYS-102131	Physics of Semiconductors, with Exercises	10 CR
M-PHYS-102301	Physics of Semiconductors, without Exercises	8 CR
M-PHYS-106482	Surface Science, with Exercises	10 CR
M-PHYS-106483	Surface Science, without Exercises	8 CR
M-PHYS-102989	Electron Microscopy I, with Exercises	8 CR
M-PHYS-102990	Electron Microscopy I, without Exercises	4 CR
M-PHYS-102146	Nano-Optics	8 CR
M-PHYS-102167	Experimental Biophysics II, without Seminar	12 CR
M-PHYS-102165	Experimental Biophysics II, with Seminar	14 CR
M-PHYS-102227	Electron Microscopy II, with Exercises	8 CR
M-PHYS-102844	Electron Microscopy II, without Exercises	4 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-102191	Superconducting Nanostructures	6 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102293	Spin Transport in Nanostructures	6 CR
M-PHYS-102169	Theoretical Molecular Biophysics, with Seminar	8 CR
M-PHYS-102171	Theoretical Molecular Biophysics, without Seminar	6 CR
M-PHYS-102277	Theoretical Optics	6 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-106508	Quantum Optics at the Nano Scale, with Exercises	8 CR
M-PHYS-106510	Quantum Optics at the Nano Scale, without Exercises	6 CR
M-PHYS-104857	Solid State Quantum Technologies	8 CR
M-PHYS-101933	Computational Photonics, with ext. Exercises	8 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises	6 CR
M-PHYS-104862	Computational Condensed Matter Physics	12 CR
M-PHYS-106833	Software Engineering in Condensed Matter Physics	6 CR
M-PHYS-106798	Fundamentals of Cryophysics, without Exercises	4 CR
M-PHYS-106799	Fundamentals of Cryophysics, with Exercises	6 CR
M-MACH-106539	Microscale Fluid Mechanics	4 CR
M-PHYS-102204	Advanced Seminar in the Area Nanophysics	4 CR

3.12 Second Major in Physics: Optics and Photonics

Credits
14

Elective Optics and Photonics (Election: at least 14 credits)		
M-PHYS-102408	Solid-State Optics	8 CR
M-PHYS-102146	Nano-Optics	8 CR
M-PHYS-102277	Theoretical Optics	6 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102337	Molecular Spectroscopy	6 CR
M-ETIT-100430	Nonlinear Optics	6 CR
M-ETIT-100513	Photovoltaics	6 CR
M-PHYS-105555	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR
M-PHYS-105556	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR
M-PHYS-105558	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab	8 CR
M-PHYS-105559	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab	4 CR
M-PHYS-102165	Experimental Biophysics II, with Seminar	14 CR
M-PHYS-102167	Experimental Biophysics II, without Seminar	12 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-101933	Computational Photonics, with ext. Exercises	8 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises	6 CR
M-PHYS-106508	Quantum Optics at the Nano Scale, with Exercises	8 CR
M-PHYS-106510	Quantum Optics at the Nano Scale, without Exercises	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102205	Advanced Seminar in the Area Optics and Photonics	4 CR

3.13 Second Major in Physics: Experimental Particle Physics

Credits
14

Mandatory		
M-PHYS-102114	Particle Physics I	8 CR
Elective Experimental Particle Physics (Election: at least 6 credits)		
M-PHYS-102127	Modern Methods of Data Analysis, with ext. Exercises	8 CR
M-PHYS-102125	Modern Methods of Data Analysis, without ext. Exercises	6 CR
M-PHYS-102184	Electronics for Physicists	10 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-102517	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises	8 CR
M-PHYS-102518	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises	6 CR
M-PHYS-102121	Detectors for Particle and Astroparticle Physics, with ext. Exercises	8 CR
M-PHYS-102119	Detectors for Particle and Astroparticle Physics, without ext. Exercises	6 CR
M-PHYS-102422	Particle Physics II - Flavour Physics, with ext. Exercises	8 CR
M-PHYS-102154	Particle Physics II - Flavour Physics, without ext. Exercises	6 CR
M-PHYS-104081	Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises	6 CR
M-PHYS-104084	Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises	8 CR
M-PHYS-104086	Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises	6 CR
M-PHYS-104088	Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises	8 CR
M-PHYS-105937	Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises	6 CR
M-PHYS-105939	Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-106193	Quantum Detectors and Sensors	8 CR
M-PHYS-107114	Plasma Physics I *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102206	Advanced Seminar in the Area Experimental Particle Physics	4 CR

3.14 Second Major in Physics: Experimental Astroparticle Physics

Credits
14

Required Experimental Astroparticle Physics (Election: at least 1 item)		
M-PHYS-102075	Astroparticle Physics I	8 CR
M-PHYS-102175	Introduction to Cosmology	6 CR
Elective Experimental Astroparticle Physics (Election:)		
M-PHYS-102525	Astroparticle Physics II - Cosmic Rays, with ext. Exercises	8 CR
M-PHYS-102078	Astroparticle Physics II - Cosmic Rays, without ext. Exercises	6 CR
M-PHYS-105683	Astroparticle Physics II - Gamma Rays and Neutrinos	6 CR
M-PHYS-105686	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises	8 CR
M-PHYS-102527	Astroparticle Physics II - Particles and Stars, with ext. Exercises	8 CR
M-PHYS-102081	Astroparticle Physics II - Particles and Stars, without ext. Exercises	6 CR
M-PHYS-102127	Modern Methods of Data Analysis, with ext. Exercises	8 CR
M-PHYS-102125	Modern Methods of Data Analysis, without ext. Exercises	6 CR
M-PHYS-102184	Electronics for Physicists	10 CR
M-PHYS-104869	Accelerator Physics, with ext. Exercises	8 CR
M-PHYS-104871	Accelerator Physics, without ext. Exercises	6 CR
M-PHYS-102517	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises	8 CR
M-PHYS-102518	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises	6 CR
M-PHYS-102121	Detectors for Particle and Astroparticle Physics, with ext. Exercises	8 CR
M-PHYS-102119	Detectors for Particle and Astroparticle Physics, without ext. Exercises	6 CR
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106193	Quantum Detectors and Sensors	8 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-102207	Advanced Seminar in the Area Experimental Astroparticle Physics	4 CR

3.15 Second Major in Physics: Theoretical Particle Physics

Credits
14

Elective Theoretical Particle Physics (Election: at least 14 credits)		
M-PHYS-102033	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR
M-PHYS-102035	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR
M-PHYS-102034	Theoretical Particle Physics I, Fundamentals, with Exercises	8 CR
M-PHYS-102036	Theoretical Particle Physics I, Fundamentals, without Exercises	6 CR
M-PHYS-102046	Theoretical Particle Physics II, with Exercises	12 CR
M-PHYS-102048	Theoretical Particle Physics II, without Exercises	8 CR
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-105535	Mathematical Methods of Theoretical Physics	12 CR
M-PHYS-102986	Introduction to Flavor Physics, Fundamentals and Advanced Topics	12 CR
M-PHYS-102987	Introduction to Flavor Physics, Fundamentals	10 CR
M-PHYS-106055	Particle Physics with Extra Dimensions	4 CR
M-PHYS-105833	New Light Particles Beyond the Standard Model, without Exercises	4 CR
M-PHYS-106727	Physics beyond the Standard Model, with Exercises	6 CR
M-PHYS-106728	Physics beyond the Standard Model, without Exercises	4 CR
M-PHYS-106848	Supersymmetry and Exotics at Colliders, with Exercises	12 CR
M-PHYS-106850	Supersymmetry and Exotics at Colliders, without Exercises	8 CR
M-PHYS-102315	Symmetries, Groups and Extended Gauge Theories	12 CR
M-PHYS-102317	Symmetries and Groups	8 CR
M-PHYS-106732	Groups, Algebras and Representations	6 CR
M-PHYS-106842	Advanced Topics in Quantum Field Theory	4 CR
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-105640	Precision Phenomenology at Colliders and Computational Methods, with Exercises	8 CR
M-PHYS-105641	Precision Phenomenology at Colliders and Computational Methods, without Exercises	4 CR
M-PHYS-107091	Effective Field Theories *First usage possible from Apr 01, 2025.*	4 CR
M-PHYS-107092	Computational Physics *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102208	Advanced Seminar in the Area Theoretical Particle Physics	4 CR

3.16 Second Major in Physics: Theoretical Cosmology and Astroparticle Physics

Credits
14

Required: Theoretical Cosmology and Astroparticle Physics (Election: 1 item)		
M-PHYS-104855	Introduction to Theoretical Cosmology	8 CR
M-PHYS-106845	Theoretical Cosmology, with Exercises	12 CR
M-PHYS-106847	Theoretical Cosmology, without Exercises	8 CR
Elective: Theoretical Cosmology an Astroparticle Physics (Election: at least 2 credits)		
M-PHYS-106532	Introduction to General Relativity	8 CR
M-PHYS-106843	Introduction to General Relativity, without Exercises	6 CR
M-PHYS-102034	Theoretical Particle Physics I, Fundamentals, with Exercises	8 CR
M-PHYS-102036	Theoretical Particle Physics I, Fundamentals, without Exercises	6 CR
M-PHYS-102033	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR
M-PHYS-102035	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR
M-PHYS-106117	Computational Methods for Particle Physics and Cosmology	6 CR
M-PHYS-105535	Mathematical Methods of Theoretical Physics	12 CR
M-PHYS-105833	New Light Particles Beyond the Standard Model, without Exercises	4 CR
M-PHYS-106727	Physics beyond the Standard Model, with Exercises	6 CR
M-PHYS-106728	Physics beyond the Standard Model, without Exercises	4 CR
M-PHYS-102525	Astroparticle Physics II - Cosmic Rays, with ext. Exercises	8 CR
M-PHYS-102078	Astroparticle Physics II - Cosmic Rays, without ext. Exercises	6 CR
M-PHYS-105686	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises	8 CR
M-PHYS-105683	Astroparticle Physics II - Gamma Rays and Neutrinos	6 CR
M-PHYS-102527	Astroparticle Physics II - Particles and Stars, with ext. Exercises	8 CR
M-PHYS-102081	Astroparticle Physics II - Particles and Stars, without ext. Exercises	6 CR
M-PHYS-102208	Advanced Seminar in the Area Theoretical Particle Physics	4 CR

3.17 Second Major in Physics: Condensed Matter Theory

Credits 14

Elective Condensed Matter Theory (Election: at least 14 credits)		
M-PHYS-102053	Condensed Matter Theory I, Fundamentals and Advanced Topics	12 CR
M-PHYS-102054	Condensed Matter Theory I, Fundamentals	8 CR
M-PHYS-102308	Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics	12 CR
M-PHYS-102313	Condensed Matter Theory II: Many-Body Theory, Fundamentals	8 CR
M-PHYS-103331	Condensed Matter Theory II: Many-Body Theory, selected topics	2 CR
M-PHYS-105942	Theory and Applications of Quantum Machines	8 CR
M-PHYS-104862	Computational Condensed Matter Physics	12 CR
M-PHYS-102171	Theoretical Molecular Biophysics, without Seminar	6 CR
M-PHYS-102169	Theoretical Molecular Biophysics, with Seminar	8 CR
M-PHYS-102295	Theoretical Nanooptics	6 CR
M-PHYS-102984	The ABC of DFT	6 CR
M-PHYS-105094	Theoretical Quantum Optics	6 CR
M-PHYS-105655	Superconductivity, Josephson Effect and Applications, with Exercises	8 CR
M-PHYS-106584	Superconductivity, Josephson Effect and Applications, without Exercises	6 CR
M-PHYS-106796	Superconductivity, Microscopic Theory and Macroscopic Phenomena	8 CR
M-PHYS-106833	Software Engineering in Condensed Matter Physics	6 CR
M-PHYS-105381	Theory of Magnetism, with Exercises	8 CR
M-PHYS-106586	Topology in Condensed Matter Physics: Fundamentals and Advanced Topics	8 CR
M-PHYS-106588	Topology in Condensed Matter Physics: Fundamentals and Selected Topics	2 CR
M-PHYS-106724	Macroscopic Quantum Coherence and Dissipation, with Exercises	8 CR
M-PHYS-106725	Macroscopic Quantum Coherence and Dissipation, without Exercises	6 CR
M-PHYS-107194	Quantum Fluctuations and Dissipation far from Equilibrium *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102209	Advanced Seminar in the Area Condensed Matter Theory	4 CR

3.18 Second Major in Physics: Geophysics

Credits 14

Elective Geophysics (Election: at least 14 credits)		
M-PHYS-105225	Seismology	8 CR
M-PHYS-102358	Physics of Seismic Instruments	6 CR
M-PHYS-102367	Theory of Seismic Waves	6 CR
M-PHYS-102368	Inversion and Tomography	8 CR
M-PHYS-101833	Geological Hazards and Risk	8 CR
M-PHYS-104186	Seismic Data Processing with Final Report (Graded)	6 CR
M-PHYS-105227	Seismic Modeling	4 CR
M-PHYS-106196	Array Techniques in Seismology (Graded)	4 CR
M-PHYS-106322	In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	6 CR
M-PHYS-106326	Seismics	8 CR

3.19 Second Major in Physics: Meteorology

Credits 14

Elective Meteorology (Election: 1 item)		
M-PHYS-104577	Selected Topics in Meteorology (Second Major, graded)	14 CR

3.20 Minor in Physics: Condensed Matter

Credits
8

Elective Condensed Matter (Election: at least 8 credits)		
M-PHYS-102087	Electronic Properties of Solids I, with Exercises (Minor)	10 CR
M-PHYS-102106	Electronic Properties of Solids II, with Exercises (Minor)	8 CR
M-PHYS-102130	Physics of Semiconductors, with Exercises (Minor)	10 CR
M-PHYS-102991	Electron Microscopy I, with Exercises (Minor)	8 CR
M-PHYS-106484	Surface Science, with Exercises (Minor)	10 CR
M-PHYS-102409	Solid-State Optics (Minor)	8 CR
M-PHYS-104858	Solid State Quantum Technologies (Minor)	8 CR
M-PHYS-104723	Superconducting Nanostructures (Minor)	6 CR
M-PHYS-105375	Spin Transport in Nanostructures (Minor)	6 CR
M-PHYS-103172	Electron Microscopy II, with Exercises (Minor)	8 CR
M-PHYS-104870	Accelerator Physics, with ext. exercises (Minor)	8 CR
M-PHYS-104872	Accelerator Physics, without ext. exercises (Minor)	6 CR
M-PHYS-105557	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor)	8 CR
M-PHYS-106324	Introduction to Neutron Scattering (Minor)	6 CR
M-PHYS-106801	Fundamentals of Cryophysics, with Exercises (Minor)	6 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102203	Advanced Seminar in the Area Condensed Matter	4 CR

3.21 Minor in Physics: Nanophysics

Credits
8

Elective Nanophysics (Election: at least 8 credits)		
M-PHYS-102096	Basics of Nanotechnology I (Minor)	4 CR
M-PHYS-102099	Basics of Nanotechnology II (Minor)	4 CR
M-PHYS-102087	Electronic Properties of Solids I, with Exercises (Minor)	10 CR
M-PHYS-102106	Electronic Properties of Solids II, with Exercises (Minor)	8 CR
M-PHYS-102130	Physics of Semiconductors, with Exercises (Minor)	10 CR
M-PHYS-106484	Surface Science, with Exercises (Minor)	10 CR
M-PHYS-102991	Electron Microscopy I, with Exercises (Minor)	8 CR
M-PHYS-102147	Nano-Optics (Minor)	8 CR
M-PHYS-102166	Experimental Biophysics II, with Seminar (Minor)	14 CR
M-PHYS-102168	Experimental Biophysics II, without Seminar (Minor)	12 CR
M-PHYS-103172	Electron Microscopy II, with Exercises (Minor)	8 CR
M-PHYS-105557	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor)	8 CR
M-PHYS-104723	Superconducting Nanostructures (Minor)	6 CR
M-PHYS-103177	Theoretical Nanooptics (Minor)	6 CR
M-PHYS-105375	Spin Transport in Nanostructures (Minor)	6 CR
M-PHYS-102172	Theoretical Molecular Biophysics, without Seminar (Minor)	6 CR
M-PHYS-102170	Theoretical Molecular Biophysics, with Seminar (Minor)	8 CR
M-PHYS-102279	Theoretical Optics (Minor)	6 CR
M-PHYS-105395	Theoretical Quantum Optics (Minor)	6 CR
M-PHYS-106509	Quantum Optics at the Nano Scale, with Exercises (Minor)	8 CR
M-PHYS-104858	Solid State Quantum Technologies (Minor)	8 CR
M-PHYS-103090	Computational Photonics, with ext. Exercises (Minor)	8 CR
M-PHYS-104863	Computational Condensed Matter Physics (Minor)	12 CR
M-PHYS-106834	Software Engineering in Condensed Matter Physics (Minor)	6 CR
M-PHYS-106801	Fundamentals of Cryophysics, with Exercises (Minor)	6 CR
M-PHYS-102204	Advanced Seminar in the Area Nanophysics	4 CR

3.22 Minor in Physics: Optics and Photonics

Credits
8

Elective Optics and Photonics (Election: at least 8 credits)		
M-PHYS-102409	Solid-State Optics (Minor)	8 CR
M-PHYS-102147	Nano-Optics (Minor)	8 CR
M-PHYS-102279	Theoretical Optics (Minor)	6 CR
M-PHYS-103177	Theoretical Nanooptics (Minor)	6 CR
M-PHYS-105557	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor)	8 CR
M-PHYS-105560	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor)	8 CR
M-PHYS-102166	Experimental Biophysics II, with Seminar (Minor)	14 CR
M-PHYS-102168	Experimental Biophysics II, without Seminar (Minor)	12 CR
M-PHYS-105395	Theoretical Quantum Optics (Minor)	6 CR
M-PHYS-103090	Computational Photonics, with ext. Exercises (Minor)	8 CR
M-PHYS-103193	Computational Photonics, without ext. Exercises (Minor)	6 CR
M-PHYS-106509	Quantum Optics at the Nano Scale, with Exercises (Minor)	8 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-102205	Advanced Seminar in the Area Optics and Photonics	4 CR

3.23 Minor in Physics: Experimental Particle Physics

Credits
8

Elective Experimental Particle Physics (Election: at least 8 credits)		
M-PHYS-102115	Particle Physics I (Minor)	8 CR
M-PHYS-102128	Modern Methods of Data Analysis, with ext. Exercises (Minor)	8 CR
M-PHYS-102126	Modern Methods of Data Analysis, without ext. Exercises (Minor)	6 CR
M-PHYS-102185	Electronics for Physicists (Minor)	10 CR
M-PHYS-104870	Accelerator Physics, with ext. exercises (Minor)	8 CR
M-PHYS-104872	Accelerator Physics, without ext. exercises (Minor)	6 CR
M-PHYS-102519	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor)	8 CR
M-PHYS-103194	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor)	6 CR
M-PHYS-102122	Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor)	8 CR
M-PHYS-102120	Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor)	6 CR
M-PHYS-103183	Particle Physics II - Flavour Physics, with ext. Exercises (Minor)	8 CR
M-PHYS-102155	Particle Physics II - Flavour Physics, without ext. Exercises (Minor)	6 CR
M-PHYS-104082	Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor)	6 CR
M-PHYS-104085	Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor)	8 CR
M-PHYS-104087	Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor)	6 CR
M-PHYS-104089	Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor)	8 CR
M-PHYS-105938	Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor)	6 CR
M-PHYS-105940	Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor)	8 CR
M-PHYS-106399	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-106194	Quantum Detectors and Sensors (Minor)	8 CR
M-PHYS-107115	Plasma Physics I (Minor) *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102206	Advanced Seminar in the Area Experimental Particle Physics	4 CR

3.24 Minor in Physics: Experimental Astroparticle Physics

Credits
8

Elective Experimental Astroparticle Physics (Election: at least 8 credits)		
M-PHYS-102076	Astroparticle Physics I (Minor)	8 CR
M-PHYS-102176	Introduction to Cosmology (Minor)	6 CR
M-PHYS-102128	Modern Methods of Data Analysis, with ext. Exercises (Minor)	8 CR
M-PHYS-102126	Modern Methods of Data Analysis, without ext. Exercises (Minor)	6 CR
M-PHYS-102185	Electronics for Physicists (Minor)	10 CR
M-PHYS-104870	Accelerator Physics, with ext. exercises (Minor)	8 CR
M-PHYS-104872	Accelerator Physics, without ext. exercises (Minor)	6 CR
M-PHYS-102519	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor)	8 CR
M-PHYS-103194	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor)	6 CR
M-PHYS-102122	Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor)	8 CR
M-PHYS-102120	Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor)	6 CR
M-PHYS-103184	Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor)	8 CR
M-PHYS-102082	Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor)	6 CR
M-PHYS-105684	Astroparticle Physics II - Gamma Rays and Neutrinos (Minor)	6 CR
M-PHYS-105685	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor)	8 CR
M-PHYS-103186	Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor)	8 CR
M-PHYS-102086	Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor)	6 CR
M-PHYS-106533	Introduction to General Relativity (Minor)	8 CR
M-PHYS-106118	Computational Methods for Particle Physics and Cosmology (Minor)	6 CR
M-PHYS-104856	Introduction to Theoretical Cosmology (Minor)	8 CR
M-PHYS-106047	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR
M-PHYS-106530	Block Practical Course: ETP Data Science	2 CR
M-PHYS-106194	Quantum Detectors and Sensors (Minor)	8 CR
M-PHYS-102207	Advanced Seminar in the Area Experimental Astroparticle Physics	4 CR

3.25 Minor in Physics: Theoretical Particle Physics

Credits
8

Elective Theoretical Particle Physics (Election: at least 8 credits)		
M-PHYS-102037	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor)	12 CR
M-PHYS-102038	Theoretical Particle Physics I, Fundamentals, with Exercises (Minor)	8 CR
M-PHYS-102044	Theoretical Particle Physics II, with Exercises (Minor)	12 CR
M-PHYS-104856	Introduction to Theoretical Cosmology (Minor)	8 CR
M-PHYS-106118	Computational Methods for Particle Physics and Cosmology (Minor)	6 CR
M-PHYS-105536	Mathematical Methods of Theoretical Physics (Minor)	12 CR
M-PHYS-103188	Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor)	12 CR
M-PHYS-103189	Introduction to Flavor Physics, Fundamentals (Minor)	10 CR
M-PHYS-106849	Supersymmetry and Exotics at Colliders, with Exercises (Minor)	12 CR
M-PHYS-102316	Symmetries, Groups and Extended Gauge Theories (Minor)	12 CR
M-PHYS-102318	Symmetries and Groups (Minor)	8 CR
M-PHYS-106743	Groups, Algebras and Representations (Minor)	6 CR
M-PHYS-106533	Introduction to General Relativity (Minor)	8 CR
M-PHYS-105639	Non-supersymmetric Extensions of the Standard Model (Minor)	4 CR
M-PHYS-105642	Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor)	8 CR
M-PHYS-107093	Computational Physics (Minor) *First usage possible from Apr 01, 2025.*	8 CR
M-PHYS-102208	Advanced Seminar in the Area Theoretical Particle Physics	4 CR

3.26 Minor in Physics: Theoretical Cosmology and Astroparticle Physics

Credits
8

Elective: Theoretical Cosmology and Astroparticle Physics (Election: at least 8 credits)		
M-PHYS-104856	Introduction to Theoretical Cosmology (Minor)	8 CR
M-PHYS-106846	Theoretical Cosmology, with Exercises (Minor)	12 CR
M-PHYS-106533	Introduction to General Relativity (Minor)	8 CR
M-PHYS-106829	Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics	4 CR

3.27 Minor in Physics: Condensed Matter Theory

Credits
8

Elective Condensed Matter Theory (Election: at least 1 item as well as at least 8 credits)		
M-PHYS-102051	Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor)	12 CR
M-PHYS-102052	Condensed Matter Theory I, Fundamentals (Minor)	8 CR
M-PHYS-102312	Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor)	12 CR
M-PHYS-102314	Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor)	8 CR
M-PHYS-105943	Theory and Applications of Quantum Machines (Minor)	8 CR
M-PHYS-104863	Computational Condensed Matter Physics (Minor)	12 CR
M-PHYS-102172	Theoretical Molecular Biophysics, without Seminar (Minor)	6 CR
M-PHYS-102170	Theoretical Molecular Biophysics, with Seminar (Minor)	8 CR
M-PHYS-103177	Theoretical Nanooptics (Minor)	6 CR
M-PHYS-105395	Theoretical Quantum Optics (Minor)	6 CR
M-PHYS-105656	Superconductivity, Josephson Effect and Applications, with Exercises (Minor)	8 CR
M-PHYS-106797	Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor)	8 CR
M-PHYS-106834	Software Engineering in Condensed Matter Physics (Minor)	6 CR
M-PHYS-105385	Theory of Magnetism, with Exercises (Minor)	8 CR
M-PHYS-106587	Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor)	8 CR
M-PHYS-106726	Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor)	8 CR
M-PHYS-102209	Advanced Seminar in the Area Condensed Matter Theory	4 CR

3.28 Minor in Physics: Geophysics

Credits
8

Elective Geophysics (Election: at least 8 credits)		
M-PHYS-105226	Seismology (Minor)	8 CR
M-PHYS-106325	Seismics (Minor)	8 CR
M-PHYS-102653	Physics of Seismic Instruments (Minor)	6 CR
M-PHYS-102658	Inversion and Tomography (Minor)	8 CR
M-PHYS-102657	Theory of Seismic Waves (Minor)	6 CR
M-PHYS-105228	Seismic Modeling (Minor)	4 CR
M-PHYS-104522	Full-Waveform Inversion (Ungraded)	6 CR

3.29 Minor in Physics: Meteorology

Credits
8

Elective Meteorology (Election: at least 8 credits)		
M-PHYS-104578	Selected Topics in Meteorology (Minor, ungraded)	8 CR

3.30 Non-Physics Elective

Credits
8

Elective Non-Physics Elective (Election: at least 8 credits)		
M-PHYS-102184	Electronics for Physicists	10 CR
M-PHYS-102091	Wildcard Non-Physics Elective, Module with 1 Brick	8 CR
M-PHYS-103129	Wildcard Non-Physics Elective, Module with 2 Bricks	8 CR
M-PHYS-103130	Wildcard Non-Physics Elective, Module with 3 Bricks	8 CR
M-PHYS-103131	Wildcard Non-Physics Elective, Module with 4 Bricks	8 CR

3.31 Advanced Physics Laboratory Course

Credits
6

Mandatory		
M-PHYS-101395	Advanced Physics Laboratory Course	6 CR

3.32 Specialization Phase

Credits
15

Mandatory		
M-PHYS-101396	Specialization Phase	15 CR

3.33 Introduction to Scientific Methods

Credits
15

Mandatory		
M-PHYS-101397	Introduction to Scientific Methods	15 CR

3.34 Interdisciplinary Qualifications

Credits
4

Mandatory		
M-PHYS-101394	Interdisciplinary Qualifications	4 CR

3.35 Additional Examinations

Additional Examinations (Election: at most 30 credits)		
M-FORUM-106753	Supplementary Studies on Science, Technology and Society	16 CR

4 Modules

M 4.1 Module: Accelerator Physics, with ext. Exercises [M-PHYS-104869]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-109904	Accelerator Physics, with ext. Exercises	8 CR	Bernhard, Müller

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104870 - Accelerator Physics, with ext. exercises (Minor) must not have been started.
2. The module M-PHYS-104871 - Accelerator Physics, without ext. Exercises must not have been started.
3. The module M-PHYS-104872 - Accelerator Physics, without ext. exercises (Minor) must not have been started.

Competence Goal
After attending the course, you will be able to present the basics of accelerator physics and calculate simple beam transport systems. You will be able to describe the basic accelerator types, compare their modes of operation and assess their suitability for use in physics experiments. You will be able to present the essential properties of synchrotron radiation, describe the physical principles as well as the most important technical concepts for its generation and calculate essential characteristics of a synchrotron radiation source. On this basis, you will be able to conceptually design radiation sources to given experimental requirements. You will be able to describe accelerator-relevant technologies and to identify, classify and justify the various methods for measuring and controlling beam parameters. Your acquired knowledge of the interaction of ensembles of particles with each other and with the radiation they produce will enable you to provide a sound description of the operation of the free-electron laser and to establish overall criteria for the optimization of accelerators for a given application. In the extended exercises you will deepen the learned material by means of selected practical examples and applications.

Content

- Basic types of accelerators (including electrostatic accelerators, linacs, circular accelerators, storage rings & colliders).
- Physics of synchrotron radiation, wigglers and undulators (electrodynamics of moving point charges, properties of normal synchrotron radiation and undulator radiation)
- Beam optics and beam dynamics (e.g., magnetic lenses, beam properties, transverse & longitudinal oscillation and damping, many-particle systems)
- Magnetic technology for accelerators and synchrotron radiation sources
- Measurement and control of beam parameters
- Free-electron laser
- Performance limits of accelerators (e.g., ultra-short electron pulses, high-intensity proton beams, beam-beam interactions in colliders)
- New technologies, current & future projects

Workload
240 hours consisting of attendance time (60 hours), preparation and wrap-up of the lecture, the integrated exercises and exam preparation (120 hours), preparation and execution of the practical exercises, evaluations and preparation of measurement protocols (60 hours).

Literature

- E.J.N. Wilson: An Introduction to Particle Accelerators, Oxford University Press,2001
- H. Wiedemann: Particle Acclerator Physics 1&2, Springer, 1993
- K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner Studienbücher, 2.Aufl., 1996
- A. Hofmann: The Physics of Synchrotron Radiation, Cambridge Univ. Press, 2004
- P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free Electron Lasers, Springer, 2010

4.2 Module: Accelerator Physics, with ext. exercises (Minor) [M-PHYS-104870]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-109903	Accelerator Physics, with ext. exercises (Minor)	8 CR	Bernhard, Müller

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104869 - Accelerator Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-104871 - Accelerator Physics, without ext. Exercises must not have been started.
3. The module M-PHYS-104872 - Accelerator Physics, without ext. exercises (Minor) must not have been started.

Competence Goal
After attending the course, you will be able to present the basics of accelerator physics and calculate simple beam transport systems. You will be able to describe the basic accelerator types, compare their modes of operation and assess their suitability for use in physics experiments. You will be able to present the essential properties of synchrotron radiation, describe the physical principles as well as the most important technical concepts for its generation and calculate essential characteristics of a synchrotron radiation source. On this basis, you will be able to conceptually design radiation sources to given experimental requirements. You will be able to describe accelerator-relevant technologies and to identify, classify and justify the various methods for measuring and controlling beam parameters. Your acquired knowledge of the interaction of ensembles of particles with each other and with the radiation they produce will enable you to provide a sound description of the operation of the free-electron laser and to establish overall criteria for the optimization of accelerators for a given application. In the extended exercises you will deepen the learned material by means of selected practical examples and applications.

Content

- Basic types of accelerators (including electrostatic accelerators, linacs, circular accelerators, storage rings & colliders).
- Physics of synchrotron radiation, wigglers and undulators (electrodynamics of moving point charges, properties of normal synchrotron radiation and undulator radiation)
- Beam optics and beam dynamics (e.g., magnetic lenses, beam properties, transverse & longitudinal oscillation and damping, many-particle systems)
- Magnetic technology for accelerators and synchrotron radiation sources
- Measurement and control of beam parameters
- Free-electron laser
- Performance limits of accelerators (e.g., ultra-short electron pulses, high-intensity proton beams, beam-beam interactions in colliders)
- New technologies, current & future projects

Workload
240 hours consisting of attendance time (60 hours), preparation and wrap-up of the lecture, the integrated exercises (120 hours), preparation and execution of the practical exercises, evaluations and preparation of measurement protocols (60 hours).

Literature

- E.J.N. Wilson: An Introduction to Particle Accelerators, Oxford University Press,2001
- H. Wiedemann: Particle Acclerator Physics 1&2, Springer, 1993
- K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner Studienbücher, 2.Aufl., 1996
- A. Hofmann: The Physics of Synchrotron Radiation, Cambridge Univ. Press, 2004
- P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free Electron Lasers, Springer, 2010

4.3 Module: Accelerator Physics, without ext. Exercises [M-PHYS-104871]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-109905	Accelerator Physics, without ext. Exercises	6 CR	Bernhard, Müller

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104869 - Accelerator Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-104870 - Accelerator Physics, with ext. exercises (Minor) must not have been started.
3. The module M-PHYS-104872 - Accelerator Physics, without ext. exercises (Minor) must not have been started.

Competence Goal
After attending the course, you will be able to present the basics of accelerator physics and calculate simple beam transport systems. You will be able to describe the basic accelerator types, compare their modes of operation and assess their suitability for use in physics experiments. You will be able to present the essential properties of synchrotron radiation, describe the physical principles as well as the most important technical concepts for its generation and calculate essential characteristics of a synchrotron radiation source. On this basis, you will be able to conceptually design radiation sources to given experimental requirements. You will be able to describe accelerator-relevant technologies and to identify, classify and justify the various methods for measuring and controlling beam parameters. Your acquired knowledge of the interaction of particle ensembles with each other and with the radiation they produce will enable you to describe the operation of the free-electron laser in a well-founded manner and to establish overall criteria for the optimization of accelerators for a given application.

Content

- Basic types of accelerators (including electrostatic accelerators, linacs, circular accelerators, storage rings & colliders).
- Physics of synchrotron radiation, wigglers and undulators (electrodynamics of moving point charges, properties of normal synchrotron radiation and undulator radiation)
- Beam optics and beam dynamics (e.g., magnetic lenses, beam properties, transverse & longitudinal oscillation and damping, many-particle systems)
- Magnetic technology for accelerators and synchrotron radiation sources
- Measurement and control of beam parameters
- Free-electron laser
- Performance limits of accelerators (e.g., ultra-short electron pulses, high-intensity proton beams, beam-beam interactions in colliders)
- New technologies, current & future projects

Workload
180 hours consisting of attendance time (60 hours), preparation and wrap-up of the lecture, the integrated exercises and exam preparation (120 hours).

Literature

- E.J.N. Wilson: An Introduction to Particle Accelerators, Oxford University Press,2001
- H. Wiedemann: Particle Acclerator Physics 1&2, Springer, 1993
- K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner Studienbücher, 2.Aufl., 1996
- A. Hofmann: The Physics of Synchrotron Radiation, Cambridge Univ. Press, 2004
- P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free Electron Lasers, Springer, 2010

M 4.4 Module: Accelerator Physics, without ext. exercises (Minor) [M-PHYS-104872]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-109906	Accelerator Physics, without ext. exercises (Minor)	6 CR	Bernhard, Müller

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104869 - Accelerator Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-104870 - Accelerator Physics, with ext. exercises (Minor) must not have been started.
3. The module M-PHYS-104871 - Accelerator Physics, without ext. Exercises must not have been started.

Competence Goal
After attending the course, you will be able to present the basics of accelerator physics and calculate simple beam transport systems. You will be able to describe the basic accelerator types, compare their modes of operation and assess their suitability for use in physics experiments. You will be able to present the essential properties of synchrotron radiation, describe the physical principles as well as the most important technical concepts for its generation and calculate essential characteristics of a synchrotron radiation source. On this basis, you will be able to conceptually design radiation sources to given experimental requirements. You will be able to describe accelerator-relevant technologies and to identify, classify and justify the various methods for measuring and controlling beam parameters. Your acquired knowledge of the interaction of particle ensembles with each other and with the radiation they produce will enable you to describe the operation of the free-electron laser in a well-founded manner and to establish overall criteria for the optimization of accelerators for a given application.

Content

- Basic types of accelerators (including electrostatic accelerators, linacs, circular accelerators, storage rings & colliders).
- Physics of synchrotron radiation, wigglers and undulators (electrodynamics of moving point charges, properties of normal synchrotron radiation and undulator radiation)
- Beam optics and beam dynamics (e.g., magnetic lenses, beam properties, transverse & longitudinal oscillation and damping, many-particle systems)
- Magnetic technology for accelerators and synchrotron radiation sources
- Measurement and control of beam parameters
- Free-electron lasers
- Performance limits of accelerators (e.g., ultra-short electron pulses, high-intensity proton beams, beam-beam interactions in colliders)
- New technologies, current & future projects

Workload
180 hours consisting of attendance time (60 hours), preparation and wrap-up of the lecture and the integrated exercises (120 hours).

Literature

- E.J.N. Wilson: An Introduction to Particle Accelerators, Oxford University Press,2001
- H. Wiedemann: Particle Acclerator Physics 1&2, Springer, 1993
- K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner Studienbücher, 2.Aufl., 1996
- A. Hofmann: The Physics of Synchrotron Radiation, Cambridge Univ. Press, 2004
- P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free Electron Lasers, Springer, 2010

M 4.5 Module: Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training [M-PHYS-106399]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Prof. Dr. Anke-Susanne Müller
Dr. Anton Plech
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Optics and Photonics
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Minor in Physics: Condensed Matter
Minor in Physics: Optics and Photonics
Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-112943	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	4 CR	Baumbach, Müller, Plech, Stankov

Competence Certificate
The regular attendance of the entire block course is required. The successful completion will be evaluated by a written final report on the basic principles and performance of a selected experiment. The results of the student group are to be presented in a final seminar with a communicated time interval (oral presentations or posters).

Prerequisites
none

Competence Goal
In the lectures, the basic accelerator types, their principles of operation and applications will be described. In particular, synchrotron radiation sources will be presented and in comparison to particle colliders for experimental high-energy particle physics will be discussed. The properties of the synchrotron radiation with the physical fundamentals, technical concepts of its generation and essential characteristics will be presented. Accelerator-relevant technologies and various methods for measuring and control of beam parameters will be discussed.

The basic concepts of synchrotron radiation and X-ray physics and their applications for the characterization of structure and dynamics of crystalline solids and nanostructures will be introduced. X-ray scattering/diffraction, -spectroscopy, and 2D and 3D X-ray imaging in real and reciprocal space, frequency and momentum spaces on laboratory sources and large-scale equipment will be presented.

Theoretical course content, tutorials and practical training are designed to enable students to understand high-tech accelerator instrumentation, to prepare and perform X-ray experiments on modern laboratory and large-scale equipment and apply the knowledge acquired in the lecture in a specific experiment.

Content
Introduction to accelerator physics with a focus on synchrotron radiation sources.

- Basic types of accelerators and their application
- Synchrotron radiation sources in comparison to colliders
- Physics of synchrotron radiation and its generation with wigglers and undulators
- Basics of beam optics and beam dynamics
- Measurement and control of beam parameters
- Free-electron lasers

Introduction to various application fields of the modern X-ray physics

- Theoretical and experimental fundamentals of X-ray physics, optics and analysis with emphasis on X-ray scattering, diffraction, spectroscopy, computed tomography, and X-ray microscopy
- Modern instrumentation in the X-ray laboratory and at large-scale facilities
- Examples of research from crystallography, nanoscience and life science on state-of-the-art X-ray equipment at the KIT Light Source.

Annotation
This module cannot be combined with an advanced seminar in the major in physics or second major in physics.

Workload
120 hours consisting of an attendance time (60 hours), a follow-up work (30 hours) and a preparation of seminar/poster incl. a rehearsal seminar (30 hours) during a two-weeks block course with lectures, tutorials and a practical training

Recommendation
Basics of classical electrodynamics, optics, quantum mechanics and basic knowledge of solid state physics.

Learning type
Two-weeks block course with lectures, tutorials and a practical training

Literature

- E. J. N. Wilson: An Introduction to Particle Accelerators, Oxford University Press,2001
- H. Wiedemann: Particle Accelerator Physics 1&2, Springer, 1993
- K. Wille: Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen, Teubner Studienbücher
- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- H. Kuzmany; Solid-State Spectroscopy, Springer (2009)
- U. Pietsch, V. Holy, T. Baumbach, High-resolution X-ray scattering, Springer NY (2004)

M 4.6 Module: Advanced Physics Laboratory Course [M-PHYS-101395]

Responsible: Dr. Gernot Guigas
PD Dr. Andreas Naber
Dr. Christoph Sürgers
Dr. Joachim Wolf

Organisation: KIT Department of Physics

Part of: Advanced Physics Laboratory Course

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each term	1 term	German/English	4	1

Mandatory			
T-PHYS-102479	Advanced Physics Laboratory Course	6 CR	Guigas, Naber, Sürgers, Wolf

Competence Certificate
The proof of performance must be provided for each individual experiment. This includes preparation, execution, evaluation and preparation of a protocol. To pass the laboratory course, it is necessary that all experiments are performed and the protocols are approved by the respective supervisors. For details see https://labs.physik.kit.edu/prakt-mod-fortg.php .

Prerequisites
none

Competence Goal
Students learn modern experimental methods and advanced techniques in the experiments. In doing so, they deepen their understanding of physical concepts and increase their ability to contrast theory and experiment. They improve the safe operation of even complex measurement setups and gain advanced knowledge of measurement data acquisition and processing. They will also learn to ensure error-free operation of complex measurement processes. They will gain a routine handling of data analysis programs for the evaluation of experimental data. They will develop a critical approach to measurement results and thus improve their ability to assess their reliability. Through the careful elaboration of their own experimental results, they increase their writing competence and deepen the correct citation of external sources.

Content
Experiments from the fields of atomic physics, nuclear physics, solid state physics, biophysics, and modern optics/quantum optics. A list of the experiments can be found at https://labs.physik.kit.edu/prakt-mod-fortg.php

Annotation
Mandatory participation in preliminary meeting with safety briefing and radiation protection instruction.

Workload
5 experiments, 180 hours consisting of attendance time (60 hours), preparation, evaluation of experiments and preparation of protocols (120 hours).

Literature
Textbooks of experimental physics. Special material for each individual experiment is provided.

M 4.7 Module: Advanced Seminar in the Area Condensed Matter [M-PHYS-102203]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Minor in Physics: Condensed Matter

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	5

Elective Adv. Sem. in Condensed Matter (Election: 4 credits)			
T-PHYS-106129	Advanced Seminar: Modern Particle Accelerators and Research with Photons	4 CR	Baumbach, Müller
T-PHYS-109977	Advanced Seminar: Neutrons and X-rays in Solid State Physics	4 CR	Baumbach
T-PHYS-113684	Advanced Seminar: Quantum Science at the Atomic Scale: Advanced Scanning Probe Techniques	4 CR	Wernsdorfer, Willke, Wulfhekel
T-PHYS-109971	Advanced Seminar: Recent Experiments in Quantum Physics	4 CR	Hunger, Le Tacon, Wernsdorfer, Willke, Zakeri-Lori
T-PHYS-111451	Advanced Seminar: Units of Measurement and Metrology: No Guessing but Precise Measurement!	4 CR	Wulfhekel

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
2. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
3. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
4. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
5. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

4.8 Module: Advanced Seminar in the Area Condensed Matter Theory [M-PHYS-102209]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	5

Elective Adv. Sem. in Condensed Matter Theory (Election: 4 credits)			
T-PHYS-113446	Advanced Seminar: Advanced Quantum Mechanics: Fundamentals and Technology	4 CR	Garst, Metelmann, Shnirman
T-PHYS-104544	Advanced Seminar: Conformational Dynamics in Biomolecules	4 CR	Nienhaus, Wenzel
T-PHYS-113683	Advanced Seminar: Nanophotonics	4 CR	Naber, Rockstuhl, Wegener
T-PHYS-112802	Advanced Seminar: Phenomena of the Quantum World	4 CR	Garst, Schmalian, Shnirman
T-PHYS-114092	Advanced Seminar: Physics of Electrons in a Magnetic Field: Quantum Hall Effects	4 CR	Garst, Schmalian, Shnirman
T-PHYS-113133	Advanced Seminar: Quantum Mechanics: Selected Chapters	4 CR	Eder
T-PHYS-110829	Advanced Seminar: Topology in Condensed Matter Systems	4 CR	Garst, Mirlin, Schmalian
T-PHYS-113685	Advanced Seminar: Topology in Quantum Condensed Matter Systems	4 CR	Gornyi, Mirlin
T-PHYS-111865	Advanced Seminar: Virtual Design of Materials	4 CR	Wenzel

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
4. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
5. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
6. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

4.9 Module: Advanced Seminar in the Area Experimental Astroparticle Physics [M-PHYS-102207]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	4

Elective Adv. Sem. in Exp. Astroparticle Physics (Election: 4 credits)			
T-PHYS-112801	Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine	4 CR	Holzapfel, Husemann, Müller, Spadea
T-PHYS-110293	Advanced Seminar: Astroparticle Physics	4 CR	Drexlin, Engel, Valerius
T-PHYS-112800	Advanced Seminar: Astroparticle Physics and Cosmology	4 CR	Drexlin, Engel, Valerius
T-PHYS-114241	Advanced Seminar: Astroparticle Physics – Modern Experiments	4 CR	Drexlin
T-PHYS-106129	Advanced Seminar: Modern Particle Accelerators and Research with Photons	4 CR	Baumbach, Müller
T-PHYS-113447	Advanced Seminar: The Dark Universe	4 CR	Kahlhöfer
T-PHYS-112236	Advanced Seminar: Unraveling the Puzzle of Dark Matter	4 CR	Mühlleitner, Schwetz-Mangold

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
4. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
5. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.10 Module: Advanced Seminar in the Area Experimental Particle Physics [M-PHYS-102206]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	5

Elective Adv. Sem. in Exp. Particle Physics (Election: 4 credits)			
T-PHYS-112801	Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine	4 CR	Holzapfel, Husemann, Müller, Spadea
T-PHYS-106525	Advanced Seminar: Experimental and Theoretical Methods in Particle Physics	4 CR	Ferber, Gieseke, Heinrich, Quast
T-PHYS-106129	Advanced Seminar: Modern Particle Accelerators and Research with Photons	4 CR	Baumbach, Müller
T-PHYS-112235	Advanced Seminar: Particle Physics	4 CR	Ferber, Husemann, Klute
T-PHYS-111863	Advanced Seminar: Particle Physics beyond the Standard Model	4 CR	Ferber, Klute

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
4. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
5. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.11 Module: Advanced Seminar in the Area Nanophysics [M-PHYS-102204]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	5

Elective Adv. Sem. in Nanophysics (Election: 4 credits)			
T-PHYS-104544	Advanced Seminar: Conformational Dynamics in Biomolecules	4 CR	Nienhaus, Wenzel
T-PHYS-104560	Advanced Seminar: Light-optical Nanoscopy	4 CR	Nienhaus
T-PHYS-111862	Advanced Seminar: Nano-Optics	4 CR	Naber, Rockstuhl, Wegener
T-PHYS-113683	Advanced Seminar: Nanophotonics	4 CR	Naber, Rockstuhl, Wegener
T-PHYS-113684	Advanced Seminar: Quantum Science at the Atomic Scale: Advanced Scanning Probe Techniques	4 CR	Wernsdorfer, Willke, Wulfhekel
T-PHYS-109971	Advanced Seminar: Recent Experiments in Quantum Physics	4 CR	Hunger, Le Tacon, Wernsdorfer, Willke, Zakeri-Lori
T-PHYS-111865	Advanced Seminar: Virtual Design of Materials	4 CR	Wenzel

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
3. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
4. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
5. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.12 Module: Advanced Seminar in the Area Optics and Photonics [M-PHYS-102205]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	5

Elective Adv. Sem. in Optics and Photonics (Election: 4 credits)			
T-PHYS-104544	Advanced Seminar: Conformational Dynamics in Biomolecules	4 CR	Nienhaus, Wenzel
T-PHYS-104560	Advanced Seminar: Light-optical Nanoscopy	4 CR	Nienhaus
T-PHYS-106129	Advanced Seminar: Modern Particle Accelerators and Research with Photons	4 CR	Baumbach, Müller
T-PHYS-111862	Advanced Seminar: Nano-Optics	4 CR	Naber, Rockstuhl, Wegener
T-PHYS-113683	Advanced Seminar: Nanophotonics	4 CR	Naber, Rockstuhl, Wegener
T-PHYS-111451	Advanced Seminar: Units of Measurement and Metrology: No Guessing but Precise Measurement!	4 CR	Wulfhekel

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
4. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
5. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.13 Module: Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics [M-PHYS-106829]

Responsible: Studiendekan Physik

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Minor in Physics: Theoretical Cosmology and Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	2

Elective Adv. Sem. in Theoretical Particle Physics (Election: 4 credits)			
T-PHYS-114093	Advanced Seminar: Gravitational Waves and Black Holes - Selected Topics	4 CR	Mühlleitner, Schwetz-Mangold
T-PHYS-113447	Advanced Seminar: The Dark Universe	4 CR	Kahlhöfer
T-PHYS-112803	Advanced Seminar: The Matter Puzzle - Baryon Asymmetry, Dark Matter and Particle Physics	4 CR	Kahlhöfer, Mühlleitner
T-PHYS-112236	Advanced Seminar: Unraveling the Puzzle of Dark Matter	4 CR	Mühlleitner, Schwetz-Mangold

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
4. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
5. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
6. The module M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics must not have been started.
7. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload
120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature
Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.14 Module: Advanced Seminar in the Area Theoretical Particle Physics [M-PHYS-102208]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each term	1 term	German/English	4	4

Elective Adv. Sem. in Theoretical Particle Physics (Election: 4 credits)			
T-PHYS-113446	Advanced Seminar: Advanced Quantum Mechanics: Fundamentals and Technology	4 CR	Garst, Metelmann, Shnirman
T-PHYS-106525	Advanced Seminar: Experimental and Theoretical Methods in Particle Physics	4 CR	Ferber, Gieseke, Heinrich, Quast
T-PHYS-112804	Advanced Seminar: Flavor Physics	4 CR	Blanke, Kahlhöfer
T-PHYS-113448	Advanced Seminar: Flavour Physics	4 CR	Blanke, Nierste
T-PHYS-114093	Advanced Seminar: Gravitational Waves and Black Holes - Selected Topics	4 CR	Mühlleitner, Schwetz-Mangold
T-PHYS-113133	Advanced Seminar: Quantum Mechanics: Selected Chapters	4 CR	Eder
T-PHYS-113447	Advanced Seminar: The Dark Universe	4 CR	Kahlhöfer
T-PHYS-112803	Advanced Seminar: The Matter Puzzle - Baryon Asymmetry, Dark Matter and Particle Physics	4 CR	Kahlhöfer, Mühlleitner
T-PHYS-113686	Advanced Seminar: Theoretical Challenges in Precision Standard Model Physics	4 CR	Melnikov
T-PHYS-112236	Advanced Seminar: Unraveling the Puzzle of Dark Matter	4 CR	Mühlleitner, Schwetz-Mangold

Competence Certificate
Study achievement. Own presentation as well as regular attendance.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter must not have been started.
2. The module M-PHYS-102204 - Advanced Seminar in the Area Nanophysics must not have been started.
3. The module M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics must not have been started.
4. The module M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics must not have been started.
5. The module M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics must not have been started.
6. The module M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory must not have been started.

Competence Goal
Students are able to present a specialized scientific topic. This includes collecting the scientific material, using a correct citation technique, considering didactic aspects, structuring the presentation, designing the slides, giving the actual presentation and answering questions from the audience.

Content
Together with the presentation techniques, depending on the choice of topic, special scientific subjects up to the current state of the art are communicated.

Workload

120 hours composed of attendance time (30 h), wrap-up of the seminar (30 h) and preparation of the own presentation incl. rehearsal presentation (60 h)

Literature

Will be communicated in the seminar, depending on the topic and specialization, textbooks and/or scientific articles are suitable.

M 4.15 Module: Advanced Topics in Quantum Field Theory [M-PHYS-106842]

Responsible: Prof. Dr. Ulrich Nierste
Dr. Robert Ziegler

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113728	Advanced Topics in Quantum Field Theory	4 CR	Nierste, Ziegler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
Students learn or deepen their knowledge of important field theoretical concepts such as the treatment of symmetries in path integral formalism, effective theories using the example of chiral perturbation theory and quantum gravity, and chiral anomalies. In particular, after this lecture students will be familiar with the description of various physical phenomena by effective theories and their renormalization.

Content
This module teaches various advanced concepts of quantum field theory as a supplement to the TTP lectures. As an introduction, the path integral formalism is briefly reviewed and Dyson-Schwinger equations and Ward identities are discussed and used to prove gauge independence in QED non-perturbatively. This is followed by a discussion of effective field theories, first conceptually and then using relevant examples such as chiral perturbation theory, Fermi theory and quantum gravity. Finally, chiral anomalies in the path integral formalism are treated and their significance for the standard model is discussed.

Workload
120 hours consisting of attendance time (30 hours), follow-up of the lecture incl. exam preparation and working on the exercises (90 hours)

4.16 Module: Array Techniques in Seismology (Graded) [M-PHYS-106196]

Responsible: apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112590	Array Techniques in Seismology, graded	4 CR	Ritter

Competence Certificate
Grading is based on written reports on exercises. A detailed rating scheme is distributed during the first lecture together with information on the required length of the reports and rating criteria.

Competence Goal
The students understand basic principles of array techniques. This includes the increase in signal-to-noise ratio due to stacking or beamforming and the estimation of simple shear-wave velocity profiles. They know how to determine the slowness or ray parameter of an incoming wavefield as well as its backazimuth. These parameters are used to estimate the location of a seismic source. Furthermore, they know how to divide different phase arrivals using a vespagram or an f-k analysis.

The students are able to work self-organized on a specific issue of array seismology, e.g., the location of a nuclear test or the local shear-wave velocity structure underneath a local array. They are able to read and understand technical and scientific literature on array seismology. They can outline and analyze seismological cases in which array techniques can solve specific problems such as seismic phase identification or source location estimation.

Content

- Fundamentals of seismic waves
- Measurable parameters of seismic waves using arrays
- Determination of source locations
- Determination of underground properties
- Global seismic arrays and their role for monitoring nuclear tests and earthquakes
- Training on array software and application to seismological data sets

Module grade calculation
Reports on exercises need to be submitted which are individually graded. The final module grade is calculated as average of all individually graded reports. A detailed rating scheme is distributed during the first lecture.

Workload
Total workload: 120h which consist of 15h lecture at GPI, 15h reading of research papers and lecture material, 15h preparation and wrap-up of lecture, 15h guided exercise in the computing room at GPI to learn about array software (basic Linux and Python knowledge required), 30h self-organized training with array software and application to data sets, and 30h preparation of reports on exercises.

Recommendation
Participants need to know the basics of seismology.

Literature

- Schweitzer, J. et al., 2012. Seismic Arrays. In: Bormann, P. (Ed.), New Manual of Seismological Observatory Practice 2 (NMSOP-2), Potsdam, Deutsches GeoForschungsZentrum GFZ, 1-80, doi:10.2312/GFZ.NMSOP-2_ch9
- Rost, S. & Thomas, C., 2002. Array seismology: Methods and applications. Rev. Geophys., 40 (3), 1008, doi:10.1029/2000RG000100
- Kind, F. et al., 2005. Array measurements of S-wave velocities from ambient vibrations. Geophysical Journal International, 160 (1), 114–126, doi:10.1111/j.1365-246X.2005.02331.x

M 4.17 Module: Astroparticle Physics I [M-PHYS-102075]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Required Experimental Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Required Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102432	Astroparticle Physics I	8 CR	Drexlin, Valerius

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102076 - Astroparticle Physics I (Minor) must not have been started.

Competence Goal
Students will be introduced to the basic concepts of astroparticle physics. The lecture teaches both the theoretical concepts and the experimental methods of this new dynamic field of work at the interface of elementary particle physics, cosmology and astrophysics. Students will learn to understand the concepts through concrete case studies from current research and will be enabled to apply the learned methods independently.

Methodological skills acquisition:

- Understanding of the fundamentals of experimental astroparticle physics.
- Recognition of methodological cross-connections to elementary particle physics, astrophysics, and cosmology.
- Acquisition of the ability to present a current research topic independently as well as in a team setting
- Acquisition of the ability to implement the concepts and experimental methods in the master thesis

Content
The topics covered include a general introduction to the field with its fundamental issues, theoretical concepts and experimental methods. Corresponding to the very different energy scales (meV - 1020 eV) of astroparticle physics, the lecture is divided into a discussion of the processes in the thermal (low energies) and non-thermal (high energies) universe. A special focus of the lecture is a comprehensive presentation of modern experimental techniques, e.g. in the search for very rare processes. Based on this, in the second part of the lecture a comprehensive introduction to the "dark universe" and the search for dark matter is given.

The lecture is the basis of further lectures on this topic (Astroparticle Physics II).

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises(180 hours)

Recommendation
Basic knowledge from the lecture "Nuclei and Particles".

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press, 2. Auflage, 2009)
- Claus Grupen, Astroparticle Physics (Springer, 2005)
- Lars Bergström & Ariel Goobar, Cosmology and Particle Astrophysics (Wiley, 2. Auflage, 2006)
- Malcolm Longair, High Energy Astrophysics (Cambridge University Press, 3. Auflage, 2011)

M 4.18 Module: Astroparticle Physics I (Minor) [M-PHYS-102076]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104379	Astroparticle Physics I (Minor)	8 CR	Drexlin, Valerius

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102075 - Astroparticle Physics I must not have been started.

Competence Goal
Students will be introduced to the basic concepts of astroparticle physics. The lecture teaches both the theoretical concepts and the experimental methods of this new dynamic field of work at the interface of elementary particle physics, cosmology and astrophysics. Students will learn to understand the concepts through concrete case studies from current research and will be enabled to apply the learned methods independently.

Methodological skills acquisition:

- Understanding of the fundamentals of experimental astroparticle physics.
- Recognition of methodological cross-connections to elementary particle physics, astrophysics, and cosmology.
- Acquisition of the ability to present a current research topic independently as well as in a team setting
- Acquisition of the ability to implement the concepts and experimental methods in the master thesis

Content
The topics covered include a general introduction to the field with its fundamental issues, theoretical concepts and experimental methods. Corresponding to the very different energy scales (meV - 1020 eV) of astroparticle physics, the lecture is divided into a discussion of the processes in the thermal (low energies) and non-thermal (high energies) universe. A special focus of the lecture is a comprehensive presentation of modern experimental techniques, e.g. in the search for very rare processes. Based on this, in the second part of the lecture a comprehensive introduction to the "dark universe" and the search for dark matter is given.

The lecture is the basis of further lectures on this topic (Astroparticle Physics II).

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge from the lecture "Nuclei and Particles".

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press, 2. Auflage, 2009)
- Claus Grupen, Astroparticle Physics (Springer, 2005)
- Lars Bergström & Ariel Goobar, Cosmology and Particle Astrophysics (Wiley, 2. Auflage, 2006)
- Malcolm Longair, High Energy Astrophysics (Cambridge University Press, 3. Auflage, 2011)

4.19 Module: Astroparticle Physics II - Cosmic Rays, with ext. Exercises [M-PHYS-102525]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-105108	Astroparticle Physics II - Cosmic Rays, with ext. Exercises	8 CR	Engel, Roth

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102082 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102078 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises must not have been started.
3. The module M-PHYS-103184 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students understand the basic terms and concepts of astrophysics of high-energy particles and apply them to the discussion of modern observational results. Typical approximations and considerations of astrophysics are comprehensible for the participants. In the extended exercises, students solve extensive problems in astroparticle physics and discuss them in the group.

Content
The lecture will be held as blackboard notes and with previously handed out visual material. Special emphasis will be placed on the explicit derivation of the essential relationships. Topics include astrophysical energy and size scales; cosmic ray properties; direct and indirect cosmic ray measurements; charged particle acceleration; galaxies and galactic magnetic fields; galactic and extra-galactic cosmic ray propagation; cosmic ray sources; particle physics and cosmic ray searches for exotic phenomena; high-energy neutrinos. Together with "Astroparticle Physics II: Gamma Radiation" the following semester, the two lectures provide a complete picture of high-energy particles with their underlying production and transport processes in the universe. The topic spectra of both lectures are designed in such a way that they can also be listened to individually.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours)

Literature

- T.K. Gaisser, R. Engel, E. Resconi: Cosmic Rays and Particle Physics (2nd Ed.)
- P. Schneider: Einführung in die Extragalaktische Astronomie und Kosmologie
- M. Longair: High Energy Astrophysics
- Thierry Courvoisier: High Energy Astrophysics
- Bradley W. Carroll and Dale Ostlie: An Introduction to Modern Astrophysics

M 4.20 Module: Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor) [M-PHYS-103184]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-106317	Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor)	8 CR	Engel, Roth

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102082 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102078 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises must not have been started.
3. The module M-PHYS-102525 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises must not have been started.

Competence Goal
The students understand the basic terms and concepts of astrophysics of high-energy particles and apply them to the discussion of modern observational results. Typical approximations and considerations of astrophysics are comprehensible for the participants. In the extended exercises, students solve extensive problems in astroparticle physics and discuss them in the group.

Content
The lecture will be given as blackboard notes and with previously handed out visual material. Special emphasis will be placed on the explicit derivation of the essential relationships. Topics include astrophysical energy and size scales; cosmic ray properties; direct and indirect cosmic ray measurements; charged particle acceleration; galaxies and galactic magnetic fields; galactic and extra-galactic cosmic ray propagation; cosmic ray sources; particle physics and cosmic ray searches for exotic phenomena; high-energy neutrinos. Together with "Astroparticle Physics II: Gamma Radiation" the following semester, the two lectures provide a complete picture of high-energy particles with their underlying production and transport processes in the universe. The topic spectra of both lectures are designed in such a way that they can also be listened to individually.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Literature

- T.K. Gaisser, R. Engel, E. Resconi: Cosmic Rays and Particle Physics (2nd Ed.)
- P. Schneider: Einführung in die Extragalaktische Astronomie und Kosmologie
- M. Longair: High Energy Astrophysic
- Thierry Courvoisier: High Energy Astrophysics
- Bradley W. Carroll and Dale Ostlie: An Introduction to Modern Astrophysics

4.21 Module: Astroparticle Physics II - Cosmic Rays, without ext. Exercises [M-PHYS-102078]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102382	Astroparticle Physics II - Cosmic Rays, without ext. Exercises	6 CR	Engel, Roth

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102082 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102525 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises must not have been started.
3. The module M-PHYS-103184 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students understand the basic terms and concepts of astrophysics of high-energy particles and apply them to the discussion of modern observational results. Typical approximations and considerations of astrophysics are comprehensible for the participants. In the exercises, students solve selected problems in astroparticle physics and discuss them in the group.

Content
The lecture will be held as blackboard notes and with previously handed out visual material. Special emphasis will be placed on the explicit derivation of the essential relationships. Topics include astrophysical energy and size scales; cosmic ray properties; direct and indirect cosmic ray measurements; charged particle acceleration; galaxies and galactic magnetic fields; galactic and extra-galactic cosmic ray propagation; cosmic ray sources; particle physics and cosmic ray searches for exotic phenomena; high-energy neutrinos. Together with "Astroparticle Physics II: Gamma Radiation" the following semester, the two lectures provide a complete picture of high-energy particles with their underlying production and transport processes in the universe. The topic spectra of both lectures are designed in such a way that they can also be listened to individually.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Literature

- T.K. Gaisser, R. Engel, E. Resconi: Cosmic Rays and Particle Physics (2nd Ed.)
- P. Schneider: Einführung in die Extragalaktische Astronomie und Kosmologie
- M. Longair: High Energy Astrophysics
- Thierry Courvoisier: High Energy Astrophysics
- Bradley W. Carroll and Dale Ostlie: An Introduction to Modern Astrophysics

M 4.22 Module: Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor) [M-PHYS-102082]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104380	Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor)	6 CR	Engel, Roth

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102078 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises must not have been started.
2. The module M-PHYS-102525 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises must not have been started.
3. The module M-PHYS-103184 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students understand the basic terms and concepts of astrophysics of high-energy particles and apply them to the discussion of modern observational results. Typical approximations and considerations of astrophysics are comprehensible for the participants. In the exercises, students solve selected problems in astroparticle physics and discuss them in the group.

Content
The lecture will be held as blackboard notes and with previously handed out visual material. Special emphasis will be placed on the explicit derivation of the essential relationships. Topics include astrophysical energy and size scales; cosmic ray properties; direct and indirect cosmic ray measurements; charged particle acceleration; galaxies and galactic magnetic fields; galactic and extra-galactic cosmic ray propagation; cosmic ray sources; particle physics and cosmic ray searches for exotic phenomena; high-energy neutrinos. Together with "Astroparticle Physics II: Gamma Radiation" the following semester, the two lectures provide a complete picture of high-energy particles with their underlying production and transport processes in the universe. The topic spectra of both lectures are designed in such a way that they can also be listened to individually.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Literature

- T.K. Gaisser, R. Engel, E. Resconi: Cosmic Rays and Particle Physics (2nd Ed.)
- P. Schneider: Einführung in die Extragalaktische Astronomie und Kosmologie
- M. Longair: High Energy Astrophysics
- Thierry Courvoisier: High Energy Astrophysics
- Bradley W. Carroll and Dale Ostlie: An Introduction to Modern Astrophysics

M 4.23 Module: Astroparticle Physics II - Gamma Rays and Neutrinos [M-PHYS-105683]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-111343	Astroparticle Physics II - Gamma Rays and Neutrinos	6 CR	Drexlin, Engel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none, the lecture is designed complementary to the module Astroparticle Physics I and can be heard independently of it

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105684 - Astroparticle Physics II - Gamma Rays and Neutrinos (Minor) must not have been started.
2. The module M-PHYS-105685 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-105686 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises must not have been started.

Competence Goal
After successful participation in this module, the student has an in-depth technical and survey knowledge in the field of high-energy astroparticle physics. He/she understands the most important formation processes of gamma rays and neutrinos, is able to interpret observed energy spectra of astrophysical objects and has basic knowledge of the astrophysics of galactic and extragalactic sources of high-energy particles.

Content
The fundamentals of astroparticle physics involving high-energy particles will be discussed, with emphasis on the application of gamma and neutrino astronomy to the study of astrophysical objects. Starting with the acceleration of charged particles, the first third of the lecture series introduces the main formation processes of gamma radiation, discusses the propagation of high-energy gamma radiation, and presents methods for detecting gamma radiation on Earth and in space. The second third of the lecture series discusses astrophysical objects and their image in gamma rays: supernova explosions and remnants, neutron stars and pulsars, black holes and Active Galactic Nuclei, and gamma-ray bursts. The course is rounded out by an introduction to the fundamentals and current issues in astronomy involving high-energy neutrinos.

Together with the course "Astroparticle Physics II: Cosmic Rays", which is offered in the WS, a complete picture of high-energy particles with their underlying production and transport processes in our universe is obtained. The subject spectra of both lectures are complementary in nature and can be heard independently, but complement each other appropriately. The lecture ATP II " Gamma Rays and Neutrinos" is complementary to further in-depth lectures (Astroparticle Physics II " Cosmic Rays" or "Particles and Stars").

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of experimental methods in this area is assumed.

Literature

- T.K. Gaisser, R. Engel, E.Resconi: Cosmic Rays and Particle Physics (Cambridge)
- M.S. Longair: High Energy Astrophysics (Cambridge)
- H. Bradt: Astrophysics Processes (Cambridge)
- C.D. Dermer, G. Menon: High Energy Radiation from Black Holes (Princeton)

Further literature will be given in the lecture.

M 4.24 Module: Astroparticle Physics II - Gamma Rays and Neutrinos (Minor) [M-PHYS-105684]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-111344	Astroparticle Physics II - Gamma Rays and Neutrinos (Minor)	6 CR	Drexlin, Engel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none, the lecture is designed complementary to the module Astroparticle Physics I and can be heard independently of it

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105683 - Astroparticle Physics II - Gamma Rays and Neutrinos must not have been started.
2. The module M-PHYS-105685 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-105686 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises must not have been started.

Competence Goal
After successful participation in this module, the student has an in-depth technical and survey knowledge in the field of high-energy astroparticle physics. He/she understands the most important formation processes of gamma rays and neutrinos, is able to interpret observed energy spectra of astrophysical objects and has basic knowledge of the astrophysics of galactic and extragalactic sources of high-energy particles.

Content
The fundamentals of astroparticle physics involving high-energy particles will be discussed, with emphasis on the application of gamma and neutrino astronomy to the study of astrophysical objects. Starting with the acceleration of charged particles, the first third of the lecture series introduces the main formation processes of gamma radiation, discusses the propagation of high-energy gamma radiation, and presents methods for detecting gamma radiation on Earth and in space. The second third of the lecture series discusses astrophysical objects and their image in gamma rays: supernova explosions and remnants, neutron stars and pulsars, black holes and Active Galactic Nuclei, and gamma-ray bursts. The course is rounded out by an introduction to the fundamentals and current issues in astronomy involving high-energy neutrinos.

Together with the course "Astroparticle Physics II: Cosmic Rays", which is offered in the WS, a complete picture of high-energy particles with their underlying production and transport processes in our universe is obtained. The subject spectra of both lectures are complementary in nature and can be heard independently, but complement each other appropriately. The lecture ATP II " Gamma Rays and Neutrinos" is complementary to further in-depth lectures (Astroparticle Physics II " Cosmic Rays" or "Particles and Stars").

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of experimental methods in this area is assumed.

Literature

- T.K. Gaisser, R. Engel, E.Resconi: Cosmic Rays and Particle Physics (Cambridge)
- M.S. Longair: High Energy Astrophysics (Cambridge)
- H. Bradt: Astrophysics Processes (Cambridge)
- C.D. Dermer, G. Menon: High Energy Radiation from Black Holes (Princeton)

Further literature will be given in the lecture.

M 4.25 Module: Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises [M-PHYS-105686]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-111346	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises	8 CR	Drexlin, Engel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none, the lecture is designed complementary to the module Astroparticle Physics I and can be heard independently of it

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105683 - Astroparticle Physics II - Gamma Rays and Neutrinos must not have been started.
2. The module M-PHYS-105684 - Astroparticle Physics II - Gamma Rays and Neutrinos (Minor) must not have been started.
3. The module M-PHYS-105685 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor) must not have been started.

Competence Goal
After successful participation in this module, the student has an in-depth technical and survey knowledge in the field of high-energy astroparticle physics. He/she understands the most important formation processes of gamma rays and neutrinos, is able to interpret observed energy spectra of astrophysical objects and has basic knowledge of the astrophysics of galactic and extragalactic sources of high-energy particles.

Content
The fundamentals of astroparticle physics involving high-energy particles will be discussed, with emphasis on the application of gamma and neutrino astronomy to the study of astrophysical objects. Starting with the acceleration of charged particles, the first third of the lecture series introduces the main formation processes of gamma radiation, discusses the propagation of high-energy gamma radiation, and presents methods for detecting gamma radiation on Earth and in space. The second third of the lecture series discusses astrophysical objects and their image in gamma rays: supernova explosions and remnants, neutron stars and pulsars, black holes and Active Galactic Nuclei, and gamma-ray bursts. The course is rounded out with an introduction to the fundamentals and current issues in astronomy involving high-energy neutrinos.

Together with the course "Astroparticle Physics II: Cosmic Rays", which is offered in the WS, a complete picture of high-energy particles with their underlying production and transport processes in our universe is obtained. The subject spectra of both lectures are complementary in nature and can be heard independently, but complement each other appropriately. The lecture ATP II " Gamma Rays and Neutrinos" is complementary to further in-depth lectures (Astroparticle Physics II " Cosmic Rays" or "Particles and Stars").

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of experimental methods in this area is assumed.

Literature

- T.K. Gaisser, R. Engel, E.Resconi: Cosmic Rays and Particle Physics (Cambridge)
- M.S. Longair: High Energy Astrophysics (Cambridge)
- H. Bradt: Astrophysics Processes (Cambridge)
- C.D. Dermer, G. Menon: High Energy Radiation from Black Holes (Princeton)

Further literature will be given in the lecture.

4.26 Module: Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor) [M-PHYS-105685]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-111345	Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor)	8 CR	Drexlin, Engel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none, the lecture is designed complementary to the module Astroparticle Physics I and can be heard independently of it

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105683 - Astroparticle Physics II - Gamma Rays and Neutrinos must not have been started.
2. The module M-PHYS-105684 - Astroparticle Physics II - Gamma Rays and Neutrinos (Minor) must not have been started.
3. The module M-PHYS-105686 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises must not have been started.

Competence Goal
After successful participation in this module, the student has an in-depth technical and survey knowledge in the field of high-energy astroparticle physics. He/she understands the most important formation processes of gamma rays and neutrinos, is able to interpret observed energy spectra of astrophysical objects and has basic knowledge of the astrophysics of galactic and extragalactic sources of high-energy particles.

Content
The fundamentals of astroparticle physics involving high-energy particles will be discussed, with emphasis on the application of gamma and neutrino astronomy to the study of astrophysical objects. Starting with the acceleration of charged particles, the first third of the lecture series introduces the main formation processes of gamma radiation, discusses the propagation of high-energy gamma radiation, and presents methods for detecting gamma radiation on Earth and in space. The second third of the lecture series discusses astrophysical objects and their image in gamma rays: supernova explosions and remnants, neutron stars and pulsars, black holes and Active Galactic Nuclei, and gamma-ray bursts. The course is rounded out by an introduction to the fundamentals and current issues in astronomy involving high-energy neutrinos.

Together with the course "Astroparticle Physics II: Cosmic Rays", which is offered in the WS, a complete picture of high-energy particles with their underlying production and transport processes in our universe is obtained. The subject spectra of both lectures are complementary in nature and can be heard independently, but complement each other appropriately. The lecture ATP II " Gamma Rays and Neutrinos" is complementary to further in-depth lectures (Astroparticle Physics II " Cosmic Rays" or "Particles and Stars").

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of experimental methods in this area is assumed.

Literature

- T.K. Gaisser, R. Engel, E.Resconi: Cosmic Rays and Particle Physics (Cambridge)
- M.S. Longair: High Energy Astrophysics (Cambridge)
- H. Bradt: Astrophysics Processes (Cambridge)
- C.D. Dermer, G. Menon: High Energy Radiation from Black Holes (Princeton)

Further literature will be given in the lecture.

M 4.27 Module: Astroparticle Physics II - Particles and Stars, with ext. Exercises [M-PHYS-102527]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-105110	Astroparticle Physics II - Particles and Stars, with ext. Exercises	8 CR	Drexlin, Valerius

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
If Experimental Astroparticle Physics is chosen as the main subject, the lecture Astroparticle Physics I or Cosmology must also be taken. The lecture ATP II - Particles and Stars is complementary to other in-depth lectures (Astroparticle Physics II - Cosmic Rays, Gamma Rays).

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102086 - Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102081 - Astroparticle Physics II - Particles and Stars, without ext. Exercises must not have been started.
3. The module M-PHYS-103186 - Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students expand their knowledge of astroparticle physics to include the areas of stellar astrophysics, neutrino physics, and multimessenger astronomy. They are able to name current and past problems and understand approaches to solving them, and are familiar with current methods and technologies in research. Cross connections to other areas of physics, especially elementary particle physics are recognized.

Students are able to understand and construct simple models to analyze problems and concepts quantitatively. They are also able to independently familiarize themselves with current research results and to present and discuss their findings and calculations.

Furthermore, the students deepen their knowledge of an experiment in astroparticle physics through a practical exercise and are able to evaluate and interpret measurement data.

Content
Building on the introductory lectures Astroparticle Physics I and Cosmology, the lecture gives an in-depth insight into two key areas of modern experimental astroparticle physics.

In the first area, a comprehensive look at the fundamentals of experimental neutrino physics is provided. The focus is on the field of neutrino properties. Topics covered include an introduction to the phenomenon of neutrino oscillations including recent results on solar & atmospheric neutrinos, as well as reactor and accelerator neutrino experiments. In addition, emphasis will be placed on experiments for direct neutrino mass determination and the search for neutrinoless double beta decay.

In the second part of the lecture, an introduction is given to the field of stellar astrophysics with a special emphasis on late stellar phases. These are characterized by degenerate matter (white dwarfs and neutron stars) and form the precursors of supernova explosions (thermonuclear and core collapse SNae). Finally, methods of ATP to detect these processes with neutrino detectors and gravitational wave observatories will be discussed.

The lecture emphasizes an in-depth presentation of fundamental physical processes and experimental methods in astroparticle physics.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of fundamental experimental methods in this area is assumed.

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press)
- Kai Zuber, Neutrino physics (Routledge Chapman & Hall), 2nd Edition
- H.V. Klapdor-Kleingrothaus & Kai Zuber, Teilchenastrophysik (Teubner)

Further literature will be announced in the lecture.

4.28 Module: Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor) [M-PHYS-103186]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-106319	Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor)	8 CR	Drexlin, Valerius

Competence Certificate
Die Studienleistung wird durch erfolgreiche Teilnahme am Übungsbetrieb erbracht. Die Details werden in der ersten Vorlesung oder beim ersten Übungstermin bekannt gegeben.

Prerequisites
If Experimental Astroparticle Physics is chosen as the main subject, the lecture Astroparticle Physics I or Cosmology must also be taken. The lecture ATP II - Particles and Stars is complementary to other in-depth lectures (Astroparticle Physics II - Cosmic Rays, Gamma Rays).

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102086 - Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102081 - Astroparticle Physics II - Particles and Stars, without ext. Exercises must not have been started.
3. The module M-PHYS-102527 - Astroparticle Physics II - Particles and Stars, with ext. Exercises must not have been started.

Competence Goal
Students expand their knowledge of astroparticle physics to include the areas of stellar astrophysics, neutrino physics, and multimessenger astronomy. They are able to name current and past problems and understand approaches to solving them, and are familiar with current methods and technologies in research. Cross connections to other areas of physics, especially elementary particle physics are recognized.

Students are able to understand and construct simple models to analyze problems and concepts quantitatively. They are also able to independently familiarize themselves with current research results and to present and discuss their findings and calculations.

Furthermore, the students deepen their knowledge of an experiment in astroparticle physics through a practical exercise and are able to evaluate and interpret measurement data.

Content
Building on the introductory lectures Astroparticle Physics I and Cosmology, the lecture gives an in-depth insight into two key areas of modern experimental astroparticle physics.

In the first area, a comprehensive look at the fundamentals of experimental neutrino physics is provided. The focus is on the field of neutrino properties. Topics covered include an introduction to the phenomenon of neutrino oscillations including recent results on solar & atmospheric neutrinos, as well as reactor and accelerator neutrino experiments. In addition, emphasis will be placed on experiments for direct neutrino mass determination and the search for neutrinoless double beta decay.

In the second part of the lecture, an introduction is given to the field of stellar astrophysics with a special emphasis on late stellar phases. These are characterized by degenerate matter (white dwarfs and neutron stars) and form the precursors of supernova explosions (thermonuclear and core collapse SNae). Finally, methods of ATP to detect these processes with neutrino detectors and gravitational wave observatories will be discussed.

The lecture emphasizes an in-depth presentation of fundamental physical processes and experimental methods in astroparticle physics.

Workload
240 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (195 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of fundamental experimental methods in this area is assumed.

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press)
- Kai Zuber, Neutrino physics (Routledge Chapman & Hall), 2nd Edition
- H.V. Klapdor-Kleingrothaus & Kai Zuber, Teilchenastrophysik (Teubner)

Further literature will be announced in the lecture.

M 4.29 Module: Astroparticle Physics II - Particles and Stars, without ext. Exercises [M-PHYS-102081]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Further Required Experimental Astroparticle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102498	Astroparticle Physics II - Particles and Stars, without ext. Exercises	6 CR	Drexlin, Valerius

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
If Experimental Astroparticle Physics is chosen as the main subject, the lecture Astroparticle Physics I or Cosmology must also be taken. The lecture ATP II - Particles and Stars is complementary to other in-depth lectures (Astroparticle Physics II - Cosmic Rays, Gamma Rays).

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102086 - Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102527 - Astroparticle Physics II - Particles and Stars, with ext. Exercises must not have been started.
3. The module M-PHYS-103186 - Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students expand their knowledge of astroparticle physics to include the areas of stellar astrophysics, neutrino physics, and multimessenger astronomy. They are able to name current and past problems and understand approaches to solving them, and are familiar with current methods and technologies in research. Cross connections to other areas of physics, especially elementary particle physics are recognized.

Students are able to understand and construct simple models to analyze problems and concepts quantitatively. In addition, they are able to independently familiarize themselves with current research results and to present and discuss their findings and calculations.

Content

Building on the introductory lectures Astroparticle Physics I and Cosmology, the lecture gives an in-depth insight into two key areas of modern experimental astroparticle physics.

In the first area, a comprehensive look at the fundamentals of experimental neutrino physics is provided. The focus is on the field of neutrino properties. Topics covered include an introduction to the phenomenon of neutrino oscillations including recent results on solar & atmospheric neutrinos, as well as reactor and accelerator neutrino experiments. In addition, emphasis will be placed on experiments for direct neutrino mass determination and the search for neutrinoless double beta decay.

In the second part of the lecture, an introduction is given to the field of stellar astrophysics with a special emphasis on late stellar phases. These are characterized by degenerate matter (white dwarfs and neutron stars) and form the precursors of supernova explosions (thermonuclear and core collapse SNae). Finally, methods of ATP to detect these processes with neutrino detectors and gravitational wave observatories will be discussed.

The lecture emphasizes an in-depth presentation of fundamental physical processes and experimental methods in astroparticle physics.

Workload

180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation

Basic knowledge of the physics of particles and nuclei and of fundamental experimental methods in this area is assumed.

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press)
- Kai Zuber, Neutrino physics (Routledge Chapman & Hall), 2nd Edition
- H.V. Klapdor-Kleingrothaus & Kai Zuber, Teilchenastrophysik (Teubner)

Further literature will be announced in the lecture.

M 4.30 Module: Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor) [M-PHYS-102086]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104383	Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor)	6 CR	Drexlin, Valerius

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
If Experimental Astroparticle Physics is chosen as the main subject, the lecture Astroparticle Physics I or Cosmology must also be taken. The lecture ATP II - Particles and Stars is complementary to other in-depth lectures (Astroparticle Physics II - Cosmic Rays, Gamma Rays).

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102081 - Astroparticle Physics II - Particles and Stars, without ext. Exercises must not have been started.
2. The module M-PHYS-102527 - Astroparticle Physics II - Particles and Stars, with ext. Exercises must not have been started.
3. The module M-PHYS-103186 - Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students expand their knowledge of astroparticle physics to include the areas of stellar astrophysics, neutrino physics, and multimessenger astronomy. They are able to name current and past problems and understand approaches to solving them, and are familiar with current methods and technologies in research. Cross connections to other areas of physics, especially elementary particle physics are recognized.

Students are able to understand and construct simple models to analyze problems and concepts quantitatively. In addition, they are able to independently familiarize themselves with current research results and to present and discuss their findings and calculations.

Content
Building on the introductory lectures Astroparticle Physics I and Cosmology, the lecture gives an in-depth insight into two key areas of modern experimental astroparticle physics.

In the first area, a comprehensive look at the fundamentals of experimental neutrino physics is provided. The focus is on the field of neutrino properties. Topics covered include an introduction to the phenomenon of neutrino oscillations including recent results on solar & atmospheric neutrinos, as well as reactor and accelerator neutrino experiments. In addition, emphasis will be placed on experiments for direct neutrino mass determination and the search for neutrinoless double beta decay.

In the second part of the lecture, an introduction is given to the field of stellar astrophysics with a special emphasis on late stellar phases. These are characterized by degenerate matter (white dwarfs and neutron stars) and form the precursors of supernova explosions (thermonuclear and core collapse SNae). Finally, methods of ATP to detect these processes with neutrino detectors and gravitational wave observatories will be discussed.

The lecture emphasizes an in-depth presentation of fundamental physical processes and experimental methods in astroparticle physics.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of the physics of particles and nuclei and of fundamental experimental methods in this area is assumed.

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press)
- Kai Zuber, Neutrino physics (Routledge Chapman & Hall), 2nd Edition
- H.V. Klapdor-Kleingrothaus & Kai Zuber, Teilchenastrophysik (Teubner)

Further literature will be announced in the lecture.

4.31 Module: Basics of Nanotechnology I [M-PHYS-102097]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (mandatory)
Second Major in Physics: Nanophysics (mandatory)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102529	Basics of Nanotechnology I	4 CR	Goll

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102096 - Basics of Nanotechnology I (Minor) must not have been started.

Competence Goal
Students deepen their knowledge in one area of nano-physics, master the relevant theoretical concepts and are familiar with basic techniques and measurement methods of nano-analytics and lithography.

Content
Introduction to central areas of nanotechnology;

Teaching of the conceptual, theoretical and, in particular, methodological fundamentals:

- Methods of imaging and characterization (nanoanalytics)
  Basic concepts of electron microscopy and associated analytical capabilities are covered in an introductory manner. Scanning probe techniques such as tunneling and force microscopy for the investigation and imaging of conductive and insulating sample surfaces, respectively, are discussed. Complementary spectroscopic capabilities of the scanning probe techniques will be explained.
- Methods of nanostructure fabrication (lithography and self-assembly)
  Along the individual process steps from coating and exposure to structure transfer by etching and vapor deposition, the methods used will be explained, their application limits discussed and current developments highlighted.

The lecture "Nanotechnology II" covers application areas and current research topics in the summer semester.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation. (90 hours)

Recommendation
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 4.32 Module: Basics of Nanotechnology I (Minor) [M-PHYS-102096]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102528	Basics of Nanotechnology I (Minor)	4 CR	Goll

Competence Certificate
The course credit is achieved through participation in the lecture and an oral review of success, e.g. in terms of a colloquium or a short presentation covering the topics of the lecture. Details will be announced in the first lecture.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102097 - Basics of Nanotechnology I must not have been started.

Competence Goal
Students deepen their knowledge in one area of nano-physics, master the relevant theoretical concepts and are familiar with basic techniques and measurement methods of nano-analytics and lithography.

Content
Introduction to central areas of nanotechnology;

Teaching of the conceptual, theoretical and, in particular, methodological fundamentals:

- Methods of imaging and characterization (nanoanalytics)
  Basic concepts of electron microscopy and associated analytical capabilities are covered in an introductory manner. Scanning probe techniques such as tunneling and force microscopy for the investigation and imaging of conductive and insulating sample surfaces, respectively, are discussed. Complementary spectroscopic capabilities of the scanning probe techniques will be explained.
- Methods of nanostructure fabrication (lithography and self-assembly)
  Along the individual process steps from coating and exposure to structure transfer by etching and vapor deposition, the methods used will be explained, their application limits discussed and current developments highlighted.

The lecture "Nanotechnology II" covers application areas and current research topics in the summer semester.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation (90 hours)

Recommendation
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 4.33 Module: Basics of Nanotechnology II [M-PHYS-102100]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (mandatory)
Second Major in Physics: Nanophysics (mandatory)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102531	Basics of Nanotechnology II	4 CR	Goll

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102099 - Basics of Nanotechnology II (Minor) must not have been started.

Competence Goal
The student deepens his knowledge in the field of nanophysics, masters the relevant theoretical concepts and is familiar with the basic application areas of nanophysics. The student is able to interpret current data and figures from the scientific literature and to present the current state of research as well as important "open questions".

Content
Introduction to central areas of nanotechnology

Teaching of the conceptual, theoretical and especially methodological basics;

Applications and current developments in the fields of nanoelectronics, nanooptics, nanomechanics, nanotribology, biological nanostructures, self-organized nanostructures, among others.

In addition, the lecture "Fundamentals of Nanotechnology I" in the winter semester deals with methods of imaging, characterization and fabrication of nanostructures.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (90 hours)

Recommendation
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 4.34 Module: Basics of Nanotechnology II (Minor) [M-PHYS-102099]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102530	Basics of Nanotechnology II (Minor)	4 CR	Goll

Competence Certificate
The course credit is achieved through participation in the lecture and an oral review of success, e.g. in terms of a colloquium or a short presentation covering the topics of the lecture. Details will be announced in the first lecture.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102100 - Basics of Nanotechnology II must not have been started.

Competence Goal
The student deepens his knowledge in the field of nanophysics, masters the relevant theoretical concepts and is familiar with the basic application areas of nanophysics. The student is able to interpret current data and figures from the scientific literature and to present the current state of research as well as important "open questions".

Content
Introduction to central areas of nanotechnology

Teaching of the conceptual, theoretical and especially methodological basics;

Applications and current developments in the fields of nanoelectronics, nanooptics, nanomechanics, nanotribology, biological nanostructures, self-organized nanostructures, among others.

In addition, the lecture "Fundamentals of Nanotechnology I" in the winter semester deals with methods of imaging, characterization and fabrication of nanostructures.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (90 hours)

Recommendation
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 4.35 Module: Block Practical Course: ETP Data Science [M-PHYS-106530]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-113159	Block Practical Course: ETP Data Science	2 CR	Ferber, Kieseler, Klute

Competence Certificate
The regular attendance of the entire block course is required. The successful completion will be evaluated by a short oral test on the preparatory work and a final presentation in the week after the course.

Prerequisites
None (preparatory material and exercises will be sent around in advance of the course)

Competence Goal
The students are familiar with the basic concepts of calorimetry, the simulation of particle showers, and the use of machine learning for the determination of the incident particle energy. This includes the interaction of high energetic particles with matter, the evolution of electromagnetic and hadronic showers through the material, and the detection of signals for determining the original particle energy. The students know different neural network architectures in addition to classical methods for energy reconstruction based on these signals.

The theoretical course content, tutorials and practical training are combined and designed to enable students to develop an intuitive understanding of the advantages and disadvantages of different calorimeter types for high energy physics experiments. Furthermore, they can simulate the response of those calorimeters with state-of-the art simulation software, explore different geometries, and are able to understand, choose, and train suitable neural network architectures for energy reconstruction hands-on.

Content

- Introduction to high-energy physics calorimetry
- Hands-on simulation of calorimeter designs with the Geant4 simulation software
- Hands-on implementation of neural network building blocks
- Application of advanced neural networks to particle energy reconstruction in calorimeters

Annotation
This module cannot be combined with an advanced seminar or any other non-graded module in the major in physics or second major in physics.

Workload
60 hours consisting of preparatory work (15 hours) in advance to the course start, an attendance time (30 hours) during the one-week block course with lectures, tutorials and a practical training, and a preparation of a final presentation (15 hours) after the block course.

Recommendation
Basic knowledge of python and neural networks is helpful

Learning type
One-week block course with lectures, tutorials and a practical training

Literature
A list will be sent around in advance of the course.

M 4.36 Module: Computational Condensed Matter Physics [M-PHYS-104862]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-109895	Computational Condensed Matter Physics	12 CR	Wenzel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104863 - Computational Condensed Matter Physics (Minor) must not have been started.

Competence Goal
In recent decades, simulation has established itself as a third pillar of research alongside analytical theory and experiment. It often bridges the gap from principled insights to applications to specific systems. Students develop and gain knowledge of materials-specific simulation for condensed matter systems, from ordered solids to soft matter. Students become familiar with available simulation techniques and apply them to specific problems in condensed matter. They acquire key skills in the use of open-source software to solve simulation problems in condensed matter, in autonomy, in synthesizing the results of different methods for a holistic description in the simulation of material properties.

Content

- Quantum mechanics of many-particle systems
- Methods of quantum chemistry (LCAO, Hartree Fock, density functional theory, electron correlations)
- Applications to molecules and solids
- Simulation methods for classical many-particle systems (Monte Carlo, molecular dynamics)
- Applications to structure formation in polymers, glasses, and solids.
- Introduction to multiscale simulations (QM/MM, multilevel methods) and artificial intelligence techniques.
- Modeling of electronic transport

Workload
360 hours consisting of attendance time (60 hours lecture, 30 hours exercises), follow-up of the lecture incl. exam preparation and working on the exercises (270 hours)

Literature

- Mark Newman: Computational Physics
- Szabo: Modern Quantum Chemistry
- Kurt Binder: Monte Carlo Simulation in Statistical Physics
- Leach: Molecular Modeling

4.37 Module: Computational Condensed Matter Physics (Minor) [M-PHYS-104863]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-109894	Computational Condensed Matter Physics (Minor)	12 CR	Wenzel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104862 - Computational Condensed Matter Physics must not have been started.

Competence Goal
In recent decades, simulation has established itself as a third pillar of research alongside analytical theory and experiment. It often bridges the gap from principled insights to applications to specific systems. Students develop and gain knowledge of materials-specific simulation for condensed matter systems, from ordered solids to soft matter. Students become familiar with available simulation techniques and apply them to specific problems in condensed matter. They acquire key skills in the use of open-source software to solve simulation problems in condensed matter, in autonomy, in synthesizing the results of different methods for a holistic description in the simulation of material properties.

Content

- Quantum mechanics of many-particle systems
- Methods of quantum chemistry (LCAO, Hartree Fock, density functional theory, electron correlations)
- Applications to molecules and solids
- Simulation methods for classical many-particle systems (Monte Carlo, molecular dynamics)
- Applications to structure formation in polymers, glasses, and solids.
- Introduction to multiscale simulations (QM/MM, multilevel methods) and artificial intelligence techniques.
- Modeling of electronic transport

Workload
360 hours consisting of attendance time (60 hours lecture, 30 hours exercises), wrap-up of the lecture and work on the exercises (270 hours)

Recommendation
Knowledge of quantum mechanics and solid state theory.

Literature

- Mark Newman: Computational Physics
- Szabo: Modern Quantum Chemistry
- Kurt Binder: Monte Carlo Simulation in Statistical Physics
- Leach: Molecular Modeling

M 4.38 Module: Computational Methods for Particle Physics and Cosmology [M-PHYS-106117]

Responsible: Prof. Dr. Felix Kahlhöfer

Organisation: KIT Department of Physics

Part of:
Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112378	Computational Methods for Particle Physics and Cosmology	6 CR	Kahlhöfer

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
Students know how to confront theoretical models with experimental data in order to identify preferred models and promising measurements. Students can use tools like FeynRules and MadGraph to calculate cross sections and generate events for processes beyond the Standard Model of particle physics. Students know how to infer model parameters from data using Markov chain Monte Carlos and perform a Bayesian model comparison. Students have some experience with machine learning and understand the range of possible applications of deep neural networks in particle physics and cosmology.

Content
The aim of this module is to explore modern methods for connecting theoretical models in particle physics and cosmology with data from experiments and observations. After a general introduction into the fundamental concepts of Frequentist and Bayesian statistics, such as likelihoods and posteriors, the module will focus on four main challenges:

- How to obtain testable predictions from a given physical theory.
- How to infer the preferred parameter regions of a model from data.
- How to identify preferred models and design experiments to test them.
- How to handle large and complex data sets.

In particular, we will discuss Monte Carlo methods and machine learning techniques and apply them to practical examples.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Experience in programming with Python and Mathematica is desireable. Basic knowledge of theoretical particle physics and cosmology is helpful but not required.

Literature

- D. S. Sivia, “Data Analysis. A Bayesian Tutorial”
- F. James “Monte Carlo theory and practice”, https://iopscience.iop.org/article/10.1088/0034-4885/43/9/002/pdf
- R. Trotta “Bayesian Methods in Cosmology”, https://arxiv.org/abs/1701.01467
- G. Bohm, G. Zech, “Introduction to Statistics and Data Analysis for Physicists”, https://www-library.desy.de/preparch/books/vstatmp_engl.pdf
- D. Guest, K. Cranmer & D. Whiteson, “Deep Learning and Its Application to LHC Physics”, https://arxiv.org/pdf/1806.11484.pdf

M 4.39 Module: Computational Methods for Particle Physics and Cosmology (Minor) [M-PHYS-106118]

Responsible: Prof. Dr. Felix Kahlhöfer
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics
Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112379	Computational Methods for Particle Physics and Cosmology (Minor)	6 CR	Kahlhöfer

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Competence Goal
Students know how to confront theoretical models with experimental data in order to identify preferred models and promising measurements. Students can use tools like FeynRules and MadGraph to calculate cross sections and generate events for processes beyond the Standard Model of particle physics. Students know how to infer model parameters from data using Markov chain Monte Carlos and perform a Bayesian model comparison. Students have some experience with machine learning and understand the range of possible applications of deep neural networks in particle physics and cosmology.

Content
The aim of this module is to explore modern methods for connecting theoretical models in particle physics and cosmology with data from experiments and observations. After a general introduction into the fundamental concepts of Frequentist and Bayesian statistics, such as likelihoods and posteriors, the module will focus on four main challenges:

- How to obtain testable predictions from a given physical theory.
- How to infer the preferred parameter regions of a model from data.
- How to identify preferred models and design experiments to test them.
- How to handle large and complex data sets.

In particular, we will discuss Monte Carlo methods and machine learning techniques and apply them to practical examples.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. preparation of the exercises (135 hours).

Recommendation
Experience in programming with Python and Mathematica is desireable. Basic knowledge of theoretical particle physics and cosmology is helpful but not required.

Literature

- D. S. Sivia, “Data Analysis. A Bayesian Tutorial”
- F. James “Monte Carlo theory and practice”, https://iopscience.iop.org/article/10.1088/0034-4885/43/9/002/pdf
- R. Trotta “Bayesian Methods in Cosmology”, https://arxiv.org/abs/1701.01467
- G. Bohm, G. Zech, “Introduction to Statistics and Data Analysis for Physicists”, https://www-library.desy.de/preparch/books/vstatmp_engl.pdf
- D. Guest, K. Cranmer & D. Whiteson, “Deep Learning and Its Application to LHC Physics”, https://arxiv.org/pdf/1806.11484.pdf

4.40 Module: Computational Photonics, with ext. Exercises [M-PHYS-101933]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-103633	Computational Photonics, with ext. Exercises	8 CR	Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-103090 - Computational Photonics, with ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-103089 - Computational Photonics, without ext. Exercises must not have been started.
3. The module M-PHYS-103193 - Computational Photonics, without ext. Exercises (Minor) must not have been started.

Competence Goal
The students can use a computer to solve optical problems and can use a computer to visualize details of the light matter interaction, know different strategies to solve Maxwell's equations on rigorous grounds, know how spatial symmetries and the arrangement of matter in space can be used to formulate Maxwell's equations such that they are amenable for a numerical solution, can implement programs with a reasonable complexity by themselves, can use a computer to discuss and explore optical phenomena, and are familiar with basic computational strategies that emerge in photonics, but comparably in any other scientific discipline as well.

The student can independently work out the numerical implementation of algorithms that were not explicitly presented in the lecture. That requires understanding of basic computational strategies. The student is, therefore, able to transfer technical knowledge to new domains. The student can develop on its own novel algorithms to solve given problems in the field of computational photonics.

Content

- Transfer Matrix Method to describe the optical response from stratified media
- Finite Differences to characterize eigenmode in fiber waveguides
- Beam propagation method to describe the evolution of light in the realm of integrated optics
- Grating methods to predict reflection and transmission from periodically arranged material in 1D and 2D
- Mie Theory to describe the scattering of light from individual cylindrical or spherical objects
- Finite-Difference Time-Domain method as a general purpose tool to solve micro- and nanooptical problems
- Multiple Multipole Method as an approach to describe light scattering from single objects with an arbitrary shape
- Greens' Methods to discuss equally the scattering from single objects but embedded in an inhomogeneous background
- Boundary Integral Method to discuss scattering from objects highly efficient using expressions for the fields on the surface

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Interest in theoretical physics, optics and electrodynamics. Moreover, interest in computational aspects is important.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- “Principles of Optics” M. Born and E. Wolf
- “Computational Electro-magnetics: The Finite- Difference Time Domain Method,” A. Taflov and S. C. Hagness
- “Light Scattering by Small Particles” H. C. van de Hulst

Specific references for the individual topics will be given during the lectures.
The lecture material that will be fully made available online.

M 4.41 Module: Computational Photonics, with ext. Exercises (Minor) [M-PHYS-103090]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-106132	Computational Photonics, with ext. Exercises (Minor)	8 CR	Rockstuhl

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-103089 - Computational Photonics, without ext. Exercises must not have been started.
2. The module M-PHYS-101933 - Computational Photonics, with ext. Exercises must not have been started.
3. The module M-PHYS-103193 - Computational Photonics, without ext. Exercises (Minor) must not have been started.

Competence Goal
The students can use a computer to solve optical problems and can use a computer to visualize details of the light matter interaction, know different strategies to solve Maxwell's equations on rigorous grounds, know how spatial symmetries and the arrangement of matter in space can be used to formulate Maxwell's equations such that they are amenable for a numerical solution, can implement programs with a reasonable complexity by themselves, can use a computer to discuss and explore optical phenomena, and are familiar with basic computational strategies that emerge in photonics, but comparably in any other scientific discipline as well.

The student can independently work out the numerical implementation of algorithms that were not explicitly presented in the lecture. That requires understanding of basic computational strategies. The student is, therefore, able to transfer technical knowledge to new domains. The student can develop on its own novel algorithms to solve given problems in the field of computational photonics.

Content

- Transfer Matrix Method to describe the optical response from stratified media
- Finite Differences to characterize eigenmode in fiber waveguides
- Beam propagation method to describe the evolution of light in the realm of integrated optics
- Grating methods to predict reflection and transmission from periodically arranged material in 1D and 2D
- Mie Theory to describe the scattering of light from individual cylindrical or spherical objects
- Finite-Difference Time-Domain method as a general purpose tool to solve micro- and nanooptical problems
- Multiple Multipole Method as an approach to describe light scattering from single objects with an arbitrary shape
- Greens' Methods to discuss equally the scattering from single objects but embedded in an inhomogeneous background
- Boundary Integral Method to discuss scattering from objects highly efficient using expressions for the fields on the surface

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Interest in theoretical physics, optics and electrodynamics. Moreover, interest in computational aspects is important.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- “Principles of Optics” M. Born and E. Wolf
- “Computational Electro-magnetics: The Finite- Difference Time Domain Method,” A. Taflov and S. C. Hagness
- “Light Scattering by Small Particles” H. C. van de Hulst

Specific references for the individual topics will be given during the lectures.
The lecture material that will be fully made available online.

4.42 Module: Computational Photonics, without ext. Exercises [M-PHYS-103089]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-106131	Computational Photonics, without ext. Exercises	6 CR	Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101933 - Computational Photonics, with ext. Exercises must not have been started.
2. The module M-PHYS-103090 - Computational Photonics, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-103193 - Computational Photonics, without ext. Exercises (Minor) must not have been started.

Competence Goal
The students can use a computer to solve optical problems and can use a computer to visualize details of the light matter interaction, know different strategies to solve Maxwell's equations on rigorous grounds, know how spatial symmetries and the arrangement of matter in space can be used to formulate Maxwell's equations such that they are amenable for a numerical solution, can implement programs with a reasonable complexity by themselves, can use a computer to discuss and explore optical phenomena, and are familiar with basic computational strategies that emerge in photonics, but comparably in any other scientific discipline as well.

Content

- Transfer Matrix Method to describe the optical response from stratified media
- Finite Differences to characterize eigenmode in fiber waveguides
- Beam propagation method to describe the evolution of light in the realm of integrated optics
- Grating methods to predict reflection and transmission from periodically arranged material in 1D and 2D
- Mie Theory to describe the scattering of light from individual cylindrical or spherical objects
- Finite-Difference Time-Domain method as a general purpose tool to solve micro- and nanooptical problems
- Multiple Multipole Method as an approach to describe light scattering from single objects with an arbitrary shape
- Greens' Methods to discuss equally the scattering from single objects but embedded in an inhomogeneous background
- Boundary Integral Method to discuss scattering from objects highly efficient using expressions for the fields on the surface

Annotation
For students of the KIT Faculty of Computer Science: The exams in this module have to be registered via admissions from ISS (KIT Faculty of Computer Science). For this, an e-mail with matriculation number and name of the desired exam to Beratung-informatik@informatik.kit.edu is sufficient.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (135 hours).

Recommendation
Interest in theoretical physics, optics and electrodynamics. Moreover, interest in computational aspects is important.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- “Principles of Optics” M. Born and E. Wolf
- “Computational Electro-magnetics: The Finite- Difference Time Domain Method,” A. Taflov and S. C. Hagness
- “Light Scattering by Small Particles” H. C. van de Hulst

Specific references for the individual topics will be given during the lectures.
The lecture material that will be fully made available online.

M 4.43 Module: Computational Photonics, without ext. Exercises (Minor) [M-PHYS-103193]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-106326	Computational Photonics, without ext. Exercises (Minor)	6 CR	Rockstuhl

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101933 - Computational Photonics, with ext. Exercises must not have been started.
2. The module M-PHYS-103090 - Computational Photonics, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-103089 - Computational Photonics, without ext. Exercises must not have been started.

Competence Goal
The students can use a computer to solve optical problems and can use a computer to visualize details of the light matter interaction, know different strategies to solve Maxwell's equations on rigorous grounds, know how spatial symmetries and the arrangement of matter in space can be used to formulate Maxwell's equations such that they are amenable for a numerical solution, can implement programs with a reasonable complexity by themselves, can use a computer to discuss and explore optical phenomena, and are familiar with basic computational strategies that emerge in photonics, but comparably in any other scientific discipline as well.

Content

- Transfer Matrix Method to describe the optical response from stratified media
- Finite Differences to characterize eigenmode in fiber waveguides
- Beam propagation method to describe the evolution of light in the realm of integrated optics
- Grating methods to predict reflection and transmission from periodically arranged material in 1D and 2D
- Mie Theory to describe the scattering of light from individual cylindrical or spherical objects
- Finite-Difference Time-Domain method as a general purpose tool to solve micro- and nanooptical problems
- Multiple Multipole Method as an approach to describe light scattering from single objects with an arbitrary shape
- Greens' Methods to discuss equally the scattering from single objects but embedded in an inhomogeneous background
- Boundary Integral Method to discuss scattering from objects highly efficient using expressions for the fields on the surface

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture and completion of exercises (135 hours).

Recommendation
Interest in theoretical physics, optics and electrodynamics. Moreover, interest in computational aspects is important.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- “Principles of Optics” M. Born and E. Wolf
- “Computational Electro-magnetics: The Finite- Difference Time Domain Method,” A. Taflov and S. C. Hagness
- “Light Scattering by Small Particles” H. C. van de Hulst

Specific references for the individual topics will be given during the lectures.
The lecture material that will be fully made available online.

4.44 Module: Computational Physics [M-PHYS-107092]

Responsible: Prof. Dr. Matthias Steinhauser
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics) (Usage from 4/1/2025)
Second Major in Physics: Theoretical Particle Physics (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-114137	Computational Physics	8 CR	Steinhauser

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major / second major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-107093 - Computational Physics (Minor) must not have been started.

Competence Goal
Students are able to implement a given algorithm on a computer using various programming languages. They apply their knowledge to various physical questions ranging from particle to solid state physics.

Content
Partial differential equations, solitons, numerical solutions of the Schroedinger equation, time dependent phenomena, fractals, applications of Monte-Carlo simulations, percolation, Ising model, and various programming languages.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises and exam preparation (180 hours).

Recommendation
Knowledge in Mathematica and Python or C.

Literature
Will be provided in the lecture.

4.45 Module: Computational Physics (Minor) [M-PHYS-107093]

Responsible: Prof. Dr. Matthias Steinhauser
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-114138	Computational Physics (Minor)	8 CR	Steinhauser

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-107092 - Computational Physics must not have been started.

Competence Goal
Students are able to implement a given algorithm on a computer using various programming languages. They apply their knowledge to various physical questions ranging from particle to solid state physics.

Content
Partial differential equations, solitons, numerical solutions of the Schroedinger equation, time dependent phenomena, fractals, applications of Monte-Carlo simulations, percolation, Ising model, and various programming languages.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises (180 hours).

Recommendation
Knowledge in Mathematica and Python or C.

Literature
Will be provided in the lecture.

M 4.46 Module: Condensed Matter Theory I, Fundamentals [M-PHYS-102054]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Required Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102559	Condensed Matter Theory I, Fundamentals	8 CR	Eder, Garst, Mirlin, Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102051 - Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor) must not have been started.
2. The module M-PHYS-102052 - Condensed Matter Theory I, Fundamentals (Minor) must not have been started.
3. The module M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a limited class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in an external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

4.47 Module: Condensed Matter Theory I, Fundamentals (Minor) [M-PHYS-102052]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102557	Condensed Matter Theory I, Fundamentals (Minor)	8 CR	Eder, Garst, Mirlin, Shnirman

Competence Certificate
Course work, ungraded.

The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102051 - Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor) must not have been started.
2. The module M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics must not have been started.
3. The module M-PHYS-102054 - Condensed Matter Theory I, Fundamentals must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a limited class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in an external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

4.48 Module: Condensed Matter Theory I, Fundamentals and Advanced Topics [M-PHYS-102053]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Required Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102558	Condensed Matter Theory I, Fundamentals and Advanced Topics	12 CR	Eder, Garst, Mirlin, Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102051 - Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor) must not have been started.
2. The module M-PHYS-102052 - Condensed Matter Theory I, Fundamentals (Minor) must not have been started.
3. The module M-PHYS-102054 - Condensed Matter Theory I, Fundamentals must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a broader class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in the external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction;
- Superconductivity: BCS theory, electrodynamics of superconductors, Ginzburg-Landau theory.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (270 hours)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

M 4.49 Module: Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor) [M-PHYS-102051]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102556	Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor)	12 CR	Eder, Garst, Mirlin, Shnirman

Competence Certificate
Course work, ungraded.

The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102052 - Condensed Matter Theory I, Fundamentals (Minor) must not have been started.
2. The module M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics must not have been started.
3. The module M-PHYS-102054 - Condensed Matter Theory I, Fundamentals must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a broader class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in the external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction;
- Superconductivity: BCS theory, electrodynamics of superconductors, Ginzburg-Landau theory.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture and work on the exercises (270 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

4.50 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals [M-PHYS-102313]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104591	Condensed Matter Theory II: Many-Body Systems, Fundamentals	8 CR	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-102312 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-102314 - Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor) must not have been started.
4. The module M-PHYS-103331 - Condensed Matter Theory II: Many-Body Theory, selected topics must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a limited class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green’s functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green’s functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

M 4.51 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor) [M-PHYS-102314]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104592	Condensed Matter Theory II: Many-Body Systems, Fundamentals (Minor)	8 CR	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Competence Certificate
Course work, ungraded.

The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-102312 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals must not have been started.
4. The module M-PHYS-103331 - Condensed Matter Theory II: Many-Body Theory, selected topics must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a limited class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green’s functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green’s functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

M 4.52 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics [M-PHYS-102308]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102560	Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics	12 CR	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102312 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor) must not have been started.
2. The module M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals must not have been started.
3. The module M-PHYS-102314 - Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor) must not have been started.
4. The module M-PHYS-103331 - Condensed Matter Theory II: Many-Body Theory, selected topics must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a broader class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green's functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green's functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension
9. Kondo effect
10. Strongly correlated electrons: Hubbard model and Mott metal-insulator transition
11. Introduction to mesoscopic physics

Workload
360 hours consisting of attendance time (90 hours), follow-up of the lecture incl. exam preparation and working on the exercises (270 hours)

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

M 4.53 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor) [M-PHYS-102312]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102562	Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics (Minor)	12 CR	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Competence Certificate
Course work, ungraded.

The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals must not have been started.
3. The module M-PHYS-102314 - Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor) must not have been started.
4. The module M-PHYS-103331 - Condensed Matter Theory II: Many-Body Theory, selected topics must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a broader class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green’s functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green’s functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension
9. Kondo effect
10. Strongly correlated electrons: Hubbard model and Mott metal-insulator transition
11. Introduction to mesoscopic physics

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture and work on the exercises (270 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

4.54 Module: Condensed Matter Theory II: Many-Body Theory, selected topics [M-PHYS-103331]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-106676	Condensed Matter Theory II: Many-Body Systems, selected topics	2 CR	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Competence Certificate

Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites

none

Modeled Conditions

The following conditions have to be fulfilled:

1. The module M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-102312 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals must not have been started.
4. The module M-PHYS-102314 - Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor) must not have been started.

Competence Goal

Acquiring basic knowledge about advanced field-theoretical approaches of condensed matter physics.

Content

Estimated structure of the lecture:

- Green's functions for non-interacting particles
- Many-body Green’s functions
- Feynman diagrams

Workload

60 hours consisting of attendance time (15 hours), wrap-up of the lecture incl. exam preparation (45 hours).

Recommendation

In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

M 4.55 Module: Detectors for Particle and Astroparticle Physics, with ext. Exercises [M-PHYS-102121]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102378	Detectors for Particle and Astroparticle Physics, with ext. Exercises	8 CR	Hartmann, Husemann, Klute

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102119 - Detectors for Particle and Astroparticle Physics, without ext. Exercises must not have been started.
2. The module M-PHYS-102120 - Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102122 - Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Advanced study in one area of experimental particle and astroparticle physics. Students learn experimental aspects of measuring particle properties. Thus, they learn the basics for a detailed analysis of experimental data, the operation of complex experiments and the work with modern particle detectors. The practical exercises introduce the students to experimental work with detectors in teams. In extended exercises, basic principles of sensors and their design optimization are simulated on the computer.

Content
Interaction of electrons, photons, muons, charged and neutral hadrons with matter; electronic detection of particle radiation and measurement of deposited energy and particle identification; gas-filled detectors, scintillators, photomultipliers, silicon detectors, electromagnetic and hadronic calorimeters, detector systems, triggers and data acquisition, reconstruction of physical objects in detector systems, applications outside basic research.

Workload
240 hours, of which attendance time (60 hours). The remaining hours are used for preparation for the experiments, preparation of practical protocols, follow-up of the lecture material and preparation for the examination (180 hours).

Recommendation
Basic knowledge of experimental nuclear and particle physics, e.g. from the lecture Modern Experimental Physics III in the bachelor's program in physics. Basic knowledge of electronics is also helpful.

Literature

- K. Kleinknecht: Detektoren für Teilchenstrahlung, Teubner (2005)
- W. R. Leo: Techniques for Nuclear and Particle Physics Experiments, Springer (1994)
- C. Grupen: Particle Detectors, Cambridge University Press (2011)
- Particle Data Group: The Review of Particle Physics
- N. Wermes, H. Kolanoski: Teilchendetektoren, Springer (2016)

M 4.56 Module: Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor) [M-PHYS-102122]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102431	Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor)	8 CR	Hartmann, Husemann, Klute

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102119 - Detectors for Particle and Astroparticle Physics, without ext. Exercises must not have been started.
2. The module M-PHYS-102120 - Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102121 - Detectors for Particle and Astroparticle Physics, with ext. Exercises must not have been started.

Competence Goal
Advanced study in one area of experimental particle and astroparticle physics. Students learn experimental aspects of measuring particle properties. Thus, they learn the basics for a detailed analysis of experimental data, the operation of complex experiments and the work with modern particle detectors. The practical exercises introduce the students to experimental work with detectors in teams. In extended exercises, basic principles of sensors and their design optimization are simulated on the computer.

Content
Interaction of electrons, photons, muons, charged and neutral hadrons with matter; electronic detection of particle radiation and measurement of deposited energy and particle identification; gas-filled detectors, scintillators, photomultipliers, silicon detectors, electromagnetic and hadronic calorimeters, detector systems, triggers and data acquisition, reconstruction of physical objects in detector systems, applications outside basic research.

Workload
240 hours, of which attendance time (60 hours). The remaining hours are for preparation for the experiments, preparation of practical protocols and follow-up of the lecture material (180 hours).

Recommendation
Basic knowledge of experimental nuclear and particle physics, e.g. from the lecture Modern Experimental Physics III in the bachelor's program in physics. Basic knowledge of electronics is also helpful.

Literature

- K. Kleinknecht: Detektoren für Teilchenstrahlung, Teubner (2005)
- W. R. Leo: Techniques for Nuclear and Particle Physics Experiments, Springer (1994)
- C. Grupen: Particle Detectors, Cambridge University Press (2011)
- Particle Data Group: The Review of Particle Physics
- N. Wermes, H. Kolanoski: Teilchendetektoren, Springer (2016)

4.57 Module: Detectors for Particle and Astroparticle Physics, without ext. Exercises [M-PHYS-102119]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104453	Detectors for Particle and Astroparticle Physics, without ext. Exercises	6 CR	Hartmann, Husemann, Klute

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102120 - Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102121 - Detectors for Particle and Astroparticle Physics, with ext. Exercises must not have been started.
3. The module M-PHYS-102122 - Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Advanced study in one area of experimental particle and astroparticle physics. Students learn experimental aspects of measuring particle properties. Thus, they learn the basics for a detailed analysis of experimental data, the operation of complex experiments and the work with modern particle detectors. The practical exercises introduce the students to experimental work with detectors in teams.

Content
Interaction of electrons, photons, muons, charged and neutral hadrons with matter; electronic detection of particle radiation and measurement of deposited energy and particle identification; gas-filled detectors, scintillators, photomultipliers, silicon detectors, electromagnetic and hadronic calorimeters, detector systems, triggers and data acquisition, reconstruction of physical objects in detector systems, applications outside basic research.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and processing of the exercises and the internship (135 hours).

Recommendation
Basic knowledge of experimental nuclear and particle physics, e.g. from the lecture Modern Experimental Physics III in the bachelor's program in physics. Basic knowledge of electronics is also helpful.

Literature

- K. Kleinknecht: Detektoren für Teilchenstrahlung, Teubner (2005)
- W. R. Leo: Techniques for Nuclear and Particle Physics Experiments, Springer (1994)
- C. Grupen: Particle Detectors, Cambridge University Press (2011)
- Particle Data Group: The Review of Particle Physics
- N. Wermes, H. Kolanoski: Teilchendetektoren, Springer (2016)

4.58 Module: Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor) [M-PHYS-102120]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104454	Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor)	6 CR	Hartmann, Husemann, Klute

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102119 - Detectors for Particle and Astroparticle Physics, without ext. Exercises must not have been started.
2. The module M-PHYS-102121 - Detectors for Particle and Astroparticle Physics, with ext. Exercises must not have been started.
3. The module M-PHYS-102122 - Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Advanced study in one area of experimental particle and astroparticle physics. Students learn experimental aspects of measuring particle properties. Thus, they learn the basics for a detailed analysis of experimental data, the operation of complex experiments and the work with modern particle detectors. The practical exercises introduce the students to experimental work with detectors in teams.

Content
Interaction of electrons, photons, muons, charged and neutral hadrons with matter; electronic detection of particle radiation and measurement of deposited energy and particle identification; gas-filled detectors, scintillators, photomultipliers, silicon detectors, electromagnetic and hadronic calorimeters, detector systems, triggers and data acquisition, reconstruction of physical objects in detector systems, applications outside basic research.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. working on the exercises and the internship (135 hours).

Recommendation
Basic knowledge of experimental nuclear and particle physics, e.g. from the lecture Modern Experimental Physics III in the bachelor's program in physics. Basic knowledge of electronics is also helpful.

Literature

- K. Kleinknecht: Detektoren für Teilchenstrahlung, Teubner (2005)
- W. R. Leo: Techniques for Nuclear and Particle Physics Experiments, Springer (1994)
- C. Grupen: Particle Detectors, Cambridge University Press (2011)
- Particle Data Group: The Review of Particle Physics
- N. Wermes, H. Kolanoski: Teilchendetektoren, Springer (2016)

M 4.59 Module: Effective Field Theories [M-PHYS-107091]

Responsible: Jun.-Prof. Dr. Anke Biekötter
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics) (Usage from 4/1/2025)
Second Major in Physics: Theoretical Particle Physics (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-114136	Effective Field Theories	4 CR	Biekötter

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major / second major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
The students are familiar with a systematic approach to theories with multiple scales. They are able to integrate out heavy degrees of freedom of a theory and calculate predictions at lower energy scales. They are also able to analyze the phenomenology of an effective Lagrangian and compare its predictions to data. Moreover, students of this course are familiar with effective field theories applied to searches beyond the Standard Model of particle physics, including theories with additional light degrees of freedom.

Content
Basics of effective field theory, decoupling, Standard Model effective field theory, phenomenology at dimension six, flavor assumptions, renormalization group evolution, matching of full models; low energy effective field theory; effective field theories with new light particles.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. preparation of the exercises and exam preparation (90 hours).

Recommendation
Prior knowledge of the basics of quantum field theory and the Standard Model of particle physics is recommended.

Literature
Literature recommendations will be given in the first lecture.

M 4.60 Module: Electron Microscopy I, with Exercises [M-PHYS-102989]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-105965	Electron Microscopy I, with Exercises	8 CR	Eggeler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none, the lectures Electron Microscopy I and II are independent of each other

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102990 - Electron Microscopy I, without Exercises must not have been started.
2. The module M-PHYS-102991 - Electron Microscopy I, with Exercises (Minor) must not have been started.

Competence Goal
From analogies to light microscopy, students will understand parallels and differences between light microscopy and transmission electron microscopy (TEM) as well as image formation in the transmission electron microscope. Students will be able to describe and explain the interaction between high energy electrons and solids (kinematic diffraction theory and its limitations in electron-solid interaction, dynamic diffraction theory). Using theoretical concepts for dynamic electron diffraction and the imaging process, interpret TEM images (What contrasts arise for perfect solids and defects in solids?). Through application examples from solid state physics and materials research, students will learn and understand the applications and limitations of TEM.

In the practical exercises the theoretical concepts from the lecture as well as TEM imaging modes will be visualized, practiced and deepened by working in small groups.

Content
Transmission electron microscopy (TEM), high-resolution TEM, scanning transmission electron microscopy, kinematic and dynamic electron diffraction in the solid state, TEM contrast generation with application examples from materials and solid state physics, electron holography, transmission electron microscopy with phase plates.

Workload
240 hours, of which attendance time (60 hours). The remaining hours are for preparation for the experiments, preparation of practical protocols, wrap-up of the lecture material and preparation for the examination (180 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics or materials science, quantum mechanics

Literature

- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer
- L. Reimer, H. Kohl, Transmission Electron Microscopy, Springer Verlag

4.61 Module: Electron Microscopy I, with Exercises (Minor) [M-PHYS-102991]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-105968	Electron Microscopy I, with Exercises (Minor)	8 CR	Eggeler

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none, the lectures Electron Microscopy I and II are independent of each other

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102989 - Electron Microscopy I, with Exercises must not have been started.
2. The module M-PHYS-102990 - Electron Microscopy I, without Exercises must not have been started.

Competence Goal
From analogies to light microscopy, students will understand parallels and differences between light microscopy and transmission electron microscopy (TEM) as well as image formation in the transmission electron microscope. Students will be able to describe and explain the interaction between high energy electrons and solids (kinematic diffraction theory and its limitations in electron-solid interaction, dynamic diffraction theory). Using theoretical concepts for dynamic electron diffraction and the imaging process, interpret TEM images (What contrasts arise for perfect solids and defects in solids?). Through application examples from solid state physics and materials research, students will learn and understand the applications and limitations of TEM.

In the practical exercises the theoretical concepts from the lecture as well as TEM imaging modes will be visualized, practiced and deepened by working in small groups.

Content
Transmission electron microscopy (TEM), high-resolution TEM, scanning transmission electron microscopy, kinematic and dynamic electron diffraction in the solid state, TEM contrast generation with application examples from materials and solid state physics, electron holography, transmission electron microscopy with phase plates.

Workload
240 hours, of which attendance time (60 hours). The remaining hours are used for preparation for the experiments, preparation of practical protocols and wrap-up of the lecture material (180 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics or materials science, quantum mechanics

Literature

- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer
- L. Reimer, H. Kohl, Transmission Electron Microscopy, Springer Verlag

4.62 Module: Electron Microscopy I, without Exercises [M-PHYS-102990]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-105967	Electron Microscopy I, without Exercises	4 CR	Eggeler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none, the lectures Electron Microscopy I and II are independent of each other

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102989 - Electron Microscopy I, with Exercises must not have been started.
2. The module M-PHYS-102991 - Electron Microscopy I, with Exercises (Minor) must not have been started.

Competence Goal
From analogies to light microscopy, students will understand parallels and differences between light microscopy and transmission electron microscopy (TEM) as well as image formation in the transmission electron microscope. Students will be able to describe and explain the interaction between high energy electrons and solids (kinematic diffraction theory and its limitations in electron-solid interaction, dynamic diffraction theory). Using theoretical concepts for dynamic electron diffraction and the imaging process, interpret TEM images (What contrasts arise for perfect solids and defects in solids?). Through application examples from solid state physics and materials research, students will learn and understand the applications and limitations of TEM.

Content
Transmission electron microscopy (TEM), high-resolution TEM, scanning transmission electron microscopy, kinematic and dynamic electron diffraction in the solid state, TEM contrast generation with application examples from materials and solid state physics, electron holography, transmission electron microscopy with phase plates.

Workload
120 hours, of which attendance time (30 hours). The remaining hours are used for wrap-up of the lecture material and preparation for the exam (90 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics or materials science, quantum mechanics

Literature

- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer
- L. Reimer, H. Kohl, Transmission Electron Microscopy, Springer Verlag

M 4.63 Module: Electron Microscopy II, with Exercises [M-PHYS-102227]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-PHYS-102349	Electron Microscopy II, with Exercises	8 CR	Eggeler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102844 - Electron Microscopy II, without Exercises must not have been started.
2. The module M-PHYS-103172 - Electron Microscopy II, with Exercises (Minor) must not have been started.

Competence Goal
Students should be able to understand and explain image formation in scanning electron microscopy and scanning ion microscopy, nanostructuring with focused ion beams, and analytical procedures in electron microscopy (chemical analysis, electronic properties). On the basis of application examples from materials and solid-state physics, students should be able to recognize possible applications and limitations of the methods. The students should be able to assess which method(s) is (are) suitable for specific problems from micro- and nanocharacterization.

In the practical exercises, the theoretical concepts from the lecture as well as imaging modes in scanning electron microscopy and scanning ion microscopy are visualized, practiced and deepened by working in small groups. Students should be able to adjust a scanning electron microscope for simple applications.

Content
Scanning electron microscopy, imaging and patterning with focused ion beams, analytical techniques in electron microscopy (energy dispersive X-ray spectroscopy and electron energy loss spectroscopy).

Workload
240 hours, of which attendance time (60 hours). The remaining hours are for preparation for the experiments, preparation of practical protocols, wrap-up of the lecture material and preparation for the examination (180 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics and materials science

Literature

- L. Reimer, Scanning Electron Microscopy, Springer
- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer

M 4.64 Module: Electron Microscopy II, with Exercises (Minor) [M-PHYS-103172]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	German/English	4	1

Mandatory			
T-PHYS-106306	Electron Microscopy II, with Exercises (Minor)	8 CR	Eggeler

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102844 - Electron Microscopy II, without Exercises must not have been started.
2. The module M-PHYS-102227 - Electron Microscopy II, with Exercises must not have been started.

Competence Goal
Students should be able to understand and explain image formation in scanning electron microscopy and scanning ion microscopy, nanostructuring with focused ion beams, and analytical procedures in electron microscopy (chemical analysis, electronic properties). On the basis of application examples from materials and solid-state physics, students should be able to recognize possible applications and limitations of the methods. The students should be able to assess which method(s) is (are) suitable for specific problems from micro- and nanocharacterization.

In the practical exercises, the theoretical concepts from the lecture as well as imaging modes in scanning electron microscopy and scanning ion microscopy are visualized, practiced and deepened by working in small groups. Students should be able to adjust a scanning electron microscope for simple applications.

Content
Scanning electron microscopy, imaging and patterning with focused ion beams, analytical techniques in electron microscopy (energy dispersive X-ray spectroscopy and electron energy loss spectroscopy).

Workload
240 hours, of which attendance time (60 hours). The remaining hours are used for preparation for the experiments, preparation of practical protocols and wrap-up of the lecture material (180 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics and materials science

Literature

- L. Reimer, Scanning Electron Microscopy, Springer
- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer

M 4.65 Module: Electron Microscopy II, without Exercises [M-PHYS-102844]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-PHYS-105817	Electron Microscopy II, without Exercises	4 CR	Eggeler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102227 - Electron Microscopy II, with Exercises must not have been started.
2. The module M-PHYS-103172 - Electron Microscopy II, with Exercises (Minor) must not have been started.

Competence Goal
Students should be able to understand and explain image formation in scanning electron microscopy and scanning ion microscopy, nanostructuring with focused ion beams, and analytical procedures in electron microscopy (chemical analysis, electronic properties). On the basis of application examples from materials and solid-state physics, students should be able to recognize possible applications and limitations of the methods. The students should be able to assess which method(s) is (are) suitable for specific problems from micro- and nanocharacterization.

Content
Scanning electron microscopy, imaging and patterning with focused ion beams, analytical techniques in electron microscopy (energy dispersive X-ray spectroscopy and electron energy loss spectroscopy).

Workload
120 hours, of which attendance time (30 hours). The remaining hours are used for wrap-up of the lecture material and preparation for the exam (90 hours).

Recommendation
Basic knowledge of optics, solid state physics, materials physics and materials science

Literature

- L. Reimer, Scanning Electron Microscopy, Springer
- D.B. Williams, C.B Carter, Transmission Electron Microscopy, 2nd edition, Springer

4.66 Module: Electronic Properties of Solids I, with Exercises [M-PHYS-102089]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Required Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102577	Electronic Properties of Solids I, with Exercises	10 CR	Le Tacon, Wernsdorfer, Wulfhekel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102087 - Electronic Properties of Solids I, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102090 - Electronic Properties of Solids I, without Exercises must not have been started.

Competence Goal
Students will be familiar with the most common experimental methods for studying the electronic properties of condensed matter and some of the key theoretical concepts that underlie them. They master the basic tools for studying and understanding heat transport, scattering mechanisms, phase transitions, and magnetism. Exercises will reinforce the acquired knowledge and apply it to classical condensed matter problems.

Content

- Metal and insulators: Band structure, Fermi surface
- Electronic and heat transport - scattering mechanisms
- Phase transitions: Landau theory, critical exponents
- Atomic magnetism and magnetic interactions
- Magnetic structures, dynamics

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
300 hours consisting of attendance time (75 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (225 hours)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics and statistical physics is assumed.

Literature

- R. Gross, A. Marx, Festkörperphysik
- N. W. Ashcroft, N. D. Mermin: Festkörperphysik
- H. Ibach, H. Lüth: Festkörperphysik
- C. Kittel: Einführung in die Festkörperphysik
- S. Blundell, Magnetism in Condensed Matter

M 4.67 Module: Electronic Properties of Solids I, with Exercises (Minor) [M-PHYS-102087]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102575	Electronic Properties of Solids I, with Exercises (Minor)	10 CR	Le Tacon, Wernsdorfer, Wulfhekel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102089 - Electronic Properties of Solids I, with Exercises must not have been started.
2. The module M-PHYS-102090 - Electronic Properties of Solids I, without Exercises must not have been started.

Competence Goal
Students will be familiar with the most common experimental methods for studying the electronic properties of condensed matter and some of the key theoretical concepts that underlie them. They master the basic tools for studying and understanding heat transport, scattering mechanisms, phase transitions, and magnetism. Exercises will reinforce the acquired knowledge and apply it to classical condensed matter problems.

Content

- Metal and insulators: Band structure, Fermi surface
- Electronic and heat transport - scattering mechanisms
- Phase transitions: Landau theory, critical exponents
- Atomic magnetism and magnetic interactions
- Magnetic structures, dynamics

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
300 hours consisting of attendance time (75 hours), wrap-up of the lecture and preparation of the exercises (225 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics and statistical physics is assumed.

Literature

- R. Gross, A. Marx, Festkörperphysik
- N. W. Ashcroft, N. D. Mermin: Festkörperphysik
- H. Ibach, H. Lüth: Festkörperphysik
- C. Kittel: Einführung in die Festkörperphysik
- S. Blundell, Magnetism in Condensed Matter

4.68 Module: Electronic Properties of Solids I, without Exercises [M-PHYS-102090]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Required Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102578	Electronic Properties of Solids I, without Exercises	8 CR	Le Tacon, Wernsdorfer, Wulfhekel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102087 - Electronic Properties of Solids I, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102089 - Electronic Properties of Solids I, with Exercises must not have been started.

Competence Goal
Students will be familiar with the most common experimental methods for studying the electronic properties of condensed matter and some of the key theoretical concepts that underlie them. They will master the basic tools for studying and understanding heat transport, scattering mechanisms, phase transitions, and magnetism.

Content

- Metal and insulators: Band structure, Fermi surface
- Electronic and heat transport - scattering mechanisms
- Phase transitions: Landau theory, critical exponents
- Atomic magnetism and magnetic interactions
- Magnetic structures, dynamics

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation (180 hours)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics and statistical physics is assumed.

Literature

- R. Gross, A. Marx, Festkörperphysik
- N. W. Ashcroft, N. D. Mermin: Festkörperphysik
- H. Ibach, H. Lüth: Festkörperphysik
- C. Kittel: Einführung in die Festkörperphysik
- S. Blundell, Magnetism in Condensed Matter

M 4.69 Module: Electronic Properties of Solids II, with Exercises [M-PHYS-102108]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104422	Electronic Properties of Solids II, with Exercises	8 CR	Le Tacon, Rotzinger, Ustinov, Wernsdorfer

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102106 - Electronic Properties of Solids II, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102109 - Electronic Properties of Solids II, without Exercises must not have been started.

Competence Goal
Students know the physical properties of superconductivity, a thermodynamic state of the electronic system of solids. They understand classical and modern experimental findings as well as basic theoretical models, such as the concept of the energy gap or the quasiparticle, which is also commonly used outside superconductivity. They apply the acquired knowledge to specific problems. The students are able to familiarize themselves with current literature on the subject of superconductivity.

Content
Foundations of superconductivity: thermodynamics, electrodynamics, flux quantization, Ginzburg-Landau theory, BCS theory, vortices, tunnel junctions, Josephson junctions, SQUIDs, superconducting electronics, superconducting qubits.

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- V.V. Schmidt, “The Physics of Superconductors: Introduction to Fundamentals and Applications”, Springer (1997), ISBN 978-3540612438
- M. Tinkham, „Introduction to Superconductivity: Vol I“, Dover Publ. (2004), ISBN: 978-0486435039
- W. Buckel und R. Kleiner, „Supraleitung: Grundlagen und Anwendungen“, Wiley-VCH (2004), ISBN: 978-3527403486

4.70 Module: Electronic Properties of Solids II, with Exercises (Minor) [M-PHYS-102106]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104420	Electronic Properties of Solids II, with Exercises (Minor)	8 CR	Le Tacon, Rotzinger, Ustinov, Wernsdorfer

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102108 - Electronic Properties of Solids II, with Exercises must not have been started.
2. The module M-PHYS-102109 - Electronic Properties of Solids II, without Exercises must not have been started.

Competence Goal
Students know the physical properties of superconductivity, a thermodynamic state of the electronic system of solids. They understand classical and modern experimental findings as well as basic theoretical models, such as the concept of the energy gap or the quasiparticle, which is also commonly used outside superconductivity. They apply the acquired knowledge to specific problems. The students are able to familiarize themselves with current literature on the subject of superconductivity.

Content
Foundations of superconductivity: thermodynamics, electrodynamics, flux quantization, Ginzburg-Landau theory, BCS theory, vortices, tunnel junctions, Josephson junctions, SQUIDs, superconducting electronics, superconducting qubits.

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- V.V. Schmidt, "The Physics of Superconductors: Introduction to Fundamentals and Applications", Springer (1997), ISBN 978-3540612438
- M. Tinkham, „Introduction to Superconductivity: Vol I", Dover Publ. (2004), ISBN: 978-0486435039
- W. Buckel und R. Kleiner, „Supraleitung: Grundlagen und Anwendungen", Wiley-VCH (2004), ISBN: 978-3527403486

M 4.71 Module: Electronic Properties of Solids II, without Exercises [M-PHYS-102109]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104423	Electronic Properties of Solids II, without Exercises	4 CR	Le Tacon, Rotzinger, Ustinov, Wernsdorfer

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102106 - Electronic Properties of Solids II, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102108 - Electronic Properties of Solids II, with Exercises must not have been started.

Competence Goal
Students know the physical properties of superconductivity, a thermodynamic state of the electronic system of solids. They understand classical and modern experimental findings as well as basic theoretical models, such as the concept of the energy gap or the quasiparticle, which is also commonly used outside of superconductivity. Students are able to familiarize themselves with current literature on superconductivity.

Content
Foundations of superconductivity: thermodynamics, electrodynamics, flux quantization, Ginzburg-Landau theory, BCS theory, vortices, tunnel junctions, Josephson junctions, SQUIDs, superconducting electronics, superconducting qubits.

Annotation
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation (90 hours)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- V.V. Schmidt, “The Physics of Superconductors: Introduction to Fundamentals and Applications”, Springer (1997), ISBN 978-3540612438
- M. Tinkham, „Introduction to Superconductivity: Vol I“, Dover Publ. (2004), ISBN: 978-0486435039
- W. Buckel und R. Kleiner, „Supraleitung: Grundlagen und Anwendungen“, Wiley-VCH (2004), ISBN: 978-3527403486

M 4.72 Module: Electronics for Physicists [M-PHYS-102184]

Responsible: PD Dr. Klaus Rabbertz
Prof. Dr. Frank Simon

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Non-Physics Elective

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104479	Electronics for Physicists	10 CR	Rabbertz, Simon

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102185 - Electronics for Physicists (Minor) must not have been started.

Competence Goal
Deepening knowledge in technical aspects of experimental physics, with an emphasis on instrumentation for particle and astroparticle physics.
Providing a basic understanding of analog and digital electronics and their application in experimental physics. Understanding of analog and digital circuits and their construction and testing. Use of modern measurement equipment such as digital oscilloscopes and evaluation of the measurement results obtained in comparison with circuit simulations of analog electronics. Use and programming of modern digital electronics hardware (FPGAs) and evaluation of the results obtained.

Content
Introduction to analog and digital electronics:

- The “electronics chain” of detectors in experimental physics
- Fundamentals, linear networks, passive components, filters
- Elementary circuit analysis and simulation
- Operational amplifiers, Bipolar and field effect transistors
- Basic circuits with one and two transistors
- Number systems, circuit algebra, logic devices, flip-flops, memories
- Analog-to-digital converters
- Programmable electronics: CPLDs, FPGAs
- Packaging and interconnection technology
- Noise in detector systems

Workload
300 hours consisting of attendance time (75 hours), follow-up of the lecture incl. exam preparation and processing of the exercises and the internship (225 hours).

Recommendation
Interest in electronics

Literature
Literature will be mentioned in the lecture. A script will also be provided.

M 4.73 Module: Electronics for Physicists (Minor) [M-PHYS-102185]

Responsible: PD Dr. Klaus Rabbertz
Prof. Dr. Frank Simon

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104480	Electronics for Physicists (Minor)	10 CR	Rabbertz, Simon

Competence Certificate
The course credit is achieved through successful participation in the practical exercises. The details will be announced in the first lecture or at the first practical exercises.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102184 - Electronics for Physicists must not have been started.

Competence Goal
Deepening knowledge in technical aspects of experimental physics, with an emphasis on instrumentation for particle and astroparticle physics.
Providing a basic understanding of analog and digital electronics and their application in experimental physics. Understanding of analog and digital circuits and their construction and testing. Use of modern measurement equipment such as digital oscilloscopes and evaluation of the measurement results obtained in comparison with circuit simulations of analog electronics. Use and programming of modern digital electronics hardware (FPGAs) and evaluation of the results obtained.

Content
Introduction to analog and digital electronics:

- The “electronics chain” of detectors in experimental physics
- Fundamentals, linear networks, passive components, filters
- Elementary circuit analysis and simulation
- Operational amplifiers, Bipolar and field effect transistors
- Basic circuits with one and two transistors
- Number systems, circuit algebra, logic devices, flip-flops, memories
- Analog-to-digital converters
- Programmable electronics: CPLDs, FPGAs
- Packaging and interconnection technology
- Noise in detector systems

Workload
300 hours consisting of attendance time (75 hours), wrap-up of lecture and completion of exercises and lab (225 hours).

Recommendation
Interest in electronics

Literature
Literature will be mentioned in the lecture. A script will also be provided.

M 4.74 Module: Experimental Biophysics II, with Seminar [M-PHYS-102165]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Required Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
14	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102532	Experimental Biophysics II, with Seminar	14 CR	Nienhaus

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102166 - Experimental Biophysics II, with Seminar (Minor) must not have been started.
2. The module M-PHYS-102167 - Experimental Biophysics II, without Seminar must not have been started.
3. The module M-PHYS-102168 - Experimental Biophysics II, without Seminar (Minor) must not have been started.

Competence Goal
The students

- are able to describe the basic structure of biomatter and are familiar with its structural, dynamic and energetic properties.
- understand the physical principles of biomolecular spectroscopy and can appreciate the application of the various methods to the study of biomolecular processes.
- are familiar with the basic approaches to relaxation and fluctuation spectroscopy.
- understand the physical principles of interactions essential to molecular functional processes (chemical bonding, electron transfer, energy transfer) and the parameters that determine transition rates.
- acquire in-depth knowledge during the exercises by solving exercise problems. They present their results and thus further develop their abilities to share the acquired knowledge with the other students.
- independently acquire in-depth knowledge on a special topic of biophysics and give a presentation on this topic. They thus develop their skills in scientific presentation, which includes the selection of the material from a didactic point of view, the structuring of the lecture, the slide design, the actual presentation and answering questions from the audience.

Content
After a brief introduction to the structure, dynamics and energetics of biomolecules, light-optical spectroscopic methods (including optical absorption and fluorescence, infrared and Raman spectroscopy) are introduced, which can be used to observe biomolecular structures and their changes as a function of time. Light microscopy including super-resolution techniques are covered as well. The physical principles on which important biomolecular processes (ligand binding, energy and electron transfer in photosynthesis) are based are then discussed.

Workload
420 hours consisting of attendance time (120 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises as well as the seminar presentation (300 hours).

Recommendation
Fundamentals of quantum mechanics, thermodynamics, and solid state physics are assumed.

Literature

- G. U. Nienhaus: Skripten zur Vorlesung Biophysik I und II
- E. Sackmann & R. Merkel: Lehrbuch der Biophysik
- C. Cantor & P. Schimmel: Biophysical Chemistry
- I. N. Serdyuk, N. R. Zaccai & J. Zaccai: Methods in Molecular Biophysics

M 4.75 Module: Experimental Biophysics II, with Seminar (Minor) [M-PHYS-102166]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
14	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102533	Experimental Biophysics II, with Seminar (Minor)	14 CR	Nienhaus

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102165 - Experimental Biophysics II, with Seminar must not have been started.
2. The module M-PHYS-102167 - Experimental Biophysics II, without Seminar must not have been started.
3. The module M-PHYS-102168 - Experimental Biophysics II, without Seminar (Minor) must not have been started.

Competence Goal
The students

- are able to describe the basic structure of biomatter and are familiar with its structural, dynamic and energetic properties.
- understand the physical principles of biomolecular spectroscopy and can appreciate the application of the various methods to the study of biomolecular processes.
- are familiar with the basic approaches to relaxation and fluctuation spectroscopy.
- understand the physical principles of interactions essential to molecular functional processes (chemical bonding, electron transfer, energy transfer) and the parameters that determine transition rates.
- acquire in-depth knowledge during the exercises by solving exercise problems. They present their results and thus further develop their abilities to share the acquired knowledge with the other students.
- independently acquire in-depth knowledge on a special topic of biophysics and give a presentation on this topic. They thus develop their skills in scientific presentation, which includes the selection of the material from a didactic point of view, the structuring of the lecture, the slide design, the actual presentation and answering questions from the audience.

Content
After a brief introduction to the structure, dynamics and energetics of biomolecules, light-optical spectroscopic methods (including optical absorption and fluorescence, infrared and Raman spectroscopy) are introduced, which can be used to observe biomolecular structures and their changes as a function of time. Light microscopy including super-resolution techniques are covered as well. The physical principles on which important biomolecular processes (ligand binding, energy and electron transfer in photosynthesis) are based are then discussed.

Workload
420 hours consisting of attendance time (120 hours), wrap-up of the lecture and preparation of the exercises as well as the seminar presentation (300 hours).

Recommendation
Fundamentals of quantum mechanics, thermodynamics, and solid state physics are assumed.

Literature

- G. U. Nienhaus: Skripten zur Vorlesung Biophysik I und II
- E. Sackmann & R. Merkel: Lehrbuch der Biophysik
- C. Cantor & P. Schimmel: Biophysical Chemistry
- I. N. Serdyuk, N. R. Zaccai & J. Zaccai: Methods in Molecular Biophysics

M 4.76 Module: Experimental Biophysics II, without Seminar [M-PHYS-102167]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Required Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104471	Experimental Biophysics II, without Seminar	12 CR	Nienhaus

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102165 - Experimental Biophysics II, with Seminar must not have been started.
2. The module M-PHYS-102166 - Experimental Biophysics II, with Seminar (Minor) must not have been started.
3. The module M-PHYS-102168 - Experimental Biophysics II, without Seminar (Minor) must not have been started.

Competence Goal
The students

- are able to describe the basic structure of biomatter and are familiar with its structural, dynamic and energetic properties.
- understand the physical principles of biomolecular spectroscopy and can appreciate the application of the various methods to the study of biomolecular processes.
- are familiar with the basic approaches to relaxation and fluctuation spectroscopy.
- understand the physical principles of interactions essential to molecular functional processes (chemical bonding, electron transfer, energy transfer) and the parameters that determine transition rates.
- acquire in-depth knowledge during the exercises by solving exercise problems. They present their results and thus further develop their ability to share the acquired knowledge with the other students.

Content
After a brief introduction to the structure, dynamics and energetics of biomolecules, light-optical spectroscopic methods (including optical absorption and fluorescence, infrared and Raman spectroscopy) are introduced, which can be used to observe biomolecular structures and their changes as a function of time. Light microscopy including super-resolution techniques are covered as well. The physical principles on which important biomolecular processes (ligand binding, energy and electron transfer in photosynthesis) are based are then discussed.

Workload
360 hours consisting of attendance time (90 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (270 hours).

Recommendation
Fundamentals of quantum mechanics, thermodynamics, and solid state physics are assumed.

Literature

- G. U. Nienhaus: Skripten zur Vorlesung Biophysik I und II
- E. Sackmann & R. Merkel: Lehrbuch der Biophysik
- C. Cantor & P. Schimmel: Biophysical Chemistry
- I. N. Serdyuk, N. R. Zaccai & J. Zaccai: Methods in Molecular Biophysics

M 4.77 Module: Experimental Biophysics II, without Seminar (Minor) [M-PHYS-102168]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104472	Experimental Biophysics II, without Seminar (Minor)	12 CR	Nienhaus

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102165 - Experimental Biophysics II, with Seminar must not have been started.
2. The module M-PHYS-102166 - Experimental Biophysics II, with Seminar (Minor) must not have been started.
3. The module M-PHYS-102167 - Experimental Biophysics II, without Seminar must not have been started.

Competence Goal
The students

- are able to describe the basic structure of biomatter and are familiar with its structural, dynamic and energetic properties.
- understand the physical principles of biomolecular spectroscopy and can appreciate the application of the various methods to the study of biomolecular processes.
- are familiar with the basic approaches to relaxation and fluctuation spectroscopy.
- understand the physical principles of interactions essential to molecular functional processes (chemical bonding, electron transfer, energy transfer) and the parameters that determine transition rates.
- acquire in-depth knowledge during the exercises by solving exercise problems. They present their results and thus further develop their ability to share the acquired knowledge with the other students.

Content
After a brief introduction to the structure, dynamics and energetics of biomolecules, light-optical spectroscopic methods (including optical absorption and fluorescence, infrared and Raman spectroscopy) are introduced, which can be used to observe biomolecular structures and their changes as a function of time. Light microscopy including super-resolution techniques are covered as well. The physical principles on which important biomolecular processes (ligand binding, energy and electron transfer in photosynthesis) are based are then discussed.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture and preparation of the exercises (270 hours).

Recommendation
Fundamentals of quantum mechanics, thermodynamics, and solid state physics are assumed.

Literature

- G. U. Nienhaus: Skripten zur Vorlesung Biophysik I und II
- E. Sackmann & R. Merkel: Lehrbuch der Biophysik
- C. Cantor & P. Schimmel: Biophysical Chemistry
- I. N. Serdyuk, N. R. Zaccai & J. Zaccai: Methods in Molecular Biophysics

M 4.78 Module: Full-Waveform Inversion (Ungraded) [M-PHYS-104522]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-109272	Full-Waveform Inversion	6 CR	Bohlen, Hertweck

Competence Certificate
Final pass based on successful participation of the exercises.

Prerequisites
None

Competence Goal
The students know the fundamentals about full-waveform inversion from theory to practical implementation. They understand the basic concept of full-waveform inversion and grid-based finite-difference schemes to solve the wave equation. They understand important practical aspects such as numerical effects and critical performance issues. Students are able to implement a basic full-waveform inversion algorithm and apply it to simple data sets. They can analyze important factors influencing the success of full-waveform inversion and assess the quality of inversion results.

Content

- Introduction to full-waveform inversion (FWI)
- Solution of the wave equation with the finite-difference method
- Practical issues and numerical effects
- Adjoint-state method
- Adaption of the adjoint-state method for FWI
- FWI of shallow seismic wavefields

Module grade calculation
The coursework is not graded.

Workload
180 h hours composed of contact time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
Knowledge of differential calculus is essential. Experience with Matlab and general computer skills are beneficial.

Learning type
4060181Seismic Full Waveform Inversion (V2)
4060182 Exercises to Seismic Full Waveform Inversion (Ü1)

Literature

- Andreas Fichtner, "Full Seismic Waveform Modelling and Inversion", 2011, Springer.

M 4.79 Module: Fundamentals of Cryophysics, with Exercises [M-PHYS-106799]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113658	Fundamentals of Cryophysics, with Exercises	6 CR	Wulfhekel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106798 - Fundamentals of Cryophysics, without Exercises must not have been started.
2. The module M-PHYS-106801 - Fundamentals of Cryophysics, with Exercises (Minor) must not have been started.

Competence Goal

- students can identify experimental problems in cryogenics, analyze them and find solutions
- students can handle basic cryostat design rules and principles
- students learn principles of superconducting coil design and can design coils and current leads
- students can estimate thermal loads and standing times of cryostats
- students can handle cooling principles in the mK range
- students can apply the methods they have learned to solve simple problems in the exercises.

Content
This module will introduce student to experimental techniques at cryogenic temperatures including:

- cooling processes, cryogenic liquids
- cryostat design, thermal isolation and conduction
- cryostat cabling, superconducting coils
- dilution refrigeration, adiabatic demagnetization
- heat switches

Annotation
Students can apply the methods they have learned to solve simple problems in the exercises.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic kowledge of Solid State Physics and Thermodynamics

Literature

- J. Ekin, Experimental Techniques for Low-Temperature Measurements, Cryostat Design, Material Properties and Superconductor Critical-Current Testing, Oxford University Press
- F. Pobell, Matter and Methods at Low Temperatures, Springer

M 4.80 Module: Fundamentals of Cryophysics, with Exercises (Minor) [M-PHYS-106801]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113660	Fundamentals of Cryophysics, with Exercises (Minor)	6 CR	Wulfhekel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106798 - Fundamentals of Cryophysics, without Exercises must not have been started.
2. The module M-PHYS-106799 - Fundamentals of Cryophysics, with Exercises must not have been started.

Competence Goal

- students can identify experimental problems in cryogenics, analyze them and find solutions
- students can handle basic cryostat design rules and principles
- students learn principles of superconducting coil design and can design coils and current leads
- students can estimate thermal loads and standing times of cryostats
- students can handle cooling principles in the mK range
- students can apply the methods they have learned to solve simple problems in the exercises.

Content
This module will introduce student to experimental techniques at cryogenic temperatures including:

- cooling processes, cryogenic liquids
- cryostat design, thermal isolation and conduction
- cryostat cabling, superconducting coils
- dilution refrigeration, adiabatic demagnetization
- heat switches

Annotation
Students can apply the methods they have learned to solve simple problems in the exercises.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. preparation of the exercises (135 hours).

Recommendation
Basic kowledge of Solid State Physics and Thermodynamics

Literature

- J. Ekin, Experimental Techniques for Low-Temperature Measurements, Cryostat Design, Material Properties and Superconductor Critical-Current Testing, Oxford University Press
- F. Pobell, Matter and Methods at Low Temperatures, Springer

4.81 Module: Fundamentals of Cryophysics, without Exercises [M-PHYS-106798]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113657	Fundamentals of Cryophysics, without Exercises	4 CR	Wulfhekel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106799 - Fundamentals of Cryophysics, with Exercises must not have been started.
2. The module M-PHYS-106801 - Fundamentals of Cryophysics, with Exercises (Minor) must not have been started.

Competence Goal

- students can identify experimental problems in cryogenics, analyze them and find solutions
- students can handle basic cryostat design rules and principles
- students learn principles of superconducting coil design and can design coils and current leads
- students can estimate thermal loads and standing times of cryostats
- students can handle cooling principles in the mK range

Content
This module will introduce student to experimental techniques at cryogenic temperatures including:

- cooling processes, cryogenic liquids
- cryostat design, thermal isolation and conduction
- cryostat cabling, superconducting coils
- dilution refrigeration, adiabatic demagnetization
- heat switches

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation (90 hours).

Recommendation
Basic kowledge of Solid State Physics and Thermodynamics

Literature

- J. Ekin, Experimental Techniques for Low-Temperature Measurements, Cryostat Design, Material Properties and Superconductor Critical-Current Testing, Oxford University Press
- F. Pobell, Matter and Methods at Low Temperatures, Springer

M 4.82 Module: Geological Hazards and Risk [M-PHYS-101833]

Responsible: Dr. Andreas Schäfer
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	5

Mandatory			
T-PHYS-103525	Geological Hazards and Risk	8 CR	Schäfer

Competence Certificate
Active and regular attendance of lecture and practicals. Project work (graded).

Prerequisites
none

Competence Goal
The students understand basic concepts of hazard and risk. They can explain in detail different aspects of earthquake hazard, volcanic hazard as well as other geological hazards, can compare and evaluate those hazards. The have fundamental knowledge of risk reduction and risk management. They know methods of risk modelling and are able to apply them.

Content

- Earthquake Hazards
  - Short introduction to seismology and seismometry (occurrence of tectonic earthquakes, types of seismic waves, magnitude, intensity, source physics)
  - Induced seismicity
  - Engineering seismology, Recurrence intervals, Gutenberg-Richter, PGA, PGV, spectral acceleration, hazard maps
  - Earthquake statistics
  - Liquefaction
- Tsunami Hazards
- Landslide Hazards
- Hazards from Sinkholes
- Volcanic Hazards
  - Short introduction to physical volcanology
  - Types of volcanic hazards
- The Concept of Risk, Damage and Loss
- Data Analysis and the use of GIS in Risk analysis
- Risk Modelling - Scenario Analysis
- Risk Reduction and Risk Management
- Analysis Feedback and Prospects in the Risk Modelling Industry

Module grade calculation
Project work will be graded.

Workload

- 60 h: active attendance during lectures and exercises
- 90 h: review, preparation and weekly assignments
- 90 h: project work

Learning type
4060121 Geological Hazards and Risk (V2)
4060122 Übungen zu Geological Hazards and Risk (Ü2)

Literature
Literature will be provided by the lecturer.

4.83 Module: Groups, Algebras and Representations [M-PHYS-106732]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113541	Groups, algebras and representations	6 CR	Nierste

Competence Certificate
Oral examination. As part of the major in Physics, the module is examined together with other modules taken. The duration of the oral examination is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106743 - Groups, Algebras and Representations (Minor) must not have been started.

Competence Goal
The students understand the role of symmetries and groups in physics. The students can use group theory methods to calculate physical properties.

Content
The goal of this module is to explain the elements of group theory that apply to physics. This
includes representation theory, Cartan subalgebras and the calculation of group invariants. The majority of the module will cover Lie groups, with a minor focus on discrete groups.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of theoretical physics and differential geometry is recommended but not required.

Literature

- H. Georgi, “Lie Algebras in Particle Physics”, Westview Press [1999]
- A. Zee, “Group Theory in a Nutshell for Physicists”, Princeton University Press [2016]

M 4.84 Module: Groups, Algebras and Representations (Minor) [M-PHYS-106743]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113558	Groups, Algebras and Representations (Minor)	6 CR	Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106732 - Groups, Algebras and Representations must not have been started.

Competence Goal
The students understand the role of symmetries and groups in physics. The students can use group theory methods to calculate physical properties.

Content
The goal of this module is to explain the elements of group theory that apply to physics. This
includes representation theory, Cartan subalgebras and the calculation of group invariants. The majority of the module will cover Lie groups, with a minor focus on discrete groups.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of theoretical physics and differential geometry is recommended but not required.

Literature

- H. Georgi, “Lie Algebras in Particle Physics”, Westview Press [1999]
- A. Zee, “Group Theory in a Nutshell for Physicists”, Princeton University Press [2016]

M 4.85 Module: In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region [M-PHYS-106322]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112830	In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	6 CR	Rietbrock

Competence Certificate
Students solve exercise sheets, prepare and give a presentation and write a final report.

Competence Goal
Students understand the geodynamic and tectonic situation in the Mediterranean and especially in seismic active regions. They gain profound knowledge about seismic hazard, can explain the concept of seismic hazard assessment, and can apply it. They can name different monitoring methods, explain them and apply them under guidance.

Content

- Geodynamics of the Mediterranean
- Tectonics in Greece, Italy and the Balkans
- Seismic hazard, with focus on the Mediterranean
- Seismic monitoring
- Field work

Module grade calculation
The final mark is computed from all submissions.

Workload
180 h in total, composed of:

1. Lecture at KIT before in-situ part: 15 h
2. Data analysis at KIT: 5 h
3. Preparation of presentation and handout: 30 h
4. In-situ lecture: 80 h
5. Wrap-up of lectures, solving exercise sheets and preparation of report: 50 h

Learning type
4060351 (In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region),

4060352 (Exercises on In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region).

Literature
Will be announced during the lecture.

M 4.86 Module: Interdisciplinary Qualifications [M-PHYS-101394]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Interdisciplinary Qualifications

Credits	Grading scale	Recurrence	Duration	Level	Version
4	pass/fail	Once	1 term	4	2

Electives Interdisciplinary Qualifications (Election: at least 4 credits)			
T-PHYS-111562	Selfassignment-MScPhysics-graded	2 CR	Studiendekan Physik
T-PHYS-111565	Selfassignment-MScPhysics-ungraded	2 CR	Studiendekan Physik

Prerequisites
none

Annotation
Interdisciplinary qualifications (IQ) completed at the House-of-Competence (HoC), at the Zentrum für Angewandte Kulturwissenschaften (ZAK) or at the Sprachenzentrum (SpZ) can be assigned in self-service.
First, select a partial accomplishment named "self-assignment" in your study schedule and second, assign an IQ-achievement via the tab "IQ achievements".

M 4.87 Module: Introduction to Cosmology [M-PHYS-102175]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Astroparticle Physics (Required Experimental Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Required Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102384	Introduction to Cosmology	6 CR	Drexlin

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102176 - Introduction to Cosmology (Minor) must not have been started.

Competence Goal
Students will be introduced to the basic concepts of cosmology. The lecture will provide both the theoretical concepts and an overview of modern experimental methods and observational techniques. The students will be enabled to understand the concepts by means of concrete case studies from modern cosmology and will be enabled to apply the learned methods in the context of later independent research.

Methodological Competency Acquisition:

- Understanding of the fundamentals of cosmology
- Recognition of methodological cross-connections to elementary particle physics and astroparticle physics.
- Acquisition of the ability to work independently on current research topics as preparation for the master thesis.

Content
The lecture offers an introduction to modern cosmology, which has taken an enormous upswing in recent years due to the use of state-of-the-art technologies (Planck satellite, galaxy surveys such as 2dF and SDSS) and accompanying computationally intensive simulations (Millennium). The large number of observations has led to the establishment of a so-called concordance model of cosmology, in which the contributions of dark energy and dark matter dominate the evolution of large-scale structures in the universe.

Starting from a description of the early universe with the supporting pillars of the Big Bang theory (Hubble expansion, nucleosynthesis, cosmic background radiation) and the phase transitions and symmetry breaking that occur in the process, the formation and evolution of large-scale structures in the universe up to today's "dark universe" is discussed (comparison of "top-down" with "bottom-up" models). Special attention is given to a detailed presentation of the most modern experimental techniques and methods of analysis, which have found their way into wide areas of physics.

The lecture thus provides a coherent picture of modern cosmology and discusses fundamental issues also in neighboring disciplines such as particle physics and astrophysics and can therefore be complemented with other lectures in the field of Experimental Astroparticle Physics and Experimental Particle Physics.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge from lecture "Nuclei and Particles

Literature
Will be mentioned in the lecture.

4.88 Module: Introduction to Cosmology (Minor) [M-PHYS-102176]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102433	Introduction to Cosmology (Minor)	6 CR	Drexlin

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102175 - Introduction to Cosmology must not have been started.

Competence Goal
Students will be introduced to the basic concepts of cosmology. The lecture will provide both the theoretical concepts and an overview of modern experimental methods and observational techniques. The students will be enabled to understand the concepts by means of concrete case studies from modern cosmology and will be enabled to apply the learned methods in the context of later independent research.

Methodological Competency Acquisition:

- Understanding of the fundamentals of cosmology
- Recognition of methodological cross-connections to elementary particle physics and astroparticle physics.
- Acquisition of the ability to work independently on current research topics as preparation for the master thesis.

Content
The lecture offers an introduction to modern cosmology, which has taken an enormous upswing in recent years due to the use of state-of-the-art technologies (Planck satellite, galaxy surveys such as 2dF and SDSS) and accompanying computationally intensive simulations (Millennium). The large number of observations has led to the establishment of a so-called concordance model of cosmology, in which the contributions of dark energy and dark matter dominate the evolution of large-scale structures in the universe.

Starting from a description of the early universe with the supporting pillars of the Big Bang theory (Hubble expansion, nucleosynthesis, cosmic background radiation) and the phase transitions and symmetry breaking that occur in the process, the formation and evolution of large-scale structures in the universe up to today's "dark universe" is discussed (comparison of "top-down" with "bottom-up" models). Special attention is given to a detailed presentation of the most modern experimental techniques and methods of analysis, which have found their way into wide areas of physics.

The lecture thus provides a coherent picture of modern cosmology and discusses fundamental issues also in neighboring disciplines such as particle physics and astrophysics and can therefore be complemented with other lectures in the field of Experimental Astroparticle Physics and Experimental Particle Physics.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge from lecture "Nuclei and Particles

Literature
Will be mentioned in the lecture.

4.89 Module: Introduction to Flavor Physics, Fundamentals [M-PHYS-102987]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-105963	Introduction to Flavor Physics, Fundamentals	10 CR	Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102986 - Introduction to Flavor Physics, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-103188 - Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-103189 - Introduction to Flavor Physics, Fundamentals (Minor) must not have been started.

Competence Goal
Students will learn the methodology of Theoretical Flavour Physics, be able to solve complex mathematical problems such as calculating the decay amplitudes of mesons, and understand the phenomenology of the Yukawa sector.

Content
Yukawa interaction in the Standard Model, Lagrangian densities of QCD and electroweak interaction, weak decays of mesons, Wilson operator product evolution, renormalization of effective field theories, particle-antiparticle mixing, CP violation.

Workload
300 h consisting of attendance time (75 h), wrap-up of the lecture incl. exam preparation and working on the exercises (225 h)

Recommendation
It is useful to have prior knowledge about quantized fields and the standard model of particle physics, e.g. from the lecture "Introduction to Theoretical Particle Physics" (4026021). For students interested in theory it is useful to attend the lecture "Theoretical Particle Physics I" in parallel.

Literature
To be stated in the lecture.

M 4.90 Module: Introduction to Flavor Physics, Fundamentals (Minor) [M-PHYS-103189]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-106322	Introduction to Flavor Physics, Fundamentals (Minor)	10 CR	Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102986 - Introduction to Flavor Physics, Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-103188 - Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-102987 - Introduction to Flavor Physics, Fundamentals must not have been started.

Competence Goal
Students will learn the methodology of Theoretical Flavour Physics, be able to solve complex mathematical problems such as calculating the decay amplitudes of mesons, and understand the phenomenology of the Yukawa sector.

Content
Yukawa interaction in the Standard Model, Lagrangian densities of QCD and electroweak interaction, weak decays of mesons, Wilson operator product evolution, renormalization of effective field theories, particle-antiparticle mixing, CP violation.

Workload
300 h consisting of attendance time (75 h), wrap-up of the lecture and work on the exercises (225 h)

Recommendation
It is useful to have prior knowledge about quantized fields and the standard model of particle physics, e.g. from the lecture "Introduction to Theoretical Particle Physics" (4026021). For students interested in theory it is useful to attend the lecture "Theoretical Particle Physics I" in parallel.

Literature
To be stated in the lecture.

4.91 Module: Introduction to Flavor Physics, Fundamentals and Advanced Topics [M-PHYS-102986]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-105962	Introduction to Flavor Physics, Fundamentals and Advanced Topics	12 CR	Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102987 - Introduction to Flavor Physics, Fundamentals must not have been started.
2. The module M-PHYS-103188 - Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor) must not have been started.
3. The module M-PHYS-103189 - Introduction to Flavor Physics, Fundamentals (Minor) must not have been started.

Competence Goal
Students will learn the methodology of Theoretical Flavour Physics, be able to solve complex mathematical problems such as calculating the decay amplitudes of mesons, and understand the phenomenology of the Yukawa sector. In addition, participants will have an understanding of CP asymmetries and decay rates of rare decays and their sensitivity to physics beyond the Standard Model.

Content
Yukawa interaction in the Standard Model, Lagrangian densities of QCD and electroweak interaction, weak decays of mesons, Wilson operator product evolution, renormalization of effective field theories, particle-antiparticle mixing, CP violation.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
It is useful to have prior knowledge about quantized fields and the standard model of particle physics, e.g. from the lecture "Introduction to Theoretical Particle Physics" (4026021). For students interested in theory it is useful to attend the lecture "Theoretical Particle Physics I" in parallel.

Literature
To be stated in the lecture.

4.92 Module: Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor) [M-PHYS-103188]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-106321	Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor)	12 CR	Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102987 - Introduction to Flavor Physics, Fundamentals must not have been started.
2. The module M-PHYS-102986 - Introduction to Flavor Physics, Fundamentals and Advanced Topics must not have been started.
3. The module M-PHYS-103189 - Introduction to Flavor Physics, Fundamentals (Minor) must not have been started.

Competence Goal
Students will learn the methodology of Theoretical Flavour Physics, be able to solve complex mathematical problems such as calculating the decay amplitudes of mesons, and understand the phenomenology of the Yukawa sector. In addition, participants will have an understanding of CP asymmetries and decay rates of rare decays and their sensitivity to physics beyond the Standard Model.

Content
Yukawa interaction in the Standard Model, Lagrangian densities of QCD and electroweak interaction, weak decays of mesons, Wilson operator product evolution, renormalization of effective field theories, particle-antiparticle mixing, CP violation.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
It is useful to have prior knowledge about quantized fields and the standard model of particle physics, e.g. from the lecture "Introduction to Theoretical Particle Physics" (4026021). For students interested in theory it is useful to attend the lecture "Theoretical Particle Physics I" in parallel.

Literature
To be stated in the lecture.

M 4.93 Module: Introduction to General Relativity [M-PHYS-106532]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-113186	Introduction to General Relativity	8 CR	Schwetz-Mangold

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106533 - Introduction to General Relativity (Minor) must not have been started.
2. The module M-PHYS-106843 - Introduction to General Relativity, without Exercises must not have been started.

Competence Goal
Students know and understand the central concepts of Special Relativity, such as index notation and Lorentz tensors and are familiar with the main concepts and techniques of General Relativity. Students know about black holes, gravitational waves and simple cosmological models. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in General Relativity.

Content
This lecture gives an introduction to general relativity, the theory of space time and gravity. After a brief review of special relativity, the necessary tools to describe curved space time are introduced, as well as concepts such as the equivalence principle and geodesic motion. The Einstein equations are discussed, which relate the geometry of space time to the matter and energy content of it. In the second part of the lecture some important application of the general relativity are discussed, including black holes, gravitational waves and the basics of cosmology.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge on Special Relativity

Literature

- S. Carrol, Spacetime and Geometry - An Introduction to General Relativity, Cambridge Univ. Press 2019;
- S. Weinberg, Gravitation and Cosmology, Wiley, 1972;

more literature will be provided during the lecture

M 4.94 Module: Introduction to General Relativity (Minor) [M-PHYS-106533]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Astroparticle Physics
Minor in Physics: Theoretical Particle Physics
Minor in Physics: Theoretical Cosmology and Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-113189	Introduction to General Relativity (Minor)	8 CR	Schwetz-Mangold

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106532 - Introduction to General Relativity must not have been started.
2. The module M-PHYS-106843 - Introduction to General Relativity, without Exercises must not have been started.

Competence Goal
Students know and understand the central concepts of Special Relativity, such as index notation and Lorentz tensors and are familiar with the main concepts and techniques of General Relativity. Students know about black holes, gravitational waves and simple cosmological models. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in General Relativity.

Content
This lecture gives an introduction to general relativity, the theory of space time and gravity. After a brief review of special relativity, the necessary tools to describe curved space time are introduced, as well as concepts such as the equivalence principle and geodesic motion. The Einstein equations are discussed, which relate the geometry of space time to the matter and energy content of it. In the second part of the lecture some important application of the general relativity are discussed, including black holes, gravitational waves and the basics of cosmology.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge on Special Relativity

Literature

- S. Carrol, Spacetime and Geometry - An Introduction to General Relativity, Cambridge Univ. Press 2019;
- S. Weinberg, Gravitation and Cosmology, Wiley, 1972;

more literature will be provided during the lecture

4.95 Module: Introduction to General Relativity, without Exercises [M-PHYS-106843]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-113729	Introduction to General Relativity, without Exercises	6 CR	Schwetz-Mangold

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106533 - Introduction to General Relativity (Minor) must not have been started.
2. The module M-PHYS-106532 - Introduction to General Relativity must not have been started.

Competence Goal
Students know and understand the central concepts of Special Relativity, such as index notation and Lorentz tensors and are familiar with the main concepts and techniques of General Relativity. Students know about black holes, gravitational waves and simple cosmological models.

Content
This lecture gives an introduction to general relativity, the theory of space time and gravity. After a brief review of special relativity, the necessary tools to describe curved space time are introduced, as well as concepts such as the equivalence principle and geodesic motion. The Einstein equations are discussed, which relate the geometry of space time to the matter and energy content of it. In the second part of the lecture some important application of the general relativity are discussed, including black holes, gravitational waves and the basics of cosmology.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation (135 hours).

Recommendation
Basic knowledge on Special Relativity

Literature

- S. Carrol, Spacetime and Geometry - An Introduction to General Relativity, Cambridge Univ. Press 2019;
- S. Weinberg, Gravitation and Cosmology, Wiley, 1972;

more literature will be provided during the lecture

M 4.96 Module: Introduction to Neutron Scattering [M-PHYS-106323]

Responsible: PD Dr. Frank Weber
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112831	Introduction to Neutron Scattering	6 CR	Weber

Competence Certificate
Zur Verwendung als Schwerpunktfach/Ergänzungsfach:
Mündliche Prüfung. Im Rahmen des Schwerpunktfachs des MSc Physik wird das Modul zusammen mit weiteren belegten Modulen geprüft. Die Dauer der mündlichen Prüfung beträgt insgesamt ca. 60 Minuten.

Competence Goal
The students understand the theoretical and technical basic principles of neutron scattering experiments. For a specific scientific question, the students are able to evaluate various neutron scattering techniques and select the best-suited one. Student are able to critically read and assess scientific publications based on neutron scattering techniques.

Content
This lecture familiarizes the students with the basic principles of neutron scattering, the theoretical description and experimental realization of neutron scattering experiments. We will discuss methods for structure determination and imaging based on nuclear and magnetic scattering mechanisms. Applications to investigate lattice and magnetic degrees of freedom discussed along with a short introduction to second quantization formalism and linear response theory. An overview and short comparison of complementary scattering methods (x-ray, electron) is given. The lecture will be illustrated with examples from current work on quantum materials.
• Basics of the neutron-matter interaction
• Concepts for the theoretical description of neutron scattering
• Production and detection of neutrons
• Structure determination with neutrons
• Inelastic neutron scattering – neutron spectroscopy
• Introduction: 2nd quantization, linear response
• Complementary scattering techniques

Workload
180 hours, composed of attendance time (45 hours), wrap-up of the lecture, working on the exercises and exam preparation (135 hours).

Recommendation
Basic knowledge of condensed matter physics, quantum mechanics, as well as thermodynamics and statistical physics are expected.

Literature

- Experimental Neutron Scattering, Willis & Carlile, Oxford
- Introduction to the theory of thermal neutron scattering, Squires, Dover
- Neutron scattering in condensed matter physics, Furrer & Strässle, World Scientific
- Neutron and synchrotron spectroscopy, ed.:Hippert et al., Springer
- Solid-State Spectroscopy, Kuzmani, Springer
- Festkörperphysik, Gross und Marx, Oldenburg

4.97 Module: Introduction to Neutron Scattering (Minor) [M-PHYS-106324]

Responsible: PD Dr. Frank Weber
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112832	Introduction to Neutron Scattering (Minor)	6 CR	Weber

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Competence Goal
The students understand the theoretical and technical basic principles of neutron scattering experiments. For a specific scientific question, the students are able to evaluate various neutron scattering techniques and select the best-suited one. Student are able to critically read and assess scientific publications based on neutron scattering techniques.

Content
This lecture familiarizes the students with the basic principles of neutron scattering, the theoretical description and experimental realization of neutron scattering experiments. We will discuss methods for structure determination and imaging based on nuclear and magnetic scattering mechanisms. Applications to investigate lattice and magnetic degrees of freedom discussed along with a short introduction to second quantization formalism and linear response theory. An overview and short comparison of complementary scattering methods (x-ray, electron) is given. The lecture will be illustrated with examples from current work on quantum materials.
• Basics of the neutron-matter interaction
• Concepts for the theoretical description of neutron scattering
• Production and detection of neutrons
• Structure determination with neutrons
• Inelastic neutron scattering – neutron spectroscopy
• Introduction: 2nd quantization, linear response
• Complementary scattering techniques

Workload
180 hours, composed of attendance time (45 hours), wrap-up of the lecture and work on the exercises (135 hours).

Recommendation
Basic knowledge of condensed matter physics, quantum mechanics, as well as thermodynamics and statistical physics are expected.

Literature

- Experimental Neutron Scattering, Willis & Carlile, Oxford
- Introduction to the theory of thermal neutron scattering, Squires, Dover
- Neutron scattering in condensed matter physics, Furrer & Strässle, World Scientific
- Neutron and synchrotron spectroscopy, ed.:Hippert et al., Springer
- Solid-State Spectroscopy, Kuzmani, Springer
- Festkörperphysik, Gross und Marx, Oldenburg

M 4.98 Module: Introduction to Scientific Methods [M-PHYS-101397]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Introduction to Scientific Methods

Credits	Grading scale	Recurrence	Duration	Level	Version
15	pass/fail	Each term	1 term	4	2

Mandatory			
T-PHYS-102480	Introduction to Scientific Methods	15 CR	Studiendekan Physik

Competence Certificate
Study achievement, ungraded.

Prerequisites
The following subjects of the course of study have to be passed:

- Major in Physics
- Second Major in Physics
- Minor in Physics
- Non-Physics Elective
- Advanced Physics Laboratory Course

Competence Goal
Students learn basic working methods that are necessary for successful scientific research. The working methods themselves are independent of the respective field of specialization, but are practiced and learned on the basis of a concrete task (topic of the master's thesis).

Workload
approx. 450 hours

M 4.99 Module: Introduction to Theoretical Cosmology [M-PHYS-104855]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-109887	Introduction to Theoretical Cosmology	8 CR	Kahlhöfer, Schwetz-Mangold

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104856 - Introduction to Theoretical Cosmology (Minor) must not have been started.
2. The module M-PHYS-106845 - Theoretical Cosmology, with Exercises must not have been started.
3. The module M-PHYS-106846 - Theoretical Cosmology, with Exercises (Minor) must not have been started.
4. The module M-PHYS-106847 - Theoretical Cosmology, without Exercises must not have been started.

Competence Goal
Students are familiar with different aspects of the Big Bang theory. They understand the basic physical concepts and can apply relevant methods of theoretical physics to cosmology. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in Cosmology.

Content
The lecture gives an introduction to the standard model of cosmology, the so-called LCDM model. The fundamental physics principles of the model are discussed. Starting from fundamental theories such as general relativity, particle physics, thermodynamics and statistical physics, we derive the properties and predictions of the LCDM model. We consider the expansion of the Universe, dark matter, dark energy, thermodynamics in the early Universe, Big Bang nucleosynthesis, cosmic structure formation, cosmic microwave background radiation.

Workload
240 h consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and working on the exercises (180 h)

Recommendation
Basic knowledge of General Relativity is recommended, but all required concepts will be introduced. Basic knowledge of particle physics is helpful.

Literature

- S. Dodelson, Modern Cosmology;
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Hot Big Bang Theory;
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Cosmological Perturbations and Inflationary Theory;
- S. Baumann, Cosmology
- S. Weinberg, Cosmology;
- V. Mukhanov, Physical Foundations of Cosmology;

Additional literature will be announced in the lecture.

M 4.100 Module: Introduction to Theoretical Cosmology (Minor) [M-PHYS-104856]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Astroparticle Physics
Minor in Physics: Theoretical Particle Physics
Minor in Physics: Theoretical Cosmology and Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-109888	Introduction to Theoretical Cosmology (Minor)	8 CR	Kahlhöfer, Schwetz-Mangold

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104855 - Introduction to Theoretical Cosmology must not have been started.
2. The module M-PHYS-106845 - Theoretical Cosmology, with Exercises must not have been started.
3. The module M-PHYS-106846 - Theoretical Cosmology, with Exercises (Minor) must not have been started.
4. The module M-PHYS-106847 - Theoretical Cosmology, without Exercises must not have been started.

Competence Goal
Students are familiar with different aspects of the Big Bang theory. They understand the basic physical concepts and can apply relevant methods of theoretical physics to cosmology. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in Cosmology.

Content
The lecture gives an introduction to the standard model of cosmology, the so-called LCDM model. The fundamental physics principles of the model are discussed. Starting from fundamental theories such as general relativity, particle physics, thermodynamics and statistical physics, we derive the properties and predictions of the LCDM model. We consider the expansion of the Universe, dark matter, dark energy, thermodynamics in the early Universe, Big Bang nucleosynthesis, cosmic structure formation, cosmic microwave background radiation.

Workload
240 h consisting of attendance time (60 h), wrap-up of the lecture and working on the exercises (180 h)

Recommendation
Basic knowledge of General Relativity is recommended, but all required concepts will be introduced. Basic knowledge of particle physics is helpful.

Literature

- S. Dodelson, Modern Cosmology;
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Hot Big Bang Theory;
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Cosmological Perturbations and Inflationary Theory;
- S. Baumann, Cosmology
- S. Weinberg, Cosmology;
- V. Mukhanov, Physical Foundations of Cosmology;

Additional literature will be announced in the lecture.

4.101 Module: Inversion and Tomography [M-PHYS-102368]

Responsible: Prof. Dr. Thomas Bohlen
apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-104737	Inversion and Tomography	8 CR	Bohlen, Ritter

Competence Certificate
To pass the module, an oral exam must be passed (approx. 20 min). As prerequisites the examinations of other type must be passed, based on successful participation of the exercises. Students write reports on their exercise work. These reports are rated. The necessary number of points is explained at the beginning of the individual exercises.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102658 - Inversion and Tomography (Minor) must not have been started.

Competence Goal
The students understand how to invert data to achieve a model of physical parameters. The students realize that seismic waves can be treated in different waves: full waveform, finite-frequency approximations (banana-doughnut theory) and rays. From this they understand how seismic images can be constructed and interpreted. Students are able to evaluate inversion models based on error bonds, resolution matrices and reconstruction tests. They know the complete chain of tomography: data pre-processing, parameterization, inversion, model assessment and interpretation. The students are used to read scientific papers on inversion and tomography and to discuss questions on these papers. Finally the students are able to understand basic inverse problems and read more advanced texts. Practically, the students understand how to code simple problems with Matlab or possibly Python. The students know how to analyze inverse problems using singular value decomposition and other methods.

Content

- Fundamentals of tomography
- Application of seismic tomography
- Regional to global seismic tomography
- Analysis of tomography problems
- Fundamentals in seismic inversion
- Application of linear and non-linear inversion

Module grade calculation
The grade of the module results from grade of the oral exam.

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
Knowledge on fundamentals of seismology and understanding of mathematics, especially matrix calculus. Fundamental skills in Linux, Matlab and computing in general.

Literature

- Nolet, G., 2008. A breviary of seismic tomography. Cambridge University Press.
- Aster, R.C., Brochers, B. & Thurber, C.H., 2012. Parameter estimation and inverse problems. Elsevier (2nd ed.).
- Menke, W.A., 2012. Geophysical data analysis: discrete inverse theory. Academic Press (3rd ed.).

M 4.102 Module: Inversion and Tomography (Minor) [M-PHYS-102658]

Responsible: Prof. Dr. Thomas Bohlen
apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-105572	Inversion and Tomography (Minor)	8 CR	Bohlen, Ritter

Competence Certificate
To pass the module, the examinations of other type must be passed, based on successful participation of the exercises. Students write reports on their exercise work. These reports are rated. The necessary number of points is explained at the beginning of the individual exercises.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102368 - Inversion and Tomography must not have been started.

Competence Goal
The students understand how to invert data to achieve a model of physical parameters. The students realize that seismic waves can be treated in different waves: full waveform, finite-frequency approximations (banana-doughnut theory) and rays. From this they understand how seismic images can be constructed and interpreted. Students are able to evaluate inversion models based on error bonds, resolution matrices and reconstruction tests. They know the complete chain of tomography: data pre-processing, parameterization, inversion, model assessment and interpretation. The students are used to read scientific papers on inversion and tomography and to discuss questions on these papers. Finally the students are able to understand basic inverse problems and read more advanced texts. Practically, the students understand how to code simple problems with Matlab or possibly Python. The students know how to analyze inverse problems using singular value decomposition and other methods.

Content

- Fundamentals of tomography
- Application of seismic tomography
- Regional to global seismic tomography
- Analysis of tomography problems
- Fundamentals in seismic inversion
- Application of linear and non-linear inversion

Module grade calculation
The module is ungraded

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
Knowledge on fundamentals of seismology and understanding of mathematics, especially matrix calculus. Fundamental skills in Linux, Matlab and computing in general.

Literature

- Nolet, G., 2008. A breviary of seismic tomography. Cambridge University Press.
- Aster, R.C., Brochers, B. & Thurber, C.H., 2012. Parameter estimation and inverse problems. Elsevier (2nd ed.).
- Menke, W.A., 2012. Geophysical data analysis: discrete inverse theory. Academic Press (3rd ed.).

M 4.103 Module: Macroscopic Quantum Coherence and Dissipation, with Exercises [M-PHYS-106724]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113528	Macroscopic Quantum Coherence and Dissipation, with Exercises	8 CR	Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106725 - Macroscopic Quantum Coherence and Dissipation, without Exercises must not have been started.
2. The module M-PHYS-106726 - Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor) must not have been started.

Competence Goal
The students understand the basic concepts of dissipation in quantum systems. The students understand the working principles of modern quantum devices. The students master theoretical techniques, such as master equation, Langevin equation, path integral, effective action. The students are able to solve simple problems related to dissipative quantum dynamics.

Content
a) Dissipative processes in quantum systems and devices: Spin relaxation in NMR (Bloch equations), quantum dots, Coulomb blockade, Josephson devices, magnetic dynamics.
b) Theoretical models: Golden rule, master equation (Bloch-Redfield equation), path integral in imaginary (Matsubara) and real (Keldysh) time.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

M 4.104 Module: Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor) [M-PHYS-106726]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113530	Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor)	8 CR	Shnirman

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106724 - Macroscopic Quantum Coherence and Dissipation, with Exercises must not have been started.
2. The module M-PHYS-106725 - Macroscopic Quantum Coherence and Dissipation, without Exercises must not have been started.

Competence Goal
The students understand the basic concepts of dissipation in quantum systems. The students understand the working principles of modern quantum devices. The students master theoretical techniques, such as master equation, Langevin equation, path integral, effective action. The students are able to solve simple problems related to dissipative quantum dynamics.

Content
a) Dissipative processes in quantum systems and devices: Spin relaxation in NMR (Bloch equations), quantum dots, Coulomb blockade, Josephson devices, magnetic dynamics.
b) Theoretical models: Golden rule, master equation (Bloch-Redfield equation), path integral in imaginary (Matsubara) and real (Keldysh) time.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises (180 hours).

M 4.105 Module: Macroscopic Quantum Coherence and Dissipation, without Exercises [M-PHYS-106725]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113529	Macroscopic Quantum Coherence and Dissipation, without Exercises	6 CR	Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106724 - Macroscopic Quantum Coherence and Dissipation, with Exercises must not have been started.
2. The module M-PHYS-106726 - Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor) must not have been started.

Competence Goal
The students understand the basic concepts of dissipation in quantum systems. The students understand the working principles of modern quantum devices. The students master theoretical techniques, such as master equation, Langevin equation, path integral, effective action.

Content
a) Dissipative processes in quantum systems and devices: Spin relaxation in NMR (Bloch equations), quantum dots, Coulomb blockade, Josephson devices, magnetic dynamics.
b) Theoretical models: Golden rule, master equation (Bloch-Redfield equation), path integral in imaginary (Matsubara) and real (Keldysh) time.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation (135 hours).

M 4.106 Module: Master's Thesis [M-PHYS-106481]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Master's Thesis

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
30	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-PHYS-113096	Master's Thesis	30 CR	Studiendekan Physik

Prerequisites
The modules "Specialisation" and "Introduction to Research Methods" have been passed.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module **M-PHYS-101396 - Specialization Phase** must have been passed.
2. The module **M-PHYS-101397 - Introduction to Scientific Methods** must have been passed.

4.107 Module: Mathematical Methods of Theoretical Physics [M-PHYS-105535]

Responsible: Prof. Dr. Kirill Melnikov
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111116	Mathematical Methods of Theoretical Physics	12 CR	Melnikov

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105536 - Mathematical Methods of Theoretical Physics (Minor) must not have been started.

Competence Goal
Students know and understand advanced mathematical methods and are able to apply them to construct approximate solutions of practical problems in theoretical physics.

Content
Perturbation theory and asymptotic expansions for obtaining analytic solutions to ordinary and differential equations and integrals. Such topics as behaviour of differential equations close to singular points, WKB approximation, large orders of perturbations theory, summation of series, asymptotic expansion of integrals, Green's functions for ordinary and partial differential equations, boundary layer theory etc. will be discussed.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
The course is suitable for students at both bachelor and master level who are interested in theoretical physics.

Literature
Relevant literature will be discussed during the first lecture.

4.108 Module: Mathematical Methods of Theoretical Physics (Minor) [M-PHYS-105536]

Responsible: Prof. Dr. Kirill Melnikov
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111117	Mathematical Methods of Theoretical Physics (Minor)	12 CR	Melnikov

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105535 - Mathematical Methods of Theoretical Physics must not have been started.

Competence Goal
Students know and understand advanced mathematical methods and are able to apply them to construct approximate solutions of practical problems in theoretical physics.

Content
Perturbation theory and asymptotic expansions for obtaining analytic solutions to ordinary and differential equations and integrals. Such topics as behaviour of differential equations close to singular points, WKB approximation, large orders of perturbations theory, summation of series, asymptotic expansion of integrals, Green's functions for ordinary and partial differential equations, boundary layer theory etc. will be discussed.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
The course is suitable for students at both bachelor and master level who are interested in theoretical physics.

Literature
Relevant literature will be discussed during the first lecture.

M 4.109 Module: Measurement Methods and Techniques in Experimental Physics, with ext. Exercises [M-PHYS-102517]

Responsible: Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-102376	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises	8 CR	Drexlin, Hartmann, Valerius

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102518 - Measurement Methods and Techniques in Experimental Physics, without ext. Exercises must not have been started.
2. The module M-PHYS-102519 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students will be able to select suitable measurement methods and measuring instruments, evaluate measured values and calculate measurement uncertainties. The students learn a practical example measurement task in the laboratory.

Content
The lecture is intended to facilitate the introduction to experimental work in a laboratory. The aim is for students to gain an overview of a wide range of important measurement methods and experimental techniques and to be able to apply the knowledge they have acquired to practical measurement tasks in examples. The focus here is on the one hand on the methodical procedure for selecting the optimum measurement procedure and on the other hand on the evaluation of measurements including the consideration of measurement uncertainties. Furthermore, the lecture shall contribute to a better communication between engineers, physicists and physicists (e.g. the engineer talks about the measurement uncertainty budget according to GUM and the physicist wonders what that is all about) and thus promote the integration of the young professionals into the mixed teams of technicians, engineers, physicists and physicists which are so typical for KIT.

Among others, the following topics will be covered:

Measuring instruments and their accuracy classes, calculation of measurement uncertainties according to GUM and determination of a confidence interval, methods of (low) temperature measurement, introduction to vacuum technology including leak detection technology, methods of magnetic field measurement and mass flow measurement, introduction to radiation measurement technology and dosimetry, as well as reading flow diagrams.

Lecture and exercises take place as a 5-day block course at the end of the semester (3 SWS) and can be supplemented by a block practical course (1 SWS, by arrangement).

Workload
240 h consisting of attendance time (45 h), wrap-up of the lecture incl. exam preparation and working on the exercises, additionally the internship with 24 h attendance time and 16 h post-processing.

Recommendation
Interest in experimental physics

Literature
Will be mentioned in the lecture.

4.110 Module: Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor) [M-PHYS-102519]

Responsible: Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-105106	Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor)	8 CR	Drexlin, Hartmann, Valerius

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102517 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-102518 - Measurement Methods and Techniques in Experimental Physics, without ext. Exercises must not have been started.

Competence Goal
Students will be able to select suitable measurement methods and measuring instruments, evaluate measured values and calculate measurement uncertainties. The students learn a practical example measurement task in the laboratory.

Content
The lecture is intended to facilitate the introduction to experimental work in a laboratory. The aim is for students to gain an overview of a wide range of important measurement methods and experimental techniques and to be able to apply the knowledge they have acquired to practical measurement tasks in examples. The focus here is on the one hand on the methodical procedure for selecting the optimal measurement procedure and on the other hand on the evaluation of measurements including the consideration of measurement uncertainties. Furthermore, the lecture shall contribute to a better communication between engineers, physicists and physicists (e.g. the engineer talks about the measurement uncertainty budget according to GUM and the physicist wonders what that is all about) and thus promote the integration of the young professionals into the mixed teams of technicians, engineers, physicists and physicists which are so typical for KIT.

Among others, the following topics will be covered:

Measuring instruments and their accuracy classes, calculation of measurement uncertainties according to GUM and determination of a confidence interval, methods of (low) temperature measurement, introduction to vacuum technology including leak detection technology, methods of magnetic field measurement and mass flow measurement, introduction to radiation measurement technology and dosimetry, as well as reading flow diagrams.

Lecture and exercises take place as a 5-day block course at the end of the semester (3 SWS) and can be supplemented by a block practical course (1 SWS, by arrangement).

Workload
240 h consisting of attendance time (45 h), wrap-up of the lecture and work on the exercises, plus the internship with 24 h attendance time and 16 h wrap-up.

Recommendation
Interest in experimental physics

Literature
Will be mentioned in the lecture.

M 4.111 Module: Measurement Methods and Techniques in Experimental Physics, without ext. Exercises [M-PHYS-102518]

Responsible: Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-105105	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises	6 CR	Drexlin, Hartmann, Valerius

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102517 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-102519 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students will be able to select suitable measurement methods and measuring instruments, evaluate measured values and calculate measurement uncertainties. The students learn a practical example measurement task in the laboratory.

Content
The lecture is intended to facilitate the introduction to experimental work in a laboratory. The aim is for students to gain an overview of a wide range of important measurement methods and experimental techniques and to be able to apply the knowledge they have acquired to practical measurement tasks in examples. The focus here is on the one hand on the methodical procedure for selecting the optimal measurement procedure and on the other hand on the evaluation of measurements including the consideration of measurement uncertainties. Furthermore, the lecture shall contribute to a better communication between engineers, physicists and physicists (e.g. the engineer talks about the measurement uncertainty budget according to GUM and the physicist wonders what that is all about) and thus promote the integration of the young professionals into the mixed teams of technicians, engineers, physicists and physicists which are so typical for KIT.

Among others, the following topics will be covered:

Measuring instruments and their accuracy classes, calculation of measurement uncertainties according to GUM and determination of a confidence interval, methods of (low) temperature measurement, introduction to vacuum technology including leak detection technology, methods of magnetic field measurement and mass flow measurement, introduction to radiation measurement technology and dosimetry, as well as reading flow diagrams.

Lecture and exercises take place as a 5-day block course at the end of the semester (3 SWS).

Workload
180 h consisting of attendance time (45 h), wrap-up of the lecture incl. exam preparation and working on the exercises.

Recommendation
Interest in experimental physics

Literature
Will be mentioned in the lecture.

M 4.112 Module: Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor) [M-PHYS-103194]

Responsible: Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-106327	Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor)	6 CR	Drexlin, Hartmann, Valerius

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102517 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises must not have been started.
2. The module M-PHYS-102519 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102518 - Measurement Methods and Techniques in Experimental Physics, without ext. Exercises must not have been started.

Competence Goal
Students will be able to select suitable measurement methods and measuring instruments, evaluate measured values and calculate measurement uncertainties. The students learn a practical example measurement task in the laboratory.

Content
The lecture is intended to facilitate the introduction to experimental work in a laboratory. The aim is for students to gain an overview of a wide range of important measurement methods and experimental techniques and to be able to apply the knowledge they have acquired to practical measurement tasks in examples. The focus here is on the one hand on the methodical procedure for selecting the optimum measurement procedure and on the other hand on the evaluation of measurements including the consideration of measurement uncertainties. Furthermore, the lecture shall contribute to a better communication between engineers, physicists and physicists (e.g. the engineer talks about the measurement uncertainty budget according to GUM and the physicist wonders what that is all about) and thus promote the integration of the young professionals into the mixed teams of technicians, engineers, physicists and physicists which are so typical for KIT.

Among others, the following topics will be covered:
measuring instruments and their accuracy classes, calculation of measurement uncertainties according to GUM and determination of a confidence interval, methods of (low) temperature measurement, introduction to vacuum technology including leak detection technology, methods of magnetic field measurement and mass flow measurement, introduction to radiation measurement technology and dosimetry, as well as reading flow diagrams.

Lecture and exercises take place as a 5-day block course at the end of the semester (3 SWS).

Workload
180 h consisting of attendance time (45 h), wrap-up of the lecture and work on the exercises (135 h)

Recommendation
Interest in experimental physics

Literature
Will be mentioned in the lecture.

M 4.113 Module: Microscale Fluid Mechanics [M-MACH-106539]

Responsible: Dr.-Ing. Philipp Marthaler
Organisation: KIT Department of Mechanical Engineering
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MACH-113144	Microscale Fluid Mechanics	4 CR	Marthaler

Competence Certificate
Oral examination, duration: 30 minutes

Competence Goal
After this course, the participants can

(1) identify microfluidic and/or electrochemical problems

(2) describe those phenomena with the respective terminology and classify them as either Stokes flow, electrohydrodynamic or electrokinetic

(3) recognize and apply the appropriate modeling approaches and solution methods

(4) analyze the multiphysical and multiscale behavior and discuss the influence of different effects, such as electric forces, surface tension or electric boundary layers

(5) assess the importance of these effects in the context of biological phenomena and evaluate design choices in microfluidic devices

Content
The lecture covers microfluidic phenomena, particularly Stokes flow and electrical phenomena that occur in fluids. Understanding the mentioned effects is crucial for the development of microfluidic systems with application fields ranging from clinical diagnostics to cell research and environmental monitoring. The basic operations performed in microsystems are particle separation and mixing, chemical analyses, characterization of biological samples, and cell capturing. The sample environment is in fluid form, in the case of fluid samples multiphase phenomena occur.

The lecture gives an overview of the basic physics, i.e., Stokes flow, analysis of hydraulic circuits, surface tension effects, transport of passive scalars, electroosmosis and electrophoresis, structure of the electric double layer, electrokinetics, the Taylor-Melcher model for the description of droplets under the influence of an electric field.

Phenomena with electric boundary layers are discussed using asymptotic methods that are introduced in the lecture. A basic understanding of fluid mechanics and differential equations is required.

4.114 Module: Modern Methods of Data Analysis, with ext. Exercises [M-PHYS-102127]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102495	Modern Methods of Data Analysis, with ext. Exercises	8 CR	Ferber, Kieseler, Quast, Wolf

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102125 - Modern Methods of Data Analysis, without ext. Exercises must not have been started.
2. The module M-PHYS-102126 - Modern Methods of Data Analysis, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102128 - Modern Methods of Data Analysis, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students will be able to formulate fundamentals of statistical data analysis, apply modern methods of data analysis to physical problems, and use and further develop tools for data analysis. On this basis, students are enabled to question and evaluate the use of statistical methods in science and society. In the extended exercises, the material is deepened by treating a problem originating from research practice

Content
Fundamentals of probability, probability distributions, Monte Carlo methods, parameter estimation, numerical optimization, convolution and deconvolution, hypothesis testing, confidence intervals, multivariate classification, time series analysis, and filtering.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Basic knowledge of statistical data analysis, such as that taught in the undergraduate course Computer Use in Physics, is desirable.

Literature

- G.Cowan: Statistical Data Analysis, Oxford University Press
- G.Bohm, G.Zech: Einführung in Statistik und Messwertanalyse für Physiker, DESYeBook
- V.Blobel, E.Lohrmann: Statistische und numerische Methoden der Datenanalyse, DESYeBook
- R.J.Barlow: Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences, Wiley
- S.Brandt: Datenanalyse, Spektrum
- W.H.Press, S.A.Teukolsky, W.T.Vetterling, B.P.Fannery: Numerical Recipes, Cambridge University Press
- T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning, Springer

4.115 Module: Modern Methods of Data Analysis, with ext. Exercises (Minor) [M-PHYS-102128]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102496	Modern Methods of Data Analysis, with ext. Exercises (Minor)	8 CR	Ferber, Kieseler, Quast, Wolf

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102125 - Modern Methods of Data Analysis, without ext. Exercises must not have been started.
2. The module M-PHYS-102126 - Modern Methods of Data Analysis, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102127 - Modern Methods of Data Analysis, with ext. Exercises must not have been started.

Competence Goal
Students will be able to formulate fundamentals of statistical data analysis, apply modern methods of data analysis to physical problems, and use and further develop tools for data analysis. On this basis, students are enabled to question and evaluate the use of statistical methods in science and society. In the extended exercises, the material is deepened by treating a problem originating from research practice

Content
Fundamentals of probability, probability distributions, Monte Carlo methods, parameter estimation, numerical optimization, convolution and deconvolution, hypothesis testing, confidence intervals, multivariate classification, time series analysis, and filtering.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Basic knowledge of statistical data analysis, such as that taught in the undergraduate course Computer Use in Physics, is desirable.

Literature

- G.Cowan: Statistical Data Analysis, Oxford University Press
- G.Bohm, G.Zech: Einführung in Statistik und Messwertanalyse für Physiker, DESYeBook
- V.Blobel, E.Lohrmann: Statistische und numerische Methoden der Datenanalyse, DESYeBook
- R.J.Barlow: Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences, Wiley
- S.Brandt: Datenanalyse, Spektrum
- W.H.Press, S.A.Teukolsky, W.T.Vetterling, B.P.Fannery: Numerical Recipes, Cambridge University Press
- T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning, Springer

4.116 Module: Modern Methods of Data Analysis, without ext. Exercises [M-PHYS-102125]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102494	Modern Methods of Data Analysis, without ext. Exercises	6 CR	Ferber, Kieseler, Quast, Wolf

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102126 - Modern Methods of Data Analysis, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102127 - Modern Methods of Data Analysis, with ext. Exercises must not have been started.
3. The module M-PHYS-102128 - Modern Methods of Data Analysis, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students will be able to formulate fundamentals of statistical data analysis, apply modern methods of data analysis to physical problems, and use and further develop tools for data analysis. On this basis, students are enabled to question and evaluate the use of statistical methods in science and society.

Content
Fundamentals of probability, probability distributions, Monte Carlo methods, parameter estimation, numerical optimization, convolution and deconvolution, hypothesis testing, confidence intervals, multivariate classification, time series analysis, and filtering.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and working on the exercises (135 hours).

Recommendation
Basic knowledge of statistical data analysis, such as that taught in the undergraduate course Computer Use in Physics, is desirable.

Literature

- G.Cowan: Statistical Data Analysis, Oxford University Press
- G.Bohm, G.Zech: Einführung in Statistik und Messwertanalyse für Physiker, DESYeBook
- V.Blobel, E.Lohrmann: Statistische und numerische Methoden der Datenanalyse, DESYeBook
- R.J.Barlow: Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences, Wiley
- S.Brandt: Datenanalyse, Spektrum
- W.H.Press, S.A.Teukolsky, W.T.Vetterling, B.P.Fannery: Numerical Recipes, Cambridge University Press
- T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning, Springer

4.117 Module: Modern Methods of Data Analysis, without ext. Exercises (Minor) [M-PHYS-102126]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102497	Modern Methods of Data Analysis, without ext. Exercises (Minor)	6 CR	Ferber, Kieseler, Quast, Wolf

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102125 - Modern Methods of Data Analysis, without ext. Exercises must not have been started.
2. The module M-PHYS-102127 - Modern Methods of Data Analysis, with ext. Exercises must not have been started.
3. The module M-PHYS-102128 - Modern Methods of Data Analysis, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students will be able to formulate fundamentals of statistical data analysis, apply modern methods of data analysis to physical problems, and use and further develop tools for data analysis. On this basis, students are enabled to question and evaluate the use of statistical methods in science and society.

Content
Fundamentals of probability, probability distributions, Monte Carlo methods, parameter estimation, numerical optimization, convolution and deconvolution, hypothesis testing, confidence intervals, multivariate classification, time series analysis, and filtering.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture and completion of exercises (135 hours).

Recommendation
Basic knowledge of statistical data analysis, such as that taught in the undergraduate course Computer Use in Physics, is desirable.

Literature

- G.Cowan: Statistical Data Analysis, Oxford University Press
- G.Bohm, G.Zech: Einführung in Statistik und Messwertanalyse für Physiker, DESYeBook
- V.Blobel, E.Lohrmann: Statistische und numerische Methoden der Datenanalyse, DESYeBook
- R.J.Barlow: Statistics: A Guide to the Use of Statistical Methods in the Physical Sciences, Wiley
- S.Brandt: Datenanalyse, Spektrum
- W.H.Press, S.A.Teukolsky, W.T.Vetterling, B.P.Fannery: Numerical Recipes, Cambridge University Press
- T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning, Springer

M 4.118 Module: Modern Methods of Spectroscopy: Applications in Astroparticle Physics [M-PHYS-106047]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	pass/fail	Each term	1 term	English	4	1

Mandatory			
T-PHYS-112237	Modern Methods of Spectroscopy: Applications in Astroparticle Physics	2 CR	Drexlin, Valerius

Competence Certificate
Regular attendance during the block course is required. Successful participation in the course is certified by a preparatory talk introducing the basics, as well as by a final talk on the implementation and results from the subgroups.

Prerequisites
None

Competence Goal
The students are able to apply spectroscopic methods in astro-particle physics. They know how to plan and execute tasks at a large-scale research project from astro-particle physics in teamwork. Furthermore they are able to prepare and present project-specific basic principles as well as own results in a short talk.

Content
Main focus:

- Precision electron spectroscopy with a MAC-E filter spectrometer.
- Tritium process monitoring using optical spectroscopic methods: (i) sample preparation, (ii) processing, and (iii) performing spectroscopic measurements

Further topics:

- Vacuum technology
- Handling of radioactive samples
- Radiochemical properties of tritium
- Superconducting and normal conducting magnets
- Measurement of magnetic fields from mT to T
- Cryogenic fluids in the lab
- High voltage techniques
- Detector technologies & signal processing
- Signal & background

Annotation
MSc Physics: This module cannot be used concurrently with an advanced seminar in the physics major. The same regulation applies to the second major in physics.

Workload
60 h consisting of 1x day introduction with short seminar talks, 5x days in the lab and 1x day concluding presentation of results.

Recommendation
Fundamentals of classical electrodynamics, optical spectroscopy, thermodynamics, atomic, nuclear and particle physics, measurement methods and techniques in experimental physics, astroparticle physics, and cosmology.

Literature

- KATRIN collaboration, The Design, Construction, and Commissioning of the KATRIN Experiment, Journal of Instrumentation 16 (2021) T08015.
- T. Tanabe, Tritium: Fuel of Fusion Reactors, Springer, Tokio (2017).
- Souers, P. C. Hydrogen Properties for Fusion Energy; University of California Press, (2020).
- B. Bornschein, Tritium Handling and Tritium Plant, in Fundamental of Magnetic Fusion Technology, IAEA (2021).
- M. Schlösser, Accurate Calibration of Raman Systems, Springer, Cham (2014).
- H. H. Telle, A. Gonzalález Ureña, Laser Spectroscopy and Laser Imaging: An Introduction, CRC Press: Boca Raton (2017).

M 4.119 Module: Molecular Spectroscopy [M-PHYS-102337]

Responsible: apl. Prof. Dr. Andreas-Neil Unterreiner
Organisation: KIT Department of Physics
Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CHEMBIO-104639	Molecular Spectroscopy	6 CR	Unterreiner

Competence Certificate
Written exam. Usually 120 minutes.

Prerequisites
none

Competence Goal
The students receive an in-depth overview of spectroscopic methods as well as the corresponding theoretical foundations, e.g. time-dependent Schrödinger equation and perturbation calculus. In addition, they will be introduced to experimental realizations of spectroscopic experiments so that they can design them independently, understand the emergence of the spectra as well as the underlying principles, such as selection rules, in the context of a quantum mechanical description and use them in all areas of chemistry for the characterization of molecules.

Content
Introduction (including electromagnetic radiation, Einstein coefficients), quantum mechanical description of light absorption (perturbation theory, coherent excitation, line shapes), magnetic resonance spectroscopy, rotational spectroscopy, rotational vibrational spectroscopy, Raman spectroscopy, electronic spectroscopy, luminescence, photoelectron spectroscopy.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Literature
For example:

- Haken, Wolf: Molekülphysik und Quantenchemie, Springer Verlag Berlin Heidelberg 2006
- Hollas: Moderne Methoden der Spektroskopie, Vieweg, 1995

M 4.120 Module: Nano-Optics [M-PHYS-102146]

Responsible: PD Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-102282	Nano-Optics	8 CR	Naber

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102147 - Nano-Optics (Minor) must not have been started.

Competence Goal
The students

- improve their understanding of general principles in electrodynamics and optics
- have a deeper understanding of the theoretical background in optical imaging and its relation to phenomena on a nanoscale
- are familiar with conventional techniques in optical microscopy and make use of their knowledge for the understanding of nano-optical methods
- realize the necessity of completely new experimental concepts to overcome the constraints of classical microscopy in the exploration of optical phenomena beyond the diffraction limit
- understand the basics of different experimental approaches for optical imaging on a nanoscale
- are able to discuss pros and cons of these techniques for applications in different fields of physics and biology
- are aware of the importance of nano-optical methods for the elucidation of long-standing interdisciplinary issues

Content
The lecture gives an introduction to theory and instrumentation of advanced methods in optical microscopy. Emphasis is laid on far- and near-field optical techniques with an optical resolution capability on a 10- to 100-nm-scale which is well below the principal limit of classical microscopy. Applications from different scientific disciplines are discussed (e.g., nano-antennas, single-molecule detection, plasmon-polariton propagation on metal surfaces, imaging of biological cell compartments including membranes).

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge in optics

Literature
Will be mentioned in the lecture.

4.121 Module: Nano-Optics (Minor) [M-PHYS-102147]

Responsible: PD Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102360	Nano-Optics (Minor)	8 CR	Naber

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102146 - Nano-Optics must not have been started.

Competence Goal
The students

- improve their understanding of general principles in electrodynamics and optics
- have a deeper understanding of the theoretical background in optical imaging and its relation to phenomena on a nanoscale
- are familiar with conventional techniques in optical microscopy and make use of their knowledge for the understanding of nano-optical methods
- realize the necessity of completely new experimental concepts to overcome the constraints of classical microscopy in the exploration of optical phenomena beyond the diffraction limit
- understand the basics of different experimental approaches for optical imaging on a nanoscale
- are able to discuss pros and cons of these techniques for applications in different fields of physics and biology
- are aware of the importance of nano-optical methods for the elucidation of long-standing interdisciplinary issues

Content
The lecture gives an introduction to theory and instrumentation of advanced methods in optical microscopy. Emphasis is laid on far- and near-field optical techniques with an optical resolution capability on a 10- to 100-nm-scale which is well below the principal limit of classical microscopy. Applications from different scientific disciplines are discussed (e.g., nano-antennas, single-molecule detection, plasmon-polariton propagation on metal surfaces, imaging of biological cell compartments including membranes).

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge in optics

Literature
Will be mentioned in the lecture.

4.122 Module: New Light Particles Beyond the Standard Model, without Exercises [M-PHYS-105833]

Responsible: Prof. Dr. Ulrich Nierste
Dr. Robert Ziegler

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-111703	New Light Particles Beyond the Standard Model, without Exercises	4 CR	Nierste, Ziegler

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
The students gain a deeper understanding of theoretical concepts such as quantum field theory anomalies, kinetic mixing, effective theories, Goldstone theorem. In addition, they understand the strong CP problem and know possible effective solutions. Students will be able to construct simple standard model expansions with light bosons, fermions as well as vector bosons.

Content
This module provides an overview of the theoretical and phenomenological aspects of new light particles beyond the Standard Model. For this purpose, the theoretical foundations of QCD axions, axion-like particles, dark photons, and sterile neutrinos are considered, with a detailed treatment of the theoretical motivation of the QCD axion in particular. The discussion of phenomenology includes possible connections with dark matter, constraints from cosmology and astrophysics, dedicated experimental searches with helioscopes and haloscopes such as CAST or ADMX, and constraints from high-precision experiments such as Belle-II, NA62, XENON1T, and KATRIN.

Workload
120 h consisting of attendance time (30 h) and wrap-up of the lecture including exam preparation (90 h)

Recommendation
Familiarity with the Standard Model and Theoretical Particle Physics.

Literature
Will be stated on the lecture website and in the lecture itself.

M 4.123 Module: Nonlinear Optics [M-ETIT-100430]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-101906	Nonlinear Optics	6 CR	Koos

Competence Certificate
The oral exam is offered continuously upon individual appointment.

Prerequisites
none

Competence Goal
The students

- understand and can mathematically describe the effect of basic nonlinear-optical phenomena using optical susceptibility tensors,
- understand and can mathematically describe wave propagation in nonlinear anisotropic materials,
- have an overview and can quantitatively describe common second-order nonlinear effects comprising the electro-optic effect, second-harmonic generation, sum- and difference frequency generation, parametric amplification and optical rectification,
- have an overview and can quantitatively describe the Kerr effect and other common third-order nonlinear effects, comprising self- and cross-phase modulation, four-wave mixing, self-focussing, and third-harmonic generation,
- have an overview and can describe nonlinear-optical interaction in active devices such as semiconductor optical amplifiers
- conceive the basic principles of various phase-matching techniques and can apply them to practical design problems,
- conceive the basic principles electro-optic modulators, can apply them to practical design problems, and have an overview on state-of-the art devices,
- conceive the basic principles third-order nonlinear signal processing and can apply them to practical design problems.

Content

1. The nonlinear optical susceptibility: Maxwell´s equations and constitutive relations, relation between electric field and polarization, formal definition and properties of the nonlinear optical susceptibility tensor,
2. Wave propagation in nonlinear anisotropic materials
3. Second-order nonlinear effects and devices: Linear electro-optic effect / Pockels effect, second-harmonic generation, sum- and difference-frequency generation, phase matching, parametric amplification, optical rectification
4. Third-order nonlinear effects and devices: Nonlinear refractive index and Kerr effect, self- and cross-phase modulation, four-wave mixing, self-focussing, third-harmonic generation
5. Nonlinear effects in active optical devices

Module grade calculation
The module grade is the grade of the oral exam.

There is a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Approx. 180 h – 30 h lectures, 30 h exercises, 120 h homework and self-studies

Literature

R. Boyd. Nonlinear Optics. Academic Press, New York, 1992.
E.H. Li S. Chiang Y. Guo, C.K. Kao. Nonlinear Photonics. Springer Verlag, 2002
G. Agrawal, Nonlinear Fiber Optics, Academic Press, San Diego, 1995.

M 4.124 Module: Non-supersymmetric Extensions of the Standard Model (Minor) [M-PHYS-105639]

Responsible: Dr. Monika Blanke
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-111277	Non-supersymmetric Extensions of the Standard Model (Minor)	4 CR	Blanke, Nierste

Competence Certificate
Study achievment, ungraded. Active participation in the flipped classroom lectures is the requirement for passing the course.

Prerequisites
basic knowledge of quantum field theory and the standard model of particle physics

Competence Goal
The students are able to study and understand concepts of modern particle physics, apply their knowledge to related problems and discuss solutions with their peers.

Content
This module introduces popular non-suspersymmetric extensions of the Standard Model and discusses their phenomenology. Topics include:

- Standard Model and its limitations: electroweak hierarchy problem, flavour problem
- dynamical symmetry breaking and Goldstone bosons
- collective symmetry breaking and Little Higgs models
- composite Higgs models
- partial compositeness and flavour
- extra dimensions and branes
- Randall-Sundrum model, AdS/CFT correspondence

Annotation
The module is held in the flipped-classroom format. Materials are provided for self-study. Questions and applications are discussed during the lecture.

Workload
120 h consisting of attendance time (30 h) and preparation and wrap-up of the lecture (90 h)

Literature
will be announced in the first lecture

M 4.125 Module: Particle Physics I [M-PHYS-102114]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (mandatory)
Second Major in Physics: Experimental Particle Physics (mandatory)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102369	Particle Physics I	8 CR	Ferber, Husemann, Klute, Quast, Rabbertz

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102115 - Particle Physics I (Minor) must not have been started.

Competence Goal
Students can classify elementary particles and qualitatively analyze interactions between elementary particles using symmetries, Feynman diagrams and Lagrangian densities. Combining this knowledge with knowledge of elementary particle detection, students will be able to discuss the operation of modern particle physics detectors. Students will be able to interpret current data and figures from the scientific literature on particle physics and present the current state of research and important "open questions". Students will be able to apply techniques of statistical data analysis and Monte Carlo simulation to simple particle physics problems and perform basic characterization of silicon track detectors in the laboratory.

Content
Lecture:

- Basic concepts of particle physics
- Detectors and accelerators
- Basics of the Standard Model
- Tests of the electroweak theory
- Flavour physics
- QCD
- Physics at high transverse momenta
- Higgs physics
- Physics of massive neutrinos
- Physics beyond the Standard Model

Practical exercises:

- Current methods of Monte Carlo simulation and data analysis in particle physics.
- Measurements on modern silicon track detectors.

Annotation
For students of the KIT Faculty of Computer Science: The exams in this module have to be registered via admissions from ISS (KIT Faculty of Computer Science). For this, an e-mail with matriculation numbers and name of the desired exam to Beratung-informatik@informatik.kit.edu is sufficient.

Workload
approx. 240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (180 hours)

Recommendation
Basic knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the bachelor's program in physics.

Literature
M. Thomson: Modern Particle Physics, Cambridge University Press (2013). D. Griffith: Introduction to Elementary Particles, Wiley (2008). A. Bettini: Introduction to Elementary Particle Physics, Cambridge University Press (2008). C. Berger: Elementarteilchenphysik, Springer (2006).

Additional references will be given in lecture.

M 4.126 Module: Particle Physics I (Minor) [M-PHYS-102115]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102488	Particle Physics I (Minor)	8 CR	Ferber, Husemann, Klute, Quast, Rabbertz

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102114 - Particle Physics I must not have been started.

Competence Goal
Students can classify elementary particles and qualitatively analyze interactions between elementary particles using symmetries, Feynman diagrams and Lagrangian densities. Combining this knowledge with knowledge of elementary particle detection, students will be able to discuss the operation of modern particle physics detectors. Students will be able to interpret current data and figures from the scientific literature on particle physics and present the current state of research and important "open questions". Students will be able to apply techniques of statistical data analysis and Monte Carlo simulation to simple particle physics problems and perform basic characterization of silicon track detectors in the laboratory.

Content
Lecture:

- Basic concepts of particle physics
- Detectors and accelerators
- Basics of the Standard Model
- Tests of the electroweak theory
- Flavour physics
- QCD
- Physics at high transverse momenta
- Higgs physics
- Physics of massive neutrinos
- Physics beyond the Standard Model

Practical exercises:

- Current methods of Monte Carlo simulation and data analysis in particle physics.
- Measurements on modern silicon track detectors.

Workload
Approx. 240 hours consisting of attendance time (60 hours), follow-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Basic knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the bachelor's program in physics.

Literature

- M. Thomson: Modern Particle Physics, Cambridge University Press (2013).
- D. Griffith: Introduction to Elementary Particles, Wiley (2008).
- A. Bettini: Introduction to Elementary Particle Physics, Cambridge University Press (2008).
- C. Berger: Elementarteilchenphysik, Springer (2006).

Additional references will be given in lecture.

M 4.127 Module: Particle Physics II - Flavour Physics, with ext. Exercises [M-PHYS-102422]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104783	Particle Physics II - Flavour Physics, with ext. Exercises	8 CR	Ferber, Goldenzweig, Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102155 - Particle Physics II - Flavour Physics, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102154 - Particle Physics II - Flavour Physics, without ext. Exercises must not have been started.
3. The module M-PHYS-103183 - Particle Physics II - Flavour Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students gain a better understanding of the fundamental laws of nature on the precision front of experimental particle physics. Students will learn the underlying concepts, and gain hands-on experience that will contribute to a successful introduction to their own research. In addition, students will be able to understand scientific publications and present them independently to other participants.

Content
Particle accelerators allow the fundamental building blocks and forces of nature to be studied. In addition to the use of ever higher energies, knowledge in this field can also be extended by measurements with ever higher precision. Such precision measurements are successfully performed at CERN and at the Tevatron on multipurpose experiments, as well as in special flavor factories at SLAC or at the SuperKEKB accelerator in Japan.

During the lecture we will present experimental methods and certain key processes - meson mixing, CP violation, rare decays. In the exercise, we will additionally discuss tools for everyday life, such as angular distributions and quantum numbers and information systems on the Internet. In addition, there will be a paper seminar at the end of the semester.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the Bachelor's program is assumed.

Literature
Will be mentioned in the lecture.

M 4.128 Module: Particle Physics II - Flavour Physics, with ext. Exercises (Minor) [M-PHYS-103183]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-106316	Particle Physics II - Flavour Physics, with ext. Exercises (Minor)	8 CR	Ferber, Goldenzweig, Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102155 - Particle Physics II - Flavour Physics, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102154 - Particle Physics II - Flavour Physics, without ext. Exercises must not have been started.
3. The module M-PHYS-102422 - Particle Physics II - Flavour Physics, with ext. Exercises must not have been started.

Competence Goal
Students gain a better understanding of the fundamental laws of nature on the precision front of experimental particle physics. Students will learn the underlying concepts, and gain hands-on experience that will contribute to a successful introduction to their own research. In addition, students will be able to understand scientific publications and present them independently to other participants.

Content
Particle accelerators allow the fundamental building blocks and forces of nature to be studied. In addition to the use of ever higher energies, knowledge in this field can also be extended by measurements with ever higher precision. Such precision measurements are successfully performed at CERN and at the Tevatron on multipurpose experiments, as well as in special flavor factories at SLAC or at the SuperKEKB accelerator in Japan.

During the lecture we will present experimental methods and certain key processes - meson mixing, CP violation, rare decays. In the exercise, we will additionally discuss tools for everyday life, such as angular distributions and quantum numbers and information systems on the Internet. In addition, there will be a paper seminar at the end of the semester.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the Bachelor's program is assumed.

Literature
Will be mentioned in the lecture.

M 4.129 Module: Particle Physics II - Flavour Physics, without ext. Exercises [M-PHYS-102154]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102371	Particle Physics II - Flavour Physics, without ext. Exercises	6 CR	Ferber, Goldenzweig, Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102155 - Particle Physics II - Flavour Physics, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-102422 - Particle Physics II - Flavour Physics, with ext. Exercises must not have been started.
3. The module M-PHYS-103183 - Particle Physics II - Flavour Physics, with ext. Exercises (Minor) must not have been started.

Competence Goal
Students gain a better understanding of the fundamental laws of nature on the precision front of experimental particle physics. Students learn the underlying concepts, and gain hands-on experience that contributes to a successful introduction to their own research.

Content
Particle accelerators allow the fundamental building blocks and forces of nature to be studied. In addition to the use of ever higher energies, knowledge in this field can also be extended by measurements with ever higher precision. Such precision measurements are successfully performed at CERN and at the Tevatron on multipurpose experiments, as well as in special flavor factories at SLAC or at the SuperKEKB accelerator in Japan.

During the lecture we will present experimental methods and certain key processes - meson mixing, CP violation, rare decays. In the exercise we will additionally discuss tools for everyday life, such as angular distributions and quantum numbers and information systems on the internet.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the Bachelor's program is assumed.

Literature
Will be mentioned in the lecture.

M 4.130 Module: Particle Physics II - Flavour Physics, without ext. Exercises (Minor) [M-PHYS-102155]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102424	Particle Physics II - Flavour Physics, without ext. Exercises (Minor)	6 CR	Ferber, Goldenzweig, Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102154 - Particle Physics II - Flavour Physics, without ext. Exercises must not have been started.
2. The module M-PHYS-103183 - Particle Physics II - Flavour Physics, with ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-102422 - Particle Physics II - Flavour Physics, with ext. Exercises must not have been started.

Competence Goal
Students gain a better understanding of the fundamental laws of nature on the precision front of experimental particle physics. Students learn the underlying concepts, and gain hands-on experience that contributes to a successful introduction to their own research.

Content
Particle accelerators allow the fundamental building blocks and forces of nature to be studied. In addition to the use of ever higher energies, knowledge in this field can also be extended by measurements with ever higher precision. Such precision measurements are successfully performed at CERN and at the Tevatron on multipurpose experiments, as well as in special flavor factories at SLAC or at the SuperKEKB accelerator in Japan.

During the lecture we will present experimental methods and certain key processes - meson mixing, CP violation, rare decays. In the exercise we will additionally discuss tools for everyday life, such as angular distributions and quantum numbers and information systems on the internet.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the Bachelor's program is assumed.

Literature
Will be mentioned in the lecture.

4.131 Module: Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises [M-PHYS-105939]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111950	Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises	8 CR	Klute

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105937 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises must not have been started.
2. The module M-PHYS-105938 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-105940 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of physics beyond the standard model of particle physics, together with the most important related measurements. Thus, they extend their knowledge in a specific field of experimental particle physics, and they are familiar with the current state of research. The students understand modern, computer-based techniques of data analysis and are able to apply them to simple problems in physics beyond the standard model. The students solve problems as a team and improve their presentation skills. The students are able to research and analyze scientific publications in the field of particle physics.

Content

- Review of the standard model of particle physics (SM)
- Experimental and theoretical motivation for searches beyond the SM
- Selected examples for theories of and searches for physics beyond the SM
- Experimental techniques and modern methods of statistical data analysis

Workload
240 hours consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 h)

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

M 4.132 Module: Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor) [M-PHYS-105940]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111951	Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor)	8 CR	Klute

Competence Certificate
The course credit is achieved through successful participation in the exercise. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105937 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises must not have been started.
2. The module M-PHYS-105938 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-105939 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of physics beyond the standard model of particle physics, together with the most important related measurements. Thus, they extend their knowledge in a specific field of experimental particle physics, and they are familiar with the current state of research. The students understand modern, computer-based techniques of data analysis and are able to apply them to simple problems in physics beyond the standard model. The students solve problems as a team and improve their presentation skills. The students are able to research and analyze scientific publications in the field of particle physics.

Content

- Review of the standard model of particle physics (SM)
- Experimental and theoretical motivation for searches beyond the SM
- Selected examples for theories of and searches for physics beyond the SM
- Experimental techniques and modern methods of statistical data analysis

Workload
240 hours consisting of attendance time (60 h), wrap-up of the lecture and preparation of the exercises (180 h).

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

4.133 Module: Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises [M-PHYS-105937]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111948	Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises	6 CR	Klute

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105938 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-105939 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises must not have been started.
3. The module M-PHYS-105940 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of physics beyond the standard model of particle physics, together with the most important related measurements. Thus, they extend their knowledge in a specific field of experimental particle physics, and they are familiar with the current state of research. The students understand modern, computer-based techniques of data analysis and are able to apply them to simple problems in physics beyond the standard model. The students solve problems as a team. The students are able to research and analyze scientific publications in the field of particle physics.

Content

- Review of the standard model of particle physics (SM)
- Experimental and theoretical motivation for searches beyond the SM
- Selected examples for theories of and searches for physics beyond the SM
- Experimental techniques and modern methods of statistical data analysis

Workload
180 hours consisting of attendance time (45 h), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 h)

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

4.134 Module: Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor) [M-PHYS-105938]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111949	Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor)	6 CR	Klute

Competence Certificate
The course credit is achieved through successful participation in the exercise. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105937 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises must not have been started.
2. The module M-PHYS-105939 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises must not have been started.
3. The module M-PHYS-105940 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of physics beyond the standard model of particle physics, together with the most important related measurements. Thus, they extend their knowledge in a specific field of experimental particle physics, and they are familiar with the current state of research. The students understand modern, computer-based techniques of data analysis and are able to apply them to simple problems in physics beyond the standard model. The students solve problems as a team. The students are able to research and analyze scientific publications in the field of particle physics.

Content

- Review of the standard model of particle physics (SM)
- Experimental and theoretical motivation for searches beyond the SM
- Selected examples for theories of and searches for physics beyond the SM
- Experimental techniques and modern methods of statistical data analysis

Workload
180 hours consisting of attendance time (45 h), wrap-up of the lecture and preparation of the exercises (135 h).

Recommendation
Basic knowledge from the bachelor lectures "Moderne Experimentalphysik III", "Moderne Theoretische Physik II" and "Rechnernutzung in der Physik" as well as from the master lecture "Particle Physics I" is assumed.

4.135 Module: Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises [M-PHYS-104088]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108474	Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises	8 CR	Müller, Rabbertz

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104086 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises must not have been started.
2. The module M-PHYS-104087 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-104089 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students have in-depth knowledge in a special field of particle physics and gain insights into the current state of research. They know current theoretical concepts and experimental techniques. The participants can solve simple and complex problems in written form or in practical exercises on the computer. They know typical computer-based methods for the simulation of particle-physical processes and for data analysis and have gained experience in more in-depth work with primary literature.

Content
Quantum chromodynamics, modern simulation programs and analysis techniques, jet algorithms, jet energy calibration, calculation and measurement of jet effective cross sections, experimental and theoretical corrections and uncertainties, determination of strong interaction constants, recent measurements at hadron colliders, production and decay of top pairs and single top quarks, top properties in the Standard Model, reconstruction of top events, boosted top, connection between top and Higgs physics, search for New Physics with top quarks.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180)

Recommendation
Basic knowledge from the courses *Modern Experimental Physics III*, *Modern Theoretical Physics II* and *Computer Use in Physics* from the Bachelor's program and *Particle Physics I* from the Master's program is assumed.

Literature

- R.K. Ellis, W.J. Stirling, B.R. Webber, "QCD and Collider Physics," Cambridge, 1996.
- G. Dissertori, I.G. Knowles, M. Schmeling, "Quantum Chromodynamics," Oxford, 2002.
- R. Cahn, G. Goldhaber, "The Experimental Foundations of Particle Physics," Cambridge, 2009.
- Particle Data Group, "The Review of Particle Physics," J.Phys. G37, 075021 (2010).
- G. Salam, "Towards Jetography," arXiv:0906.1833, 2009.
- V. D. Barger, R. J. N. Phillips: Collider Physics, Westview Press (1996).
- J. M. Campbell, J. W. Huston, W. J. Stirling, Rep. Prog. Phys. 70 (2007) 89.
- T. Plehn: Lectures on LHC Physics, Springer (2012), arXiv:0910.4182 [hep-ph].
- W. Bernreuther, J. Phys. G: Nucl. Part. Phys. 35 (2008) 083001.
- J. Incandela, A. Quadt, W. Wagner, D. Wicke, Prog. Part. Nucl. Phys. 63 (2009) 239.
- F.-P. Schilling, Int. J. Mod. Phys. A27 (2012) 1230016.
- Several habilitation theses: W. Wagner (Karlsruhe 2005), A. Quadt (Bonn 2006), F.Fiedler (Munich 2007), M.-A. Pleier (Bonn 2008), D. Wicke (Wuppertal 2009), and recent scientific publications and reviews.

4.136 Module: Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor) [M-PHYS-104089]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108475	Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor)	8 CR	Müller, Rabbertz

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104086 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises must not have been started.
2. The module M-PHYS-104087 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-104088 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises must not have been started.

Competence Goal
The students have in-depth knowledge in a special field of particle physics and gain insights into the current state of research. They know current theoretical concepts and experimental techniques. The participants can solve simple and complex problems in written form or in practical exercises on the computer. They know typical computer-based methods for the simulation of particle-physical processes and for data analysis and have gained experience in more in-depth work with primary literature.

Content
Quantum chromodynamics, modern simulation programs and analysis techniques, jet algorithms, jet energy calibration, calculation and measurement of jet effective cross sections, experimental and theoretical corrections and uncertainties, determination of strong interaction constants, recent measurements at hadron colliders, production and decay of top pairs and single top quarks, top properties in the Standard Model, reconstruction of top events, boosted top, connection between top and Higgs physics, search for New Physics with top quarks.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180).

Recommendation
Basic knowledge from the courses *Modern Experimental Physics III*, *Modern Theoretical Physics II* and *Computer Use in Physics* from the Bachelor's program and *Particle Physics I* from the Master's program is assumed.

Literature

- R.K. Ellis, W.J. Stirling, B.R. Webber, "QCD and Collider Physics," Cambridge, 1996.
- G. Dissertori, I.G. Knowles, M. Schmeling, "Quantum Chromodynamics," Oxford, 2002.
- R. Cahn, G. Goldhaber, "The Experimental Foundations of Particle Physics," Cambridge, 2009.
- Particle Data Group, "The Review of Particle Physics," J.Phys. G37, 075021 (2010).
- G. Salam, "Towards Jetography," arXiv:0906.1833, 2009.
- V. D. Barger, R. J. N. Phillips: Collider Physics, Westview Press (1996).
- J. M. Campbell, J. W. Huston, W. J. Stirling, Rep. Prog. Phys. 70 (2007) 89.
- T. Plehn: Lectures on LHC Physics, Springer (2012), arXiv:0910.4182 [hep-ph].
- W. Bernreuther, J. Phys. G: Nucl. Part. Phys. 35 (2008) 083001.
- J. Incandela, A. Quadt, W. Wagner, D. Wicke, Prog. Part. Nucl. Phys. 63 (2009) 239.
- F.-P. Schilling, Int. J. Mod. Phys. A27 (2012) 1230016.
- Several habilitation theses: W. Wagner (Karlsruhe 2005), A. Quadt (Bonn 2006), F.Fiedler (Munich 2007), M.-A. Pleier (Bonn 2008), D. Wicke (Wuppertal 2009).and recent scientific publications and reviews.

M 4.137 Module: Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises [M-PHYS-104086]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108472	Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises	6 CR	Müller, Rabbertz

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104087 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-104088 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises must not have been started.
3. The module M-PHYS-104089 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students have in-depth knowledge in a special field of particle physics and gain insights into the current state of research. They know current theoretical concepts and experimental techniques. The participants can solve simple problems in written form or in practical exercises on the computer. They know typical computer-based methods for simulating particle-physical processes and for data analysis and have gained experience in working with primary literature.

Content
Quantum chromodynamics, modern simulation programs and analysis techniques, jet algorithms, jet energy calibration, calculation and measurement of jet effective cross sections, experimental and theoretical corrections and uncertainties, determination of strong interaction constants, recent measurements at hadron colliders, production and decay of top pairs and single top quarks, top properties in the Standard Model, reconstruction of top events, boosted top, connection between top and Higgs physics, search for New Physics with top quarks.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge from the courses *Modern Experimental Physics III*, *Modern Theoretical Physics II* and *Computer Use in Physics* from the Bachelor's program and *Particle Physics I* from the Master's program is assumed.

Literature

- R.K. Ellis, W.J. Stirling, B.R. Webber, "QCD and Collider Physics," Cambridge, 1996.
- G. Dissertori, I.G. Knowles, M. Schmeling, "Quantum Chromodynamics," Oxford, 2002.
- R. Cahn, G. Goldhaber, "The Experimental Foundations of Particle Physics," Cambridge, 2009.
- Particle Data Group, "The Review of Particle Physics," J.Phys. G37, 075021 (2010).
- G. Salam, "Towards Jetography," arXiv:0906.1833, 2009.
- V. D. Barger, R. J. N. Phillips: Collider Physics, Westview Press (1996).
- J. M. Campbell, J. W. Huston, W. J. Stirling, Rep. Prog. Phys. 70 (2007) 89.
- T. Plehn: Lectures on LHC Physics, Springer (2012), arXiv:0910.4182 [hep-ph].
- W. Bernreuther, J. Phys. G: Nucl. Part. Phys. 35 (2008) 083001.
- J. Incandela, A. Quadt, W. Wagner, D. Wicke, Prog. Part. Nucl. Phys. 63 (2009) 239.
- F.-P. Schilling, Int. J. Mod. Phys. A27 (2012) 1230016.
- Several habilitation theses: W. Wagner (Karlsruhe 2005), A. Quadt (Bonn 2006), F.Fiedler (Munich 2007), M.-A. Pleier (Bonn 2008), D. Wicke (Wuppertal 2009).and recent scientific publications and reviews.

M 4.138 Module: Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor) [M-PHYS-104087]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108473	Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor)	6 CR	Müller, Rabbertz

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104086 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises must not have been started.
2. The module M-PHYS-104088 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises must not have been started.
3. The module M-PHYS-104089 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students have in-depth knowledge in a special field of particle physics and gain insights into the current state of research. They know current theoretical concepts and experimental techniques. The participants can solve simple problems in written form or in practical exercises on the computer. They know typical computer-based methods for simulating particle-physical processes and for data analysis and have gained experience in working with primary literature.

Content
Quantum chromodynamics, modern simulation programs and analysis techniques, jet algorithms, jet energy calibration, calculation and measurement of jet effective cross sections, experimental and theoretical corrections and uncertainties, determination of strong interaction constants, recent measurements at hadron colliders, production and decay of top pairs and single top quarks, top properties in the Standard Model, reconstruction of top events, boosted top, connection between top and Higgs physics, search for New Physics with top quarks.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge from the courses *Modern Experimental Physics III*, *Modern Theoretical Physics II* and *Computer Use in Physics* from the Bachelor's program and *Particle Physics I* from the Master's program is assumed.

Literature

- R.K. Ellis, W.J. Stirling, B.R. Webber, "QCD and Collider Physics," Cambridge, 1996.
- G. Dissertori, I.G. Knowles, M. Schmeling, "Quantum Chromodynamics," Oxford, 2002.
- R. Cahn, G. Goldhaber, "The Experimental Foundations of Particle Physics," Cambridge, 2009.
- Particle Data Group, "The Review of Particle Physics," J.Phys. G37, 075021 (2010).
- G. Salam, "Towards Jetography," arXiv:0906.1833, 2009.
- V. D. Barger, R. J. N. Phillips: Collider Physics, Westview Press (1996).
- J. M. Campbell, J. W. Huston, W. J. Stirling, Rep. Prog. Phys. 70 (2007) 89.
- T. Plehn: Lectures on LHC Physics, Springer (2012), arXiv:0910.4182 [hep-ph].
- W. Bernreuther, J. Phys. G: Nucl. Part. Phys. 35 (2008) 083001.
- J. Incandela, A. Quadt, W. Wagner, D. Wicke, Prog. Part. Nucl. Phys. 63 (2009) 239.
- F.-P. Schilling, Int. J. Mod. Phys. A27 (2012) 1230016.
- Several habilitation theses: W. Wagner (Karlsruhe 2005), A. Quadt (Bonn 2006), F.Fiedler (Munich 2007), M.-A. Pleier (Bonn 2008), D. Wicke (Wuppertal 2009).and recent scientific publications and reviews.

M 4.139 Module: Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises [M-PHYS-104084]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108470	Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises	8 CR	Klute, Quast, Rabbertz, Wolf

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104081 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises must not have been started.
2. The module M-PHYS-104082 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-104085 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of the physics of massive bosons in the Standard Model, together with the most important related measurements at colliders. Thus, they extend their knowledge in a specific field of experimental particle physics , and they are familiar with the current state of research. The students understand modern, computerbased techniques of data analysis and are able to apply them to simple problems in W/Z/H physics. The students solve problems as a team and improve their presentation skills. ONLY 8 ECTS: The students are able to research and analyse scientific publications in the field of particle physics.

Content
Historic introduction, electroweak symmetry breaking in the Standard Model, experimental techniques and modern methods of statisitcal data analysis, W and Z boson physics at colliders, properties of the Higgs bosons, search for and discovery of the Higgs boson, multi-boson processes, W/Z/Higgs processes in physics beyond the Standard Model.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

Literature

- ALEPH, DELPHI, L3, OPAL, SLD: Precision Electroweak measurements on the Z Resonance, Phys.Rept. 427 (2006) 257.
- ALEPH, DELPHI, L3, OPAL : Electroweak Measurements in Electron-Positron Collisions at W-Boson-Pair Energies at LEP, Phys. Rept. 532 (2013) 119.
- M. Mozer: Electroweak Physics at the LHC, Springer (2016)
- R. Wolf: The Higgs Boson Discovery at the Large Hadron Collider, Springer 2015
- J. Ellis: Higgs Physics, arXiv:1312.567 [hep-ph]
- A. Djouadi: The anatomy of electroweak symmetry breaking I,Phys. Rep. 457 (2008) 1

M 4.140 Module: Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor) [M-PHYS-104085]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108471	Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor)	8 CR	Klute, Quast, Rabbertz, Wolf

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104081 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises must not have been started.
2. The module M-PHYS-104082 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor) must not have been started.
3. The module M-PHYS-104084 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of the physics of massive bosons in the Standard Model, together with the most important related measurements at colliders. Thus, they extend their knowledge in a specific field of experimental particle physics , and they are familiar with the current state of research. The students understand modern, computerbased techniques of data analysis and are able to apply them to simple problems in W/Z/H physics. The students solve problems as a team and improve their presentation skills. The students are able to research and analyse scientific publications in the field of particle physics.

Content
Historic introduction, electroweak symmetry breaking in the Standard Model, experimental techniques and modern methods of statisitcal data analysis, W and Z boson physics at colliders, properties of the Higgs bosons, search for and discovery of the Higgs boson, multi-boson processes, W/Z/Higgs processes in physics beyond the Standard Model.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

Literature

- ALEPH, DELPHI, L3, OPAL, SLD: Precision Electroweak measurements on the Z Resonance, Phys.Rept. 427 (2006) 257.
- ALEPH, DELPHI, L3, OPAL : Electroweak Measurements in Electron-Positron Collisions at W-Boson-Pair Energies at LEP, Phys. Rept. 532 (2013) 119.
- M. Mozer: Electroweak Physics at the LHC, Springer (2016)
- R. Wolf: The Higgs Boson Discovery at the Large Hadron Collider, Springer 2015
- J. Ellis: Higgs Physics, arXiv:1312.567 [hep-ph]
- A. Djouadi: The anatomy of electroweak symmetry breaking I,Phys. Rep. 457 (2008) 1

M 4.141 Module: Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises [M-PHYS-104081]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Required Elective Experimental Particle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108468	Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises	6 CR	Klute, Quast, Rabbertz, Wolf

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104082 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor) must not have been started.
2. The module M-PHYS-104084 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises must not have been started.
3. The module M-PHYS-104085 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of the physics of massive bosons in the Standard Model, together with the most important related measurements at colliders. Thus, they extend their knowledge in a specific field of experimental particle physics , and they are familiar with the current state of research. The students understand modern, computerbased techniques of data analysis and are able to apply them to simple problems in W/Z/H physics. The students solve problems as a team and improve their presentation skills.

Content
Historic introduction, electroweak symmetry breaking in the Standard Model, experimental techniques and modern methods of statisitcal data analysis, W and Z boson physics at colliders, properties of the Higgs bosons, search for and discovery of the Higgs boson, multi-boson processes, W/Z/Higgs processes in physics beyond the Standard Model.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Particle Physics I“ is assumed.

Literature

- ALEPH, DELPHI, L3, OPAL, SLD: Precision Electroweak measurements on the Z Resonance, Phys.Rept. 427 (2006) 257.
- ALEPH, DELPHI, L3, OPAL : Electroweak Measurements in Electron-Positron Collisions at W-Boson-Pair Energies at LEP, Phys. Rept. 532 (2013) 119.
- M. Mozer: Electroweak Physics at the LHC, Springer (2016)
- R. Wolf: The Higgs Boson Discovery at the Large Hadron Collider, Springer 2015
- J. Ellis: Higgs Physics, arXiv:1312.567 [hep-ph]
- A. Djouadi: The anatomy of electroweak symmetry breaking I,Phys. Rep. 457 (2008) 1

M 4.142 Module: Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor) [M-PHYS-104082]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-108469	Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor)	6 CR	Klute, Quast, Rabbertz, Wolf

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104081 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises must not have been started.
2. The module M-PHYS-104084 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises must not have been started.
3. The module M-PHYS-104085 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor) must not have been started.

Competence Goal
The students are able to present the theoretical and experimental basics of the physics of massive bosons in the Standard Model, together with the most important related measurements at colliders. Thus, they extend their knowledge in a specific field of experimental particle physics , and they are familiar with the current state of research. The students understand modern, computerbased techniques of data analysis and are able to apply them to simple problems in W/Z/H physics. The students solve problems as a team and improve their presentation skills.

Content
Historic introduction, electroweak symmetry breaking in the Standard Model, experimental techniques and modern methods of statisitcal data analysis, W and Z boson physics at colliders, properties of the Higgs bosons, search for and discovery of the Higgs boson, multi-boson processes, W/Z/Higgs processes in physics beyond the Standard Model.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture and preparation of exercises (135 hours).

Recommendation
Basic knowledge from the bachelor lectures “Moderne Experimentalphysik III”, “Moderne Theoretische Physik II” and “Rechnernutzung in der Physik” as well as from the master lecture “Teilchenphysik I“ is assumed.

Literature

- ALEPH, DELPHI, L3, OPAL, SLD: Precision Electroweak measurements on the Z Resonance, Phys.Rept. 427 (2006) 257.
- ALEPH, DELPHI, L3, OPAL : Electroweak Measurements in Electron-Positron Collisions at W-Boson-Pair Energies at LEP, Phys. Rept. 532 (2013) 119.
- M. Mozer: Electroweak Physics at the LHC, Springer (2016)
- R. Wolf: The Higgs Boson Discovery at the Large Hadron Collider, Springer 2015
- J. Ellis: Higgs Physics, arXiv:1312.567 [hep-ph]
- A. Djouadi: The anatomy of electroweak symmetry breaking I,Phys. Rep. 457 (2008) 1

M 4.143 Module: Particle Physics with Extra Dimensions [M-PHYS-106055]

Responsible: Dr. Monika Blanke
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112244	Particle Physics with Extra Dimensions	4 CR	Blanke, Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
Knowledge of quantum field theory and the standard model of particle physics is required.

Competence Goal
The students are able to study and understand concepts of modern particle physics, in particular related to extensions of the Standard Model with extra space-time dimensions.

Content
This module introduces theoretical concepts of particle physics with extra space-time dimensions and discusses their phenomenology. Topics include:

- compactification, orbifolds and boundary conditions
- 5D fields and Kaluza-Klein decomposition
- gauge-Higgs unification
- warped geometry and the Randall-Sundrum model
- gauge and flavour hierarchies in RS
- AdS/CFT correspondence

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation (90 hours).

Literature
Will be announced in the first lecture

M 4.144 Module: Photovoltaics [M-ETIT-100513]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-101939	Photovoltaics	6 CR	Powalla

Prerequisites
Module "M-ETIT-100524 - Solar Energy" must not have started.

4.145 Module: Physics beyond the Standard Model, with Exercises [M-PHYS-106727]

Responsible: Prof. Dr. Milada Margarete Mühlleitner

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-PHYS-113531	Physics beyond the Standard Model, with Exercises	6 CR	Mühlleitner

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
Useful is knowledge on quantum field theory and the Standard Model of particle physics (e.g. from the lecture „Introduction to Theoretical Particle Physics"). It is useful to attend in parallel the lecture „Theoretical Particle Physics I".

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106728 - Physics beyond the Standard Model, without Exercises must not have been started.

Competence Goal
The students get to know the methodology of extension of the Standard Model Higgs sector under consideration of certain symmetries. They get to know the phenomenology of extended Higgs sectors and how they can solve problems of the Standard Model. They are able to perform complex calculations for the determination of Higgs observables and for the determination of constrains on extended Higgs sectors.

Content

- Open problems of the Standard Modell
- Extended Higgs sectors: singlet-extended Higgs sectors, 2-Higgs-Doublet Models, supersymmetry, composite Higgs models
- Constraints on extended Higgs sectors (theoretical constraints, constraints from collider observables, from low-energy experiments, from Dark Matter searches, from the requirement of a strong first-order electroweak phase transition)

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Literature
Will be given in the lecture.

4.146 Module: Physics beyond the Standard Model, without Exercises [M-PHYS-106728]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-PHYS-113532	Physics beyond the Standard Model, without Exercises	4 CR	Mühlleitner

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
Useful is knowledge on quantum field theory and the Standard Model of particle physics (e.g. from the lecture „Introduction to Theoretical Particle Physics“). It is useful to attend in parallel the lecture „Theoretical Particle Physics I“.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106727 - Physics beyond the Standard Model, with Exercises must not have been started.

Competence Goal
The students get to know the methodology of extension of the Standard Model Higgs sector under consideration of certain symmetries. They get to know the phenomenology of extended Higgs sectors and how they can solve problems of the Standard Model. They are able to perform complex calculations for the determination of Higgs observables and for the determination of constrains on extended Higgs sectors.

Content

- Open problems of the Standard Modell
- Extended Higgs sectors: singlet-extended Higgs sectors, 2-Higgs-Doublet Models, supersymmetry, composite Higgs models
- Constraints on extended Higgs sectors (theoretical constraints, constraints from collider observables, from low-energy experiments, from Dark Matter searches, from the requirement of a strong first-order electroweak phase transition)

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation (90 hours).

Literature
Will be given in the lecture.

M 4.147 Module: Physics of Seismic Instruments [M-PHYS-102358]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-104727	Physics of Seismic Instruments	6 CR	Forbriger

Competence Certificate
To pass the module, an oral exam must be passed (approx. 20 minutes). As prerequisite a student must successfully participate in the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102653 - Physics of Seismic Instruments (Minor) must not have been started.

Competence Goal
The students understand the causes and consequences of different physical excitation mechanisms for inertial seismometers. They can explain essential considerations for installation and shielding. The students understand the concept of frequency response and are able to express a transfer function in terms of poles and zeroes. They can apply these concepts to sensors with electrodynamic transducers. The students can explain the significance of linearity. They are able to quantitatively infer the physical input signal from the recording of a seismic instrument. The stundents are able to use the concepts of bandwidth and dynamic range when expressing properties of signals and instruments. The students know means to express noise levels and to estimate instrumental self-noise. They can explain measures to increase the sensitivity and can explain the essential principles of modern force-balance feedback seismometers.

Content

- The mechanical sensor and the driven harmonic oscillator
- Various driving forces and wanted and unwanted sensitivity
- Installation and shielding
- The seismometer with electrodynamic transducer, effective gain, and damping due to passive electrodynamic feedback
- The frequency response, transfer function, poles and zeroes, non-linearity
- Seismic signals, bandwidth, dynamic range, and noise floor
- The force-balance feedback seismometer, displacement transducer, phase sensitive rectifier, controller, and the role of open-loop gain
- Effective transfer function of the velocity broad-band seismometer

Workload
180 hours composed of attendance time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
A sound knowledge of the theory of ordinary differential equations and integral transformations (Fourier transformation) is expected. Basic skills in pratical signal processing using elementary computer programming techniques are needed in the exercises. A basic understanding of seismic waves in the Earth is helpful.

Literature

- Bormann, P., (ed.), 2012. New Manual of Seismological Observatory Practice. 2nd edition. GeoForschungsZentrum Potsdam. DOI: 10.2312/GFZ.NMSOP-2. http://dx.doi.org/10.2312/GFZ.NMSOP-2. Chapters 4 and 5 in particular.

Further recommendations will be given during the course.

M 4.148 Module: Physics of Seismic Instruments (Minor) [M-PHYS-102653]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-105567	Physics of Seismic Instruments (Minor)	6 CR	Forbriger

Competence Certificate
To pass the module, a student must successfully participate the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102358 - Physics of Seismic Instruments must not have been started.

Competence Goal
The students understand the causes and consequences of different physical excitation mechanisms for inertial seismometers. They can explain essential considerations for installation and shielding. The students understand the concept of frequency response and are able to express a transfer function in terms of poles and zeroes. They can apply these concepts to sensors with electrodynamic transducers. The students can explain the significance of linearity. They are able to quantitatively infer the physical input signal from the recording of a seismic instrument. The stundents are able to use the concepts of bandwidth and dynamic range when expressing properties of signals and instruments. The students know means to express noise levels and to estimate instrumental self-noise. They can explain measures to increase the sensitivity and can explain the essential principles of modern force-balance feedback seismometers.

Content

- The mechanical sensor and the driven harmonic oscillator
- Various driving forces and wanted and unwanted sensitivity
- Installation and shielding
- The seismometer with electrodynamic transducer, effective gain, and damping due to passive electrodynamic feedback
- The frequency response, transfer function, poles and zeroes, non-linearity
- Seismic signals, bandwidth, dynamic range, and noise floor
- The force-balance feedback seismometer, displacement transducer, phase sensitive rectifier, controller, and the role of open-loop gain
- Effective transfer function of the velocity broad-band seismometer

Workload
180 hours composed of attendance time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
A sound knowledge of the theory of ordinary differential equations and integral transformations (Fourier transformation) is expected. Basic skills in pratical signal processing using elementary computer programming techniques are needed in the exercises. A basic understanding of seismic waves in the Earth is helpful.

Literature

- Bormann, P., (ed.), 2012. New Manual of Seismological Observatory Practice. 2nd edition. GeoForschungsZentrum Potsdam. DOI: 10.2312/GFZ.NMSOP-2. http://dx.doi.org/10.2312/GFZ.NMSOP-2. Chapters 4 and 5 in particular.

Further recommendations will be given during the course.

M 4.149 Module: Physics of Semiconductors, with Exercises [M-PHYS-102131]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Required Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-102343	Physics of Semiconductors, with Exercises	10 CR	Kalt

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102130 - Physics of Semiconductors, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102301 - Physics of Semiconductors, without Exercises must not have been started.

Competence Goal
The students

- know characteristic details of the semiconductor band structure and can justify them theoretically
- know the description of equilibrium and non-equilibrium processes and are able to calculate typical phenomena in semiconductors
- can explain and calculate transport phenomena and dynamic problems with the help of differential equations of internal electronics
- understand the importance of temporal or spatial inhomogeneity as a driving force for these processes
- understand the band characteristics and physical properties of semiconductor transitions
- can describe and theoretically justify the phenomenological behavior and typical applications of semiconductor devices on the basis of the fundamentals they have learned
- can calculate the behavior of devices themselves using selected examples

Content

1. Basic properties of semiconductors (material classes, band structure, k*p theory, statistics, Boltzmann equilibrium).
2. Non-equilibrium processes in semiconductors (Boltzmann equation, generation and recombination, transport phenomena)
3. Semiconductor junctions in thermodynamic equilibrium (pn junction, heterojunctions, low-dimensional semiconductors, Schottky contact, ohmic contact, insulator-semiconductor transition)
4. Semiconductor junctions in non-equilibrium/ devices (diode, photodiode, solar cell, LED, diode laser, microwave devices, bipolar transistor, field effect transistor, CCD, memory devices, ...)
5. Semiconductor technology (epitaxy, doping, structuring, integration)

Workload
300 hours consisting of attendance time (75 hrs.), wrap-up of the lecture, processing of the exercises as well as exam preparation (225 hrs.)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

R. Enderlein, N. Horing: *Fundamentals of Semiconductor Physics and Devices*

M. Grundmann: *The Physics of Semiconductors*

S.M. Sze, K.K. Ng: *Physics of Semiconductor Devices*

4.150 Module: Physics of Semiconductors, with Exercises (Minor) [M-PHYS-102130]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	pass/fail	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-102301	Physics of Semiconductors, with Exercises (Minor)	10 CR	Kalt

Competence Certificate
Proof of this module as a minor subject in physics requires successful participation in the exercises. This is certified as an ungraded course achievement.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102131 - Physics of Semiconductors, with Exercises must not have been started.
2. The module M-PHYS-102301 - Physics of Semiconductors, without Exercises must not have been started.

Competence Goal
The students

- know characteristic details of the semiconductor band structure and can justify them theoretically
- know the description of equilibrium and non-equilibrium processes and are able to calculate typical phenomena in semiconductors
- can explain and calculate transport phenomena and dynamic problems with the help of differential equations of internal electronics
- understand the importance of temporal or spatial inhomogeneity as a driving force for these processes
- understand the band characteristics and physical properties of semiconductor transitions
- can describe and theoretically justify the phenomenological behavior and typical applications of semiconductor devices on the basis of the fundamentals they have learned
- can calculate the behavior of devices themselves using selected examples

Content

1. Basic properties of semiconductors (material classes, band structure, k*p theory, statistics, Boltzmann equilibrium).
2. Non-equilibrium processes in semiconductors (Boltzmann equation, generation and recombination, transport phenomena)
3. Semiconductor junctions in thermodynamic equilibrium (pn junction, heterojunctions, low-dimensional semiconductors, Schottky contact, ohmic contact, insulator-semiconductor transition)
4. Semiconductor junctions in non-equilibrium/ devices (diode, photodiode, solar cell, LED, diode laser, microwave devices, bipolar transistor, field effect transistor, CCD, memory devices, ...)
5. Semiconductor technology (epitaxy, doping, structuring, integration)

Workload
300 hours consisting of attendance time (75 hrs.), wrap-up of lecture, completion of exercises (225 hrs.)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
R. Enderlein, N. Horing: *Fundamentals of Semiconductor Physics and Devices*

M. Grundmann: *The Physics of Semiconductors*

S.M. Sze, K.K. Ng: *Physics of Semiconductor Devices*

M 4.151 Module: Physics of Semiconductors, without Exercises [M-PHYS-102301]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Required Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-104590	Physics of Semiconductors, without Exercises	8 CR	Kalt

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102130 - Physics of Semiconductors, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102131 - Physics of Semiconductors, with Exercises must not have been started.

Competence Goal
The students

- know characteristic details of the semiconductor band structure and can justify them theoretically
- know the description of equilibrium and non-equilibrium processes
- can explain transport phenomena and dynamic problems with the help of the differential equations of internal electronics
- understand the importance of temporal or spatial inhomogeneity as a driving force for these processes
- understand the band characteristics and physical properties of semiconductor transitions
- can describe and theoretically justify the phenomenological behavior and typical applications of semiconductor devices on the basis of the fundamentals learned

Content

1. Basic properties of semiconductors (material classes, band structure, k*p theory, statistics, Boltzmann equilibrium).
2. Non-equilibrium processes in semiconductors (Boltzmann equation, generation and recombination, transport phenomena)
3. Semiconductor junctions in thermodynamic equilibrium (pn junction, heterojunctions, low-dimensional semiconductors, Schottky contact, ohmic contact, insulator-semiconductor transition)
4. Semiconductor junctions in non-equilibrium/ devices (diode, photodiode, solar cell, LED, diode laser, microwave devices, bipolar transistor, field effect transistor, CCD, memory devices, ...)
5. Semiconductor technology (epitaxy, doping, structuring, integration)

Workload
240 hours consisting of attendance time (60 hrs.), wrap-up of the lecture as well as exam preparation (180 hrs.)

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
R. Enderlein, N. Horing: *Fundamentals of Semiconductor Physics and Devices*

M. Grundmann: *The Physics of Semiconductors*

S.M. Sze, K.K. Ng: *Physics of Semiconductor Devices*

4.152 Module: Plasma Physics I [M-PHYS-107114]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Physics
Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics) (Usage from 4/1/2025)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics) (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-114146	Plasma Physics I	8 CR	Scherer

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major / second major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-107115 - Plasma Physics I (Minor) must not have been started.

Competence Goal
This lecture qualifies the students in understanding physical charging processes in gases (plasmas), ionization effects and resulting behavior of them. Students can calculate plasma properties from theoretical considerations and they are able to transfer this knowledge to experimental studies. Starting from gas electronics by using classical methods of electrodynamics students get involved into magnetohydrodynamic (MHD) considerations. Transport theory formalisms for processes in plasmas with and without collisions are part of the basic understanding of charge carrier movements. Students learn on base of different applications the use of plasma technology in technical systems, like plasma processing, plasma diagnostics and nuclear plasma fusion for carbon-free energy production (Tokamaks and Stellerator power plants).

Content

- Basics of plasma physics (density, ionization processes, excitation and relaxation processes, Saha-Eggert equation, Maxwell distribution, charge effects in plasmas, conductivity, magnetic fields in plasmas
- Plasma radiation effects
- Magnetohydrodynamics (MHD)
- Classic transport theory with and without collisions (Boltzmann, Vlasov equation)
- Waves and plasma interaction with and without magnetic field / cold and hot plasmas)
- Plasma creation (methods: discharges and HF excitation)
- Technical plasmas (sources for thin film technology)
- Plasma diagnostics (Langmuir probes, Optical emission spectroscopy (OES), holographical methods by using Abel-Inversion integral transformation, Faraday rotation)
- Introduction in to Fusion technology (Tokamak and Stellarator, Laser fusion)

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises and exam preparation (180 hours).

Recommendation
Fundamentals of electrodynamics, atomic and molecular physics

M 4.153 Module: Plasma Physics I (Minor) [M-PHYS-107115]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Physics
Part of: Minor in Physics: Experimental Particle Physics (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-114148	Plasma Physics I (Minor)	8 CR	Scherer

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-107114 - Plasma Physics I must not have been started.

Competence Goal
This lecture qualifies the students in understanding physical charging processes in gases (plasmas), ionization effects and resulting behavior of them. Students can calculate plasma properties from theoretical considerations and they are able to transfer this knowledge to experimental studies. Starting from gas electronics by using classical methods of electrodynamics students get involved into magnetohydrodynamic (MHD) considerations. Transport theory formalisms for processes in plasmas with and without collisions are part of the basic understanding of charge carrier movements. Students learn on base of different applications the use of plasma technology in technical systems, like plasma processing, plasma diagnostics and nuclear plasma fusion for carbon-free energy production (Tokamaks and Stellerator power plants).

Content

- Basics of plasma physics (density, ionization processes, excitation and relaxation processes, Saha-Eggert equation, Maxwell distribution, charge effects in plasmas, conductivity, magnetic fields in plasmas
- Plasma radiation effects
- Magnetohydrodynamics (MHD)
- Classic transport theory with and without collisions (Boltzmann, Vlasov equation)
- Waves and plasma interaction with and without magnetic field / cold and hot plasmas)
- Plasma creation (methods: discharges and HF excitation)
- Technical plasmas (sources for thin film technology)
- Plasma diagnostics (Langmuir probes, Optical emission spectroscopy (OES), holographical methods by using Abel-Inversion integral transformation, Faraday rotation)
- Introduction in to Fusion technology (Tokamak and Stellarator, Laser fusion)

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises (180 hours).

Recommendation
Fundamentals of electrodynamics, atomic and molecular physics

4.154 Module: Precision Phenomenology at Colliders and Computational Methods, with Exercises [M-PHYS-105640]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-111279	Precision Phenomenology at Colliders and Computational Methods, with Exercises	8 CR	Heinrich

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105641 - Precision Phenomenology at Colliders and Computational Methods, without Exercises must not have been started.
2. The module M-PHYS-105642 - Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor) must not have been started.

Competence Goal
The course provides knowledge about perturbative Quantum Chromodynamics (QCD) and its infrared structure, as well as on current topics in particle physics phenomenology, i.e. the comparison of measurements at colliders like the CERN Large Hadron Collider to theoretical predictions. Concepts and tools to calculate simple processes at at next-to-leading order in perturbation theory are acquired and computer programs that are used in the field of precision calculations are presented. The knowledge is deepened by the accompanying exercises.

Content
This Module gives an overview on current techniques and topics in collider physics from a theoretical physics point of view. Topics are QCD, colour algebra, factorisation, jets and event shapes, top-quark and Higgs physics. The treatment of infrared divergences in QCD is discussed, as well as parton evolution and parton densities. Methods and tools to perform calculations beyond the leading order in perturbation theory are introduced.

Workload
240 hours consisting of attendance time (60 h), follow-up of the lecture incl. exam preparation and preparation and follow-up of the exercises (180 h).

Recommendation
Knowledge on the level of TTP0 or TTP>0 is an advantage

Literature

- Dissertori, Knowles, Schmelling, "Quantum Chromodynamics: High energy experiments and theory", Oxford University Press;
- Campbell, Houston, Krauss, "The black book of Quantum Chromodynamics", Oxford University Press;
- V.A. Smirnov, "Feynman Integral Calculus", Springer 2006; Dawson, Englert, Plehn, "Higgs Physics: It ain't over till it's over", https://arxiv.org/abs/1808.01324

4.155 Module: Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor) [M-PHYS-105642]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-111281	Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor)	8 CR	Heinrich

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105640 - Precision Phenomenology at Colliders and Computational Methods, with Exercises must not have been started.
2. The module M-PHYS-105641 - Precision Phenomenology at Colliders and Computational Methods, without Exercises must not have been started.

Competence Goal
The course provides knowledge about perturbative Quantum Chromodynamics (QCD) and its infrared structure, as well as on current topics in particle physics phenomenology, i.e. the comparison of measurements at colliders like the CERN Large Hadron Collider to theoretical predictions. Concepts and tools to calculate simple processes at at next-to-leading order in perturbation theory are acquired and computer programs that are used in the field of precision calculations are presented. The knowledge is deepened by the accompanying exercises.

Content
This Module gives an overview on current techniques and topics in collider physics from a theoretical physics point of view. Topics are QCD, colour algebra, factorisation, jets and event shapes, top-quark and Higgs physics. The treatment of infrared divergences in QCD is discussed, as well as parton evolution and parton densities. Methods and tools to perform calculations beyond the leading order in perturbation theory are introduced.

Workload
240 hours consisting of attendance time (60 h), follow-up of the lecture and preparation and follow-up of the exercises (180 h).

Recommendation
Knowledge on the level of TTP0 or TTP>0 is an advantage

Literature

- Dissertori, Knowles, Schmelling, "Quantum Chromodynamics: High energy experiments and theory", Oxford University Press;
- Campbell, Houston, Krauss, "The black book of Quantum Chromodynamics", Oxford University Press;
- V.A. Smirnov, "Feynman Integral Calculus", Springer 2006; Dawson, Englert, Plehn, "Higgs Physics: It ain't over till it's over", https://arxiv.org/abs/1808.01324

4.156 Module: Precision Phenomenology at Colliders and Computational Methods, without Exercises [M-PHYS-105641]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-111280	Precision Phenomenology at Colliders and Computational Methods, without Exercises	4 CR	Heinrich

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105640 - Precision Phenomenology at Colliders and Computational Methods, with Exercises must not have been started.
2. The module M-PHYS-105642 - Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor) must not have been started.

Competence Goal
The course provides knowledge about perturbative Quantum Chromodynamics (QCD) and its infrared structure, as well as on current topics in particle physics phenomenology, i.e. the comparison of measurements at colliders like the CERN Large Hadron Collider to theoretical predictions. Concepts and tools to calculate simple processes at at next-to-leading order in perturbation theory are acquired and computer programs that are used in the field of precision calculations are presented.

Content
This Module gives an overview on current techniques and topics in collider physics from a theoretical physics point of view. Topics are QCD, colour algebra, factorisation, jets and event shapes, top-quark and Higgs physics. The treatment of infrared divergences in QCD is discussed, as well as parton evolution and parton densities. Methods and tools to perform calculations beyond the leading order in perturbation theory are introduced. For this variant without the exercises there will be less details on the computational aspects.

Workload
120 hours consisting of attendance time (30 h), wrap-up of lecture incl. exam preparation (90 h).

Recommendation
Knowledge on the level of TTP0 or TTP>0 is an advantage

Literature

- Dissertori, Knowles, Schmelling, "Quantum Chromodynamics: High energy experiments and theory", Oxford University Press;
- Campbell, Houston, Krauss, "The black book of Quantum Chromodynamics", Oxford University Press; V.A. Smirnov, "Feynman Integral Calculus", Springer 2006;
- Dawson, Englert, Plehn, "Higgs Physics: It ain't over till it's over", https://arxiv.org/abs/1808.01324

4.157 Module: Quantum Detectors and Sensors [M-PHYS-106193]

Responsible: Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Physics

Part of: Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)
Second Major in Physics: Experimental Particle Physics (Elective Experimental Particle Physics)
Second Major in Physics: Experimental Astroparticle Physics (Elective Experimental Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-112582	Quantum Detectors and Sensors	8 CR	Kempf

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
Students know the basics and fundamentals of quantum detectors and sensors and understand how quantum technology can be used to design and realize devices those performance reaches far beyond the limits of any classical sensor or detector. They know the basic components of quantum sensors and detectors, in particular in the field of superconducting quantum technology, and are able to analyze the operation of such detectors and sensors on the basis of circuit diagrams. Students are able to develop quantum sensors and detectors for given applications and know how to consider special requirements in a concrete component.

Content
This module provides a comprehensive overview of the basics and physical principles of quantum detectors and sensors and discusses in detail how quantum technology can be used to design and realize detectors and sensors with performance that reaches far beyond the limits of any classical sensor or detector. The discussion includes particularly an introduction to the basic components of quantum sensors and detectors, especially in the field of superconducting quantum technology, and their fabrication. Using simplified circuit diagrams, the functionality and operation of quantum detectors and sensors such as superconducting quantum interference devices, low-temperature detectors, noise thermometers or superconducting radiation detectors is analyzed. Furthermore, methods and simple models are developed allowing to realize quantum sensors and detectors that are matched to given applications. Within this context, typical applications of quantum detectors and sensors are also discussed.

The tutorial is closely related to the lecture and deals with special aspects concerning the development of quantum detectors and sensors. In particular, the development and system integration of quantum detectors and sensors for applications in precision metrology, particle detection or applied sciences is discussed by means of exercises.

Annotation
The lecture and exercise will be offered in English. However, questions and discussions can of course also be held in German.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and working on the exercises (180 hours)

Literature
Will be announced in the lecture.

M 4.158 Module: Quantum Detectors and Sensors (Minor) [M-PHYS-106194]

Responsible: Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Physics

Part of: Minor in Physics: Experimental Particle Physics
Minor in Physics: Experimental Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-112583	Quantum Detectors and Sensors (Minor)	8 CR	Kempf

Competence Certificate
The course credit is achieved through successful participation in the written exam by reaching at least 50% of the total points.

Prerequisites
none

Competence Goal
Students know the basics and fundamentals of quantum detectors and sensors and understand how quantum technology can be used to design and realize devices those performance reaches far beyond the limits of any classical sensor or detector. They know the basic components of quantum sensors and detectors, in particular in the field of superconducting quantum technology, and are able to analyze the operation of such detectors and sensors on the basis of circuit diagrams. Students are able to develop quantum sensors and detectors for given applications and know how to consider special requirements in a concrete component.

Content
This module provides a comprehensive overview of the basics and physical principles of quantum detectors and sensors and discusses in detail how quantum technology can be used to design and realize detectors and sensors with performance that reaches far beyond the limits of any classical sensor or detector. The discussion includes particularly an introduction to the basic components of quantum sensors and detectors, especially in the field of superconducting quantum technology, and their fabrication. Using simplified circuit diagrams, the functionality and operation of quantum detectors and sensors such as superconducting quantum interference devices, low-temperature detectors, noise thermometers or superconducting radiation detectors is analyzed. Furthermore, methods and simple models are developed allowing to realize quantum sensors and detectors that are matched to given applications. Within this context, typical applications of quantum detectors and sensors are also discussed.

The tutorial is closely related to the lecture and deals with special aspects concerning the development of quantum detectors and sensors. In particular, the development and system integration of quantum detectors and sensors for applications in precision metrology, particle detection or applied sciences is discussed by means of exercises.

Annotation
The lecture and exercise will be offered in English. However, questions and discussions can of course also be held in German.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises incl. exam preparation (180 hours).

Literature
Will be announced in the lecture.

4.159 Module: Quantum Fluctuations and Dissipation far from Equilibrium [M-PHYS-107194]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory) (Usage from 4/1/2025)
Second Major in Physics: Condensed Matter Theory (Usage from 4/1/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-114216	Quantum Fluctuations and Dissipation far from Equilibrium	8 CR	Gornyi, Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
The students understand the basic concepts of dissipation in quantum systems. The students understand the working principles of modern quantum devices. The students master theoretical techniques, such as master equation, Langevin equation, path integral, effective action, renormalization group. The students are able to solve simple problems related to dissipative quantum dynamics.

Content

1. Dissipative processes in quantum systems and devices: Spin relaxation in NMR (Bloch equations), quantum dots, Coulomb blockade, Josephson devices, magnetic dynamics. Kinetics and fluctuations far from equilibrium, Kardar-Parisi-Zhang universality.
2. Theoretical methods: Golden rule, master equation (Bloch-Redfield equation), path integral in imaginary (Matsubara) and real (Keldysh) time, strong-disorder renormalization group.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and exam preparation (180 hours).

M 4.160 Module: Quantum Optics at the Nano Scale, with Exercises [M-PHYS-106508]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113126	Quantum Optics at the Nano Scale, with Exercises	8 CR	Hunger

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106509 - Quantum Optics at the Nano Scale, with Exercises (Minor) must not have been started.
2. The module M-PHYS-106510 - Quantum Optics at the Nano Scale, without Exercises must not have been started.

Competence Goal
Students gain knowledge about the fundamentals in the field of quantum- and nano optics and learn about basic concepts and examples of optical quantum systems. This is intended to enable participants to follow current research in the field. The Tutorial is designed as a journal club, where selected publications will be presented by students. Students learn how to become familiar with current research topics, how to interpret research results based on the concepts presented in the lecture, and how to present scientific results.

Content

- Fundamentals of quantized light fields and light-matter interactions
- Micro- and nanooptical devices
- Dipole emission in structured environments
- Solid state quantum emitters
- Optical readout of single spins
- Quantum communication
- Quantum networks
- Quantum sensing
- Quantum computing

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Basic knowledge in classical electromagnetism and optics, quantum mechanics, atomic physics; quantum optics is beneficial but not mandatory

Literature

- Principles of Nano-Optics, Novotny, Hecht, Cambridge University Press
- Quantum Optics, M. Scully, M. Suhail Zubairy, Cambridge University Press
- Fundamentals of Photonics, Saleh,Teich
- research articles (will be sent around)

M 4.161 Module: Quantum Optics at the Nano Scale, with Exercises (Minor) [M-PHYS-106509]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113127	Quantum Optics at the Nano Scale, with Exercises (Minor)	8 CR	Hunger

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106508 - Quantum Optics at the Nano Scale, with Exercises must not have been started.
2. The module M-PHYS-106510 - Quantum Optics at the Nano Scale, without Exercises must not have been started.

Competence Goal
Students gain knowledge about the fundamentals in the field of quantum- and nano optics and learn about basic concepts and examples of optical quantum systems. This is intended to enable participants to follow current research in the field. The Tutorial is designed as a journal club, where selected publications will be presented by students. Students learn how to become familiar with current research topics, how to interpret research results based on the concepts presented in the lecture, and how to present scientific results.

Content

- Fundamentals of quantized light fields and light-matter interactions
- Micro- and nanooptical devices
- Dipole emission in structured environments
- Solid state quantum emitters
- Optical readout of single spins
- Quantum communication
- Quantum networks
- Quantum sensing
- Quantum computing

Workload
240 hours consisting of attendance time (60 hours), wrap-up of lecture and preparation of exercises (180 hours).

Recommendation
Basic knowledge in classical electromagnetism and optics, quantum mechanics, atomic physics; quantum optics is beneficial but not mandatory

Literature

- Principles of Nano-Optics, Novotny, Hecht, Cambridge University Press
- Quantum Optics, M. Scully, M. Suhail Zubairy, Cambridge University Press
- Fundamentals of Photonics, Saleh,Teich
- research articles (will be sent around)

M 4.162 Module: Quantum Optics at the Nano Scale, without Exercises [M-PHYS-106510]

Responsible: Prof. Dr. David Hunger

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Physics

Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113128	Quantum Optics at the Nano Scale, without Exercises	6 CR	Hunger

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106508 - Quantum Optics at the Nano Scale, with Exercises must not have been started.
2. The module M-PHYS-106509 - Quantum Optics at the Nano Scale, with Exercises (Minor) must not have been started.

Competence Goal
Students gain knowledge about the fundamentals in the field of quantum- and nano optics and learn about basic concepts and examples of optical quantum systems. This is intended to enable participants to follow current research in the field.

Content

- Fundamentals of quantized light fields and light-matter interactions
- Micro- and nanooptical devices
- Dipole emission in structured environments
- Solid state quantum emitters
- Optical readout of single spins
- Quantum communication
- Quantum networks
- Quantum sensing
- Quantum computing

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture incl. exam preparation (135 hours).

Recommendation
Basic knowledge in classical electromagnetism and optics, quantum mechanics, atomic physics; quantum optics is beneficial but not mandatory

Literature

- Principles of Nano-Optics, Novotny, Hecht, Cambridge University Press
- Quantum Optics, M. Scully, M. Suhail Zubairy, Cambridge University Press
- Fundamentals of Photonics, Saleh,Teich
- research articles (will be sent around)

4.163 Module: Seismic Data Processing with Final Report (Graded) [M-PHYS-104186]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-108656	Seismic Data Processing, Final Report (Graded)	4 CR	Bohlen, Hertweck
T-PHYS-108686	Seismic Data Processing, Coursework	2 CR	Bohlen, Hertweck

Competence Certificate
Students have to participate the lecture/exercise on a regular basis and give a final presentation about their processing results (2 ECTS points). Students who would like to get the full 6 ECTS points also need to prepare and hand in a seismic data processing report. The report will determine the final grade (if applicable).

Prerequisites
None

Competence Goal
The students have hands-on experience applying typical seismic processing and imaging techniques to reflection seismic field data. In this way, they understand the reflection seismic method and have practical skills in data analysis and problem solving which are beneficial in their professional life later on, not only in exploration. Students can set up a basic processing and imaging flow, understand the individual processing steps and their purpose, and describe the influence of important parameters on processing results. They are able to identify data shortcomings and imaging challenges and develop basic solutions, analyze the success of individual processing/imaging steps, and critically assess the overall quality of their work. Finally, students are able to present their processing results in oral and written form.

Content

- Field data loading, quality control, trace edits and geometry setup
- Spectral analysis, filter application, geometrical spreading correction
- Deconvolution, zero-phasing
- Denoising using various approaches
- Multiple identification and removal (SRME, Radon)
- CMP sort, velocity analysis, NMO correction, mute and stack
- Time migration (prestack and poststack)
- Post-migration processing
- Basic interpretation (in cooperation with KIT-AGW)
- Optional: depth velocity model building and depth migration

Module grade calculation
The report will determine the final grade.

Annotation
A commercial data processing software is used during this course.

Workload
180 h hours composed of contact time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
No explicit requirements. However, basic knowledge of the reflection seismic method and general computer skills are essential. This course does not require any programming skills.

Learning type
4060321 Th.Bohlen, Th. Hertweck (V1)

4060322 Th.Bohlen, Th. Hertweck (Ü2)

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Robert Sheriff and Lloyd Geldart, "Exploration Seismology", 1995, Cambridge University Press.

4.164 Module: Seismic Modeling [M-PHYS-105227]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-110605	Seismic Modeling	4 CR	Bohlen

Competence Certificate
To pass the module, the oral exam (approx. 20 minutes) must be passed. As prerequisites the examinations of other type must be passed, based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., 1D finite-difference implementation) and is based on hands-on work, usually involving the use of computers.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105228 - Seismic Modeling (Minor) must not have been started.

Competence Goal
The students know the fundamental concepts of seismic wavefield simulations, including the mathematical descriptions and their basic numeric implementations. They understand the complexity of wave propagation and the advantages and disadvantages of the individual methods. They are able to apply the methods using synthetic Earth models to calculate amplitudes and traveltimes of propagating elastic and/or acoustic waves.

Content

- Factors influencing traveltimes and amplitudes of seismic wavefields
- Analytical solutions
- Fast traveltime calculation using the eikonal equation
- Raytracing
- Reflectivity method for acoustic 1D media
- Time-domain finite-difference solutions of the acoustic/elastic wave equations
- Fourier methods
- Introduction to the finite-element method

Module grade calculation
The grade of the module results from grade of the oral exam.

Recommendation
Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Learning type
V1 Ü1, 2 SWS, 4 ECTS

Literature
Carcione, Herman and Kroode, "Seismic modeling", 2000, Geophysics 67(4).

4.165 Module: Seismic Modeling (Minor) [M-PHYS-105228]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-110607	Seismic Modeling (Minor)	4 CR	Bohlen

Competence Certificate
To pass the module, the examinations of other type must be passed, based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., 1D finite-difference implementation) and is based on hands-on work, usually involving the use of computers.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105227 - Seismic Modeling must not have been started.

Competence Goal
The students know the fundamental concepts of seismic wavefield simulations, including the mathematical descriptions and their basic numeric implementations. They understand the complexity of wave propagation and the advantages and disadvantages of the individual methods. They are able to apply the methods using synthetic Earth models to calculate amplitudes and traveltimes of propagating elastic and/or acoustic waves.

Content

- Factors influencing traveltimes and amplitudes of seismic wavefields
- Analytical solutions
- Fast traveltime calculation using the eikonal equation
- Raytracing
- Reflectivity method for acoustic 1D media
- Time-domain finite-difference solutions of the acoustic/elastic wave equations
- Fourier methods
- Introduction to the finite-element method

Recommendation
Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Learning type
V1 Ü1, 2 SWS, 4 ECTS

Literature
Carcione, Herman and Kroode, "Seismic modeling", 2000, Geophysics 67(4).

4.166 Module: Seismics [M-PHYS-106326]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-112843	Seismics	8 CR	Bohlen

Competence Certificate
To pass the module, an oral exam must be passed (approx. 20 min). As prerequisite a student must successfully participate the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106325 - Seismics (Minor) must not have been started.

Competence Goal
The students know the fundamental concepts of seismic acquisition, processing and imaging in reflection seismics. They can correctly name equipment, tools and processes and effectively communicate with specialists in the field of seismics. Students understand the various steps involved in seismic processing/imaging, their underlying theory and how they affect the data. They are able to apply the concepts and equations to simple exemplary seismic data.

Content

- Overview of seismic methods and wave propagation basics
- Essential signal processing concepts and tools
- Seismic acquisition, sources and receivers, marine and land
- Geometries and traveltimes, NMO and DMO
- Processing steps: from data loading to denoise and demultiple
- Velocity analysis, NMO correction, stacking, SNR
- Imaging: basic concepts, time and depth migration, migration methods
- Seismic resolution
- Optional: advanced acquisition, processing and imaging technologies

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
Experience with Matlab, the Linux commandline, and shell scripts is beneficial. Knowledge of fundamental signal processing theory is essential.

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Jon Claerbout, "Fundamentals of geophysical data processing", 1976, McGraw-Hill.
- Etienne Robein, "Seismic Imaging: A Review of the Techniques, their Principles, Merits and Limitations", 2010, European Association of Geoscientists and Engineers.

4.167 Module: Seismics (Minor) [M-PHYS-106325]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-112833	Seismics (Minor)	8 CR	Bohlen

Competence Certificate
To pass the module, a student must successfully participate in the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106326 - Seismics must not have been started.

Competence Goal
The students know the fundamental concepts of seismic acquisition, processing and imaging in reflection seismics. They can correctly name equipment, tools and processes and effectively communicate with specialists in the field of seismics. Students understand the various steps involved in seismic processing/imaging, their underlying theory and how they affect the data. They are able to apply the concepts and equations to simple exemplary seismic data.

Content

- Overview of seismic methods and wave propagation basics
- Essential signal processing concepts and tools
- Seismic acquisition, sources and receivers, marine and land
- Geometries and traveltimes, NMO and DMO
- Processing steps: from data loading to denoise and demultiple
- Velocity analysis, NMO correction, stacking, SNR
- Imaging: basic concepts, time and depth migration, migration methods
- Seismic resolution
- Optional: advanced acquisition, processing and imaging technologies

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
Experience with Python/Matlab, the Linux commandline, and shell scripts is beneficial. Knowledge of fundamental signal processing theory is essential.

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Jon Claerbout, "Fundamentals of geophysical data processing", 1976, McGraw-Hill.
- Etienne Robein, "Seismic Imaging: A Review of the Techniques, their Principles, Merits and Limitations", 2010, European Association of Geoscientists and Engineers.

4.168 Module: Seismology [M-PHYS-105225]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-110603	Seismology	8 CR	Rietbrock

Competence Certificate
To pass the module, an oral exam must be passed (approx. 20 min). As prerequisites the examinations of other type must be passed, based on successful participation of the exercises. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and presentations based on research papers held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105226 - Seismology (Minor) must not have been started.

Competence Goal
The students understand the fundamental concepts of seismology and the earthquake rupture process. They have a knowledge of seismogram interpretation, fundamentals of seismic wave propagation and the representations of the earthquake source. Students are able to apply their knowledge to observed data to gain an insight into the Earth structure and the earthquake source.

Content

- History of seismology
- Elasticity and seismic waves
- Body waves and surface waves
- Seismogram interpretation
- Earthquake location
- Determination of Earth structure
- Seismic sources
- Seismic moment tensor
- Earthquake kinematics and dynamics
- Seismotectonics

Module grade calculation
The grade of the module results from grade of the oral exam.

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
A sound knowledge of the fundamentals in Geophysics. Basic skills in programming and Python to solve exercises.

Literature

- Peter M. Shearer, "Introduction to Seismology", Cambridge Uniersity Press.
- Thorne Lay and Terry C. Wallace, "Modern Global Seismology", Academic Press.
- Seth Stein and Michael Wysession, "An Introduction to Seismology, Earthquakes, and Earth Structure", Blackwell Publishing.

M 4.169 Module: Seismology (Minor) [M-PHYS-105226]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-110604	Seismology (Minor)	8 CR	Rietbrock

Competence Certificate
In order to pass the course Seismology, a student must successfully participate in the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and presentations based on research papers held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105225 - Seismology must not have been started.

Competence Goal
The students understand the fundamental concepts of seismology and the earthquake rupture process. They have a knowledge of seismogram interpretation, fundamentals of seismic wave propagation and the representations of the earthquake source. Students are able to apply their knowledge to observed data to gain an insight into the Earth structure and the earthquake source.

Content

- History of seismology
- Elasticity and seismic waves
- Body waves and surface waves
- Seismogram interpretation
- Earthquake location
- Determination of Earth structure
- Seismic sources
- Seismic moment tensor
- Earthquake kinematics and dynamics
- Seismotectonics

Workload
240 hours composed of attendance time (60 h), wrap-up of the lectures and solving the exercises (180 h)

Recommendation
A sound knowledge of the fundamentals in Geophysics. Basic skills in programming and Python to solve exercises.

Literature

- Peter M. Shearer, "Introduction to Seismology", Cambridge Uniersity Press.
- Thorne Lay and Terry C. Wallace, "Modern Global Seismology", Academic Press.
- Seth Stein and Michael Wysession, "An Introduction to Seismology, Earthquakes, and Earth Structure", Blackwell Publishing.

M 4.170 Module: Selected Topics in Meteorology (Minor, ungraded) [M-PHYS-104578]

Responsible: Prof. Dr. Corinna Hoose
Organisation: KIT Department of Physics
Part of: Minor in Physics: Meteorology

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each term	2 terms	English	4	4

Elective Subjects (Election: at least 8 credits)			
T-PHYS-111410	Seminar on IPCC Assessment Report	2 CR	Ginete Werner Pinto
T-PHYS-111411	Tropical Meteorology	4 CR	Knippertz
T-PHYS-111412	Climate Modeling & Dynamics with ICON	4 CR	Ginete Werner Pinto
T-PHYS-111413	Middle Atmosphere in the Climate System	2 CR	Höpfner, Sinnhuber
T-PHYS-111414	Ocean-Atmosphere Interactions	2 CR	Fink
T-PHYS-111416	Cloud Physics	4 CR	Hoose
T-PHYS-111417	Energetics	2 CR	Fink
T-PHYS-111418	Atmospheric Aerosols	4 CR	Möhler
T-PHYS-111419	Atmospheric Radiation	2 CR	Höpfner
T-PHYS-111424	Remote Sensing of Atmosphere and Ocean	4 CR	Sinnhuber
T-PHYS-111426	Methods of Data Analysis	4 CR	Ginete Werner Pinto, Knippertz
T-PHYS-111427	Turbulent Diffusion	4 CR	Hoose, Hoshyaripour
T-PHYS-111428	Energy Meteorology	2 CR	Emeis, Ginete Werner Pinto
T-PHYS-111429	Advanced Numerical Weather Prediction	4 CR	Knippertz
T-PHYS-109177	Physics of Planetary Atmospheres	6 CR	Leisner
T-PHYS-111273	Arctic Climate System	2 CR	Sinnhuber

Competence Certificate
Coursework can be computer and modelling classes, exercise sheets or preparation of a presentation.

Credits will be awarded after passing all courseworks/exercises.

Prerequisites
None

Competence Goal
Depending on their choice students can

- explain essential aspects of application aspects of meteorology and assign them to specific application areas. They are capable to describe the functionality of a modern weather forecasting system in detail and can predict the potential for extreme events and their impact on the population and the insurance industry depending on the region and the season. The students are capable of using weather information to derive levels of air pollution and of yields of renewable energy. They can analyse meteorological data using statistical and computer-based methods.
- explain the functionality of modern meteorological measuring methods and measuring principles and name their possible uses. This is especially true for remote sensing, advanced in-situ, trace gas and aerosol measurements. The students can build and execute experiments in the lab or in the field according to instructions, to record and scientifically evaluate data and then interpret and present the results.
- explain essential components of the climate system and their physical properties as well as causes of climate change. Students can know systems for climate monitoring and understand how climate models work. The students can designate essential processes in the atmosphere and ocean, and explain them using physical and chemical laws. They can analyze and interpret climate and weather data based on diagnostic methods. In addition, they can expertly present and discuss learned or self-developed scientific findings.
- name essential processes in the atmosphere and explain these using physical and chemical laws. In particular, students are capable of explaining thestructure and dynamics of different cloud systems and o**f** estimating the microphysical processes in clouds or calculating them directly for idealized conditions. In addition, the students are capable of mathematically evaluating the radiation transport in the atmosphere and of describing the importance of radiation processes for the structure of the atmosphere, for climate change and for the measurement of different atmospheric variables. They can also explain the chemical structure and the composition of the aerosols in the troposphere and the stratosphere based on atmospheric physico-chemical processes and transformations. The students can explain the chemical and physical causes of thestratospheric ozone hole and its future development, can describe and classify the main aerosol-cloud processes and are capable of reproducing the main points of the *Köhler theory* and the classical nucleation theory.

Content
This module aims to give students of other master programs an insight into various areas of meteorology:

- **Applications of meteorology** such as weather forecasting (T-PHYS-109139) and warning (T-PHYS-109140), insurance and energy industry (T-PHYS-109141), data analysis (T-PHYS-109142) and air quality (T-PHYS-108610).
- **Experimental modern measurement methods** in meteorology such as satellite remote sensing (T-PHYS-109133).
- **Components of the climate system** such as the tropics (T-PHYS-107693), the ocean (T-PHYS-108932) and the middle atmosphere (T-PHYS-8931) and their physical and chemical backgrounds as well as modelling their temporal and spatial changes with ICON (T-PHYS-108928) and analysing general climate dynamics and changes (T-PHYS-107692).
- Physical and chemical **processes in the atmopshere** such as cloud physics (T-PHYS-107694), radiation (T-PHYS-107696), aerosols (T-PHYS-8938) and a**tmospheric** energetics (T-PHYS-107695).
- Formation and properties of **planets and their atmospheres** in our solar system applying fundamental principles of physics.

Workload
240 hours composed of active time (45h), wrap-up of the lectures and solving the exercises (195h)

Recommendation
Basic knowledge in Physics, Physical Chemistry and Fluid Dynamics at BSc level

M 4.171 Module: Selected Topics in Meteorology (Second Major, graded) [M-PHYS-104577]

Responsible: Prof. Dr. Corinna Hoose
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Meteorology

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
14	Grade to a tenth	Each term	2 terms	English	4	4

Mandatory			
T-PHYS-109380	Exam on Selected Topics in Meteorology (Second Major)	4 CR	Hoose
Elective Subjects (Election: at least 3 items as well as at least 10 credits)			
T-PHYS-111410	Seminar on IPCC Assessment Report	2 CR	Ginete Werner Pinto
T-PHYS-111411	Tropical Meteorology	4 CR	Knippertz
T-PHYS-111412	Climate Modeling & Dynamics with ICON	4 CR	Ginete Werner Pinto
T-PHYS-111413	Middle Atmosphere in the Climate System	2 CR	Höpfner, Sinnhuber
T-PHYS-111414	Ocean-Atmosphere Interactions	2 CR	Fink
T-PHYS-111416	Cloud Physics	4 CR	Hoose
T-PHYS-111417	Energetics	2 CR	Fink
T-PHYS-111418	Atmospheric Aerosols	4 CR	Möhler
T-PHYS-111419	Atmospheric Radiation	2 CR	Höpfner
T-PHYS-111424	Remote Sensing of Atmosphere and Ocean	4 CR	Sinnhuber
T-PHYS-111426	Methods of Data Analysis	4 CR	Ginete Werner Pinto, Knippertz
T-PHYS-111427	Turbulent Diffusion	4 CR	Hoose, Hoshyaripour
T-PHYS-111428	Energy Meteorology	2 CR	Emeis, Ginete Werner Pinto
T-PHYS-111429	Advanced Numerical Weather Prediction	4 CR	Knippertz
T-PHYS-109177	Physics of Planetary Atmospheres	6 CR	Leisner
T-PHYS-111273	Arctic Climate System	2 CR	Sinnhuber

Competence Certificate
Coursework can be computer and modelling classes, exercise sheets or preparation of a presentation.

→ successful completion of the prerequisites entitles to exam

(T-PHYS-109380) Exam on Selected Topics in Meteorology (Second Major):

Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Physik Master

Prerequisites
None

Competence Goal
Depending on their choice students can

- explain essential aspects of application aspects of meteorology and assign them to specific application areas. They are capable to describe the functionality of a modern weather forecasting system in detail and can predict the potential for extreme events and their impact on the population and the insurance industry depending on the region and the season. The students are capable of using weather information to derive levels of air pollution and of yields of renewable energy. They can analyse meteorological data using statistical and computer-based methods.
- explain the functionality of modern meteorological measuring methods and measuring principles and name their possible uses. This is especially true for remote sensing, advanced in-situ, trace gas and aerosol measurements. The students can build and execute experiments in the lab or in the field according to instructions, to record and scientifically evaluate data and then interpret and present the results.
- explain essential components of the climate system and their physical properties as well as causes of climate change. Students can know systems for climate monitoring and understand how climate models work. The students can designate essential processes in the atmosphere and ocean, and explain them using physical and chemical laws. They can analyze and interpret climate and weather data based on diagnostic methods. In addition, they can expertly present and discuss learned or self-developed scientific findings.
- name essential processes in the atmosphere and explain these using physical and chemical laws. In particular, students are capable of explaining the structure and dynamics of different cloud systems and of estimating the microphysical processes in clouds or calculating them directly for idealized conditions. In addition, the students are capable of mathematically evaluating the radiation transport in the atmosphere and of describing the importance of radiation processes for the structure of the atmosphere, for climate change and for the measurement of different atmospheric variables. They can also explain the chemical structure and the composition of the aerosols in the troposphere and the stratosphere based on atmospheric physico-chemical processes and transformations. The students can explain the chemical and physical causes of the stratospheric ozone hole and its future development, can describe and classify the main aerosol-cloud processes and are capable of reproducing the main points of the *Köhler theory* and the classical nucleation theory.

Content
This module aims to give students of other master programs an insight into various areas of meteorology:

- **Applications of meteorology** such as weather forecasting (T-PHYS-109139) and warning (T-PHYS-109140), insurance and energy industry (T-PHYS-109141), data analysis (T-PHYS-109142) and air quality (T-PHYS-108610).
- **Experimental modern measurement methods** in meteorology such as satellite remote sensing (T-PHYS-109133).
- **Components of the climate system** such as the tropics (T-PHYS-107693), the ocean (T-PHYS-108932), the arctic (T-PHYS-111273) and the middle atmosphere (T-PHYS-8931) and their physical and chemical backgrounds as well as modelling their temporal and spatial changes with ICON (T-PHYS-108928) and analysing general climate dynamics and changes (T-PHYS-107692).
- Physical and chemical **processes in the atmopshere** such as cloud physics (T-PHYS-107694), radiation (T-PHYS-107696), aerosols (T-PHYS-8938) and atmospheric energetics (T-PHYS-107695).
- Formation and properties of **planets and their atmospheres** in our solar system applying fundamental principles of physics.

Module grade calculation
Grade of he Oral Exam.

Workload
420 hours composed of

- active time (79 h),
- wrap-up of the lectures incl. preparation of the oral exam (170 h) and
- solving the exercises (171 h)

Recommendation
Basic knowledge in Physics, Physical Chemistry and Fluid Dynamics at BSc level

M 4.172 Module: Software Engineering in Condensed Matter Physics [M-PHYS-106833]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113706	Software Engineering in Condensed Matter Physics	6 CR	Wenzel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106834 - Software Engineering in Condensed Matter Physics (Minor) must not have been started.

Competence Goal
In recent decades, simulation has established itself as a third pillar of research alongside analytical theory and experiment, but the complexity of the underlying software is steadily increasing. In order to bridge this gap students in this course acquire skills in advanced software engineering in python with application to simulation problems in condensed matter systems, from ordered solids to soft matter. They are familiar with object-oriented programming, rapid prototyping, test-driven development, the use and development of python libraries and basics in machine learning (scikit/pytorch). In addition workflow technologies and data-driven model development are known.

Content

- Object Oriented Programming techniques in Python (Software Patterns)
- Rapid prototyping, test-driven development
- Introduction to machine learning (scikit: classification, interpolation)
- Neural Networks (Dense, Deep, Recursive, ...)
- Data-driven model development (Materials Project)
- Workflow Environments (pymatgen, simstack)
- Applications to problem in condensed matter physics

Workload
180 hours consisting of attendance time (30 hours lecture, 15 hours exercises), follow-up of the lecture incl. exam preparation and working on the exercises (135 hours)

Literature

- Percical/Gregory: Architecture Patterns with Python
- Rajput: Ultimate Neural Network Programming with Python: Create Powerful Modern AI Systems by Harnessing Neural Networks with Python, Keras, and TensorFlow
- Geron: Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

M 4.173 Module: Software Engineering in Condensed Matter Physics (Minor) [M-PHYS-106834]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113707	Software Engineering in Condensed Matter Physics (Minor)	6 CR	Wenzel

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106833 - Software Engineering in Condensed Matter Physics must not have been started.

Competence Goal
In recent decades, simulation has established itself as a third pillar of research alongside analytical theory and experiment, but the complexity of the underlying software is steadily increasing. In order to bridge this gap students in this course acquire skills in advanced software engineering in python with application to simulation problems in condensed matter systems, from ordered solids to soft matter. They are familiar with object-oriented programming, rapid prototyping, test-driven development, the use and development of python libraries and basics in machine learning (scikit/pytorch). In addition workflow technologies and data-driven model development are known.

Content

- Object Oriented Programming techniques in Python (Software Patterns)
- Rapid prototyping, test-driven development
- Introduction to machine learning (scikit: classification, interpolation)
- Neural Networks (Dense, Deep, Recursive, ...)
- Data-driven model development (Materials Project)
- Workflow Environments (pymatgen, simstack)
- Applications to problem in condensed matter physics

Workload
180 hours consisting of attendance time (30 hours lecture, 15 hours exercises), follow-up of the lecture incl.working on the exercises (135hours)

Literature

- Percical/Gregory: Architecture Patterns with Python
- Rajput: Ultimate Neural Network Programming with Python: Create Powerful Modern AI Systems by Harnessing Neural Networks with Python, Keras, and TensorFlow
- Geron: Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

4.174 Module: Solid State Quantum Technologies [M-PHYS-104857]

Responsible: Prof. Dr. Wolfgang Wernsdorfer
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-109889	Solid State Quantum Technologies	8 CR	Wernsdorfer

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104858 - Solid State Quantum Technologies (Minor) must not have been started.

Competence Goal
The development and comprehensive use of Quantum Technology is one of the most ambitious technological goals of today's science,with expected dramatic impact on the whole society and economy. The field of quantum information processing using solid state quantum bits (qubits) has witnessed an exponential growth during the last years. The current performances suggest that within a horizon of a few years, solid state quantum machines could outperform even the best classical machines for a few types of particularly hard tasks. During this class, the students will acquire a basic understanding of the principles of quantum information processing and the functioning of computers based on qubits, with an emphasis on experimental implementations using superconducting circuits and cavities and spin based solid state qubits. The supporting problems will cover in detail a broad set of calculations, from derivations of basic results, to solving practical problems one could encounter in a research laboratory.

Content
After a general introduction to the concepts of quantum information processing, we will present an overview of different experimental implementations. We will then focus on spin qubits and superconducting circuit qubits. We will discuss sources of loss and dephasing, and we will mention several strategies to increase the coherence of qubits. During the last few lectures, we will focus on advanced topics such as circuit quantum electrodynamics (cQED) and quantum optics in the microwave domain.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendation
Basic knowledge of quantum mechanics

Literature
Will be announced in the lecture

M 4.175 Module: Solid State Quantum Technologies (Minor) [M-PHYS-104858]

Responsible: Prof. Dr. Wolfgang Wernsdorfer
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-109890	Solid State Quantum Technologies (Minor)	8 CR	Wernsdorfer

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104857 - Solid State Quantum Technologies must not have been started.

Competence Goal
The development and comprehensive use of Quantum Technology is one of the most ambitious technological goals of today's science,with expected dramatic impact on the whole society and economy. The field of quantum information processing using solid state quantum bits (qubits) has witnessed an exponential growth during the last years. The current performances suggest that within a horizon of a few years, solid state quantum machines could outperform even the best classical machines for a few types of particularly hard tasks. During this class, the students will acquire a basic understanding of the principles of quantum information processing and the functioning of computers based on qubits, with an emphasis on experimental implementations using superconducting circuits and cavities and spin based solid state qubits. The supporting problems will cover in detail a broad set of calculations, from derivations of basic results, to solving practical problems one could encounter in a research laboratory.

Content
After a general introduction to the concepts of quantum information processing, we will present an overview of different experimental implementations. We will then focus on spin qubits and superconducting circuit qubits. We will discuss sources of loss and dephasing, and we will mention several strategies to increase the coherence of qubits. During the last few lectures, we will focus on advanced topics such as circuit quantum electrodynamics (cQED) and quantum optics in the microwave domain.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and work on the exercises (180 hours).

Recommendation
Basic knowledge of quantum mechanics

Literature
Will be announced in the lecture

M 4.176 Module: Solid-State Optics [M-PHYS-102408]

Responsible: PD Dr. Michael Hetterich
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Optics and Photonics (mandatory)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-PHYS-104773	Solid-State Optics, without Exercises	8 CR	Hetterich

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102409 - Solid-State Optics (Minor) must not have been started.

Competence Goal
The students

- know the basic interaction processes between light and matter and are familiar with the polariton concept
- can explain the optical properties of insulators, semiconductors (including quantum structures) and metals
- comprehend the concept of the dielectric function and can utilize it to calculate relevant optical quantities
- are familiar with the classical Drude-Lorentz model and its implications for the optical properties of solids
- understand the relation between classical and quantum mechanical models for the dielectric function as well as the importance of the Kramers Kronig relations
- can explain near-band-edge optical spectra of semiconductors and insulators based on the concepts of joint density of states, oscillator strength, as well as excitonic effects
- are familiar with common experimental techniques of optical spectroscopy
- understand the origin of different optical nonlinearities and high-excitation effects as well as their mathematical description, their experimental realization and their applications
- comprehend the basics of group theory and can apply it to solid state optics

Content
Maxwell's equations, refractive index, dispersion, dielectric function, extinction, absorption, reflection, continuity conditions at interfaces, anisotropic media and layered systems, Drude–Lorentz model, reststrahlen bands, Bloch states and band structure, perturbation theory of light–matter interaction, band to band transitions, joint density of states, van Hove singularities, phonon and exciton polaritons, plasmons, metals, semiconductor heterostructures, low-dimensional systems, group theory and selection rules, nonlinear optics, high-excitation effects in semiconductors, measurement of optical functions: Fourier spectroscopy, ellipsometry, modulation spectroscopy, photoluminescence, reflectometry, absorptivity.

Workload
240 hours, consisting of attendance time (60 hours) and follow-up work incl. preparation of the exam (180 hours)

Recommendation
Basic knowledge of solid-state physics and quantum mechanics is expected.

Literature

- H. Kalt, C. Klingshirn: Semiconductor Optics
- F. Wooten: Optical Properties of Solids
- P.K. Basu: Theory of optical processes in semiconductors
- H. Ibach and H. Lüth: Solid-State Physics

M 4.177 Module: Solid-State Optics (Minor) [M-PHYS-102409]

Responsible: PD Dr. Michael Hetterich
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-104774	Solid-State Optics, without Exercises (Minor)	8 CR	Hetterich

Competence Certificate
The course credit for the physics minor will be an ungraded oral examination of the stated qualification objectives.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102408 - Solid-State Optics must not have been started.

Competence Goal
The students

- know the basic interaction processes between light and matter and are familiar with the polariton concept
- can explain the optical properties of insulators, semiconductors (including quantum structures) and metals
- comprehend the concept of the dielectric function and can utilize it to calculate relevant optical quantities
- are familiar with the classical Drude-Lorentz model and its implications for the optical properties of solids
- understand the relation between classical and quantum mechanical models for the dielectric function as well as the importance of the Kramers Kronig relations
- can explain near-band-edge optical spectra of semiconductors and insulators based on the concepts of joint density of states, oscillator strength, as well as excitonic effects
- are familiar with common experimental techniques of optical spectroscopy
- understand the origin of different optical nonlinearities and high-excitation effects as well as their mathematical description, their experimental realization and their applications
- comprehend the basics of group theory and can apply it to solid state optics

Content
Maxwell's equations, refractive index, dispersion, dielectric function, extinction, absorption, reflection, continuity conditions at interfaces, anisotropic media and layered systems, Drude–Lorentz model, reststrahlen bands, Bloch states and band structure, perturbation theory of light–matter interaction, band to band transitions, joint density of states, van Hove singularities, phonon and exciton polaritons, plasmons, metals, semiconductor heterostructures, low-dimensional systems, group theory and selection rules, nonlinear optics, high-excitation effects in semiconductors, measurement of optical functions: Fourier spectroscopy, ellipsometry, modulation spectroscopy, photoluminescence, reflectometry, absorptivity.

Workload
240 hours, consisting of attendance time (60 hours) and follow-up work incl. preparation of the exam (180 hours)

Recommendation
Basic knowledge of solid-state physics and quantum mechanics is expected.

Literature

- H. Kalt, C. Klingshirn: Semiconductor Optics
- F. Wooten: Optical Properties of Solids
- P.K. Basu: Theory of optical processes in semiconductors
- H. Ibach and H. Lüth: Solid-State Physics

M 4.178 Module: Specialization Phase [M-PHYS-101396]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Specialization Phase

Credits	Grading scale	Recurrence	Duration	Level	Version
15	pass/fail	Each term	1 term	4	2

Mandatory			
T-PHYS-102481	Specialization Phase	15 CR	Studiendekan Physik

Competence Certificate
Study achievement, ungraded.

Prerequisites
The following subjects of the course of study have to be passed:

- Major in Physics
- Second Major in Physics
- Minor in Physics
- Non-Physics Elective
- Advanced Physics Laboratory Course

Competence Goal
Students acquire essential working techniques for the completion of their master's thesis; the working techniques are specific to the area of specialization.

Workload
approx. 450 hours

4.179 Module: Spin Transport in Nanostructures [M-PHYS-102293]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104586	Spin Transport in Nanostructures	6 CR	Beckmann

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105375 - Spin Transport in Nanostructures (Minor) must not have been started.

Competence Goal
The students know the basic concepts of spin-polarized transport and their application to transport properties in nanostructures. They are able to solve concrete problems from this subject area using the factual knowledge acquired in the lecture.

Content
The lecture will first introduce the basics of electronic transport and magnetism. Based on this, magnetoresistive effects in nanoscale structures important for spin electronics are discussed (giant magnetoresistance, spin accumulation, tunnel magnetoresistance). Further topics are magnetization dynamics (micromagnetics, spin torque, domain walls, spin waves) and the coupling of spin and thermal transport (spin caloritronics).

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
Will be mentioned in the lecture.

4.180 Module: Spin Transport in Nanostructures (Minor) [M-PHYS-105375]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-110858	Spin Transport in Nanostructures (Minor)	6 CR	Beckmann

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102293 - Spin Transport in Nanostructures must not have been started.

Competence Goal
The students know the basic concepts of spin-polarized transport and their application to transport properties in nanostructures. They are able to solve concrete problems from this subject area using the factual knowledge acquired in the lecture.

Content
The lecture will first introduce the basics of electronic transport and magnetism. Based on this, magnetoresistive effects in nanoscale structures important for spin electronics are discussed (giant magnetoresistance, spin accumulation, tunnel magnetoresistance). Further topics are magnetization dynamics (micromagnetics, spin torque, domain walls, spin waves) and the coupling of spin and thermal transport (spin caloritronics).

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
Will be mentioned in the lecture.

M 4.181 Module: Superconducting Nanostructures [M-PHYS-102191]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104513	Superconducting Nanostructures	6 CR	Beckmann

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104723 - Superconducting Nanostructures (Minor) must not have been started.

Competence Goal
The students are introduced to the basic concepts of superconductivity and understand their application to transport properties in nanostructures. In the exercise, the students solve concrete problems from this subject area using the factual knowledge imparted in the lecture.

Content
In the lecture, the fundamentals of superconductivity are first discussed (BCS theory). These are applied to electronic transport properties of nanostructures whose dimensions are comparable to the coherence length of superconductivity. The main transport processes (tunneling, Andreev reflection, Josephson effect) are treated, the competition of superconductivity with other ground states (normal metal, ferromagnet) is discussed (proximity effect), and their interplay in complex nanostructures is highlighted. The fundamentals are illustrated by numerous examples from current research.

Workload
180 hours consisting of attendance time (45 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
Literature will be mentioned in the lecture.

M 4.182 Module: Superconducting Nanostructures (Minor) [M-PHYS-104723]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-109621	Superconducting Nanostructures (Minor)	6 CR	Beckmann

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102191 - Superconducting Nanostructures must not have been started.

Competence Goal
The students are introduced to the basic concepts of superconductivity and understand their application to transport properties in nanostructures. In the exercise, the students solve concrete problems from this subject area using the factual knowledge imparted in the lecture.

Content
In the lecture, the fundamentals of superconductivity are first discussed (BCS theory). These are applied to electronic transport properties of nanostructures whose dimensions are comparable to the coherence length of superconductivity. The main transport processes (tunneling, Andreev reflection, Josephson effect) are treated, the competition of superconductivity with other ground states (normal metal, ferromagnet) is discussed (proximity effect), and their interplay in complex nanostructures is highlighted. The fundamentals are illustrated by numerous examples from current research.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture and preparation of exercises (135 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
Literature will be mentioned in the lecture.

M 4.183 Module: Superconductivity, Josephson Effect and Applications, with Exercises [M-PHYS-105655]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111293	Superconductivity, Josephson Effect and Applications, with Exercises	8 CR	Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105656 - Superconductivity, Josephson Effect and Applications, with Exercises (Minor) must not have been started.
2. The module M-PHYS-106584 - Superconductivity, Josephson Effect and Applications, without Exercises must not have been started.

Competence Goal
The students master the basic concepts of theory of superconductivity.

The students are able to analyze and structure problems in the field of superconductivity.

The students acquire deep understanding of the Josephson effect.

The students are able to solve problems related to coherent quantum dynamics is superconducting circuits with Josephson elements.

Content
This Module covers the theoretical description of the phenomenon of superconductivity along with the introduction into various applications of superconducting systems. In particular the following subjects will be covered:

- Phenomenology, Meissner effect and London equation
- Ginzburg-Landau theory
- BCS theory
- Electrodynamics of superconductors, Anderson-Higgs mechanism
- Josephson effect in tunnel junctions
- Andreev states and Josephson effect
- Macroscopic quantum coherence
- Josephson qubits
- Microwave optics in Josephson circuits
- Arrays of Josephson junctions

Workload
240 hours consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and preparation and follow-up of the exercises (180 h).

M 4.184 Module: Superconductivity, Josephson Effect and Applications, with Exercises (Minor) [M-PHYS-105656]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-111294	Superconductivity, Josephson Effect and Applications, with Exercises (Minor)	8 CR	Shnirman

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105655 - Superconductivity, Josephson Effect and Applications, with Exercises must not have been started.
2. The module M-PHYS-106584 - Superconductivity, Josephson Effect and Applications, without Exercises must not have been started.

Competence Goal
The students master the basic concepts of theory of superconductivity.

The students are able to analyze and structure problems in the field of superconductivity.

The students acquire deep understanding of the Josephson effect.

The students are able to solve problems related to coherent quantum dynamics is superconducting circuits with Josephson elements.

Content
This Module covers the theoretical description of the phenomenon of superconductivity along with the introduction into various applications of superconducting systems. In particular the following subjects will be covered:

- Phenomenology, Meissner effect and London equation
- Ginzburg-Landau theory
- BCS theory
- Electrodynamics of superconductors, Anderson-Higgs mechanism
- Josephson effect in tunnel junctions
- Andreev states and Josephson effect
- Macroscopic quantum coherence
- Josephson qubits
- Microwave optics in Josephson circuits
- Arrays of Josephson junctions

Workload
240 hours consisting of attendance time (60 h), follow-up of the lecture and preparation and follow-up of the exercises (180 h).

M 4.185 Module: Superconductivity, Josephson Effect and Applications, without Exercises [M-PHYS-106584]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-113257	Superconductivity, Josephson Effect and Applications, without Exercises	6 CR	Shnirman

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105656 - Superconductivity, Josephson Effect and Applications, with Exercises (Minor) must not have been started.
2. The module M-PHYS-105655 - Superconductivity, Josephson Effect and Applications, with Exercises must not have been started.

Competence Goal
The students master the basic concepts of theory of superconductivity.

The students are able to analyze and structure problems in the field of superconductivity.

The students acquire deep understanding of the Josephson effect.

Content
This Module covers the theoretical description of the phenomenon of superconductivity along with the introduction into various applications of superconducting systems. In particular the following subjects will be covered:

- Phenomenology, Meissner effect and London equation
- Ginzburg-Landau theory
- BCS theory
- Electrodynamics of superconductors, Anderson-Higgs mechanism
- Josephson effect in tunnel junctions
- Andreev states and Josephson effect
- Macroscopic quantum coherence
- Josephson qubits
- Microwave optics in Josephson circuits
- Arrays of Josephson junctions

Workload
180 hours consisting of attendance time (45 h), wrap-up of the lecture incl. exam preparation and preparation and follow-up of the exercises (135 h).

M 4.186 Module: Superconductivity, Microscopic Theory and Macroscopic Phenomena [M-PHYS-106796]

Responsible: Prof. Dr. Jörg Schmalian
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113655	Superconductivity, Microscopic Theory and Macroscopic Phenomena	8 CR	Schmalian

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106797 - Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor) must not have been started.

Competence Goal

- Students are able to analyze, structure and formally describe problems in the field of superconductivity theory.
- Students are able to apply the methods of many-body theory.
- Students are able to carry out microscopic calculations using the BCS theory of superconductivity and the renormalization group description of many-body systems.

Content
This module aims to provide students with the theoretical aspects of the theory of superconductivity as a state of macroscopic quantum coherence.
Molecular field theory, renormalization group approaches, the Eliashberg theory of superconductivity, topological superconductivity, unconventional superconductivity are covered.
The module "Superconductivity, Microscopic Theory and Macroscopic Phenomena" provides an overview of the concept of off-diagonal long-range order and the connection to macroscopic observations in superconductors.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Knowledge of the content of TKM1 ("Condensed Matter Theory 1") is required, further knowledge of TKM2 ("Condensed Matter Theory 2") is an advantage.

Literature
We will supply a script of the lecture.

M 4.187 Module: Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor) [M-PHYS-106797]

Responsible: Prof. Dr. Jörg Schmalian
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113656	Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor)	8 CR	Schmalian

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106796 - Superconductivity, Microscopic Theory and Macroscopic Phenomena must not have been started.

Competence Goal

- Students are able to analyze, structure and formally describe problems in the field of superconductivity theory.
- Students are able to apply the methods of many-body theory.
- Students are able to carry out microscopic calculations using the BCS theory of superconductivity and the renormalization group description of many-body systems.

Content
This module aims to provide students with the theoretical aspects of the theory of superconductivity as a state of macroscopic quantum coherence.
Molecular field theory, renormalization group approaches, the Eliashberg theory of superconductivity, topological superconductivity, unconventional superconductivity are covered.
The module "Superconductivity, Microscopic Theory and Macroscopic Phenomena" provides an overview of the concept of off-diagonal long-range order and the connection to macroscopic observations in superconductors.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. preparation of the exercises (180 hours).

Recommendation
Knowledge of the content of TKM1 ("Condensed Matter Theory 1") is required, further knowledge of TKM2 ("Condensed Matter Theory 2") is an advantage.

Literature
We will supply a script of the lecture.

4.188 Module: Supersymmetry and Exotics at Colliders, with Exercises [M-PHYS-106848]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-PHYS-113734	Supersymmetry and Exotics at Colliders, with Exercises	12 CR	Mühlleitner

Competence Certificate
Oral examination. As part of the major subject of the MSc Physics, the module is examined together with other modules taken. The duration of the oral examination is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106849 - Supersymmetry and Exotics at Colliders, with Exercises (Minor) must not have been started.
2. The module M-PHYS-106850 - Supersymmetry and Exotics at Colliders, without Exercises must not have been started.

Competence Goal
The students get to know the theoretical concepts and methodology of supersymmetric as well as exotic extensions of the Standard Model. They get to know the phenomenology of the simplest and more complex supersymmetric extensions and of exotic field theories at present and future colliders. The students will apply the concepts and techniques they have learned to solve selected problems in supersymmetry.

Content
The following topics will be covered: supersymmetry algebra and its representations, supersymmetric field theories and superfield formalism, supersymmetric gauge theories, the minimal supersymmetric Standard Model (MSSM), the next-to-minimal supersymmetric Standard Model (NMSSM), their phenomenological applications; exotic extensions of the Standard Model and their phenomenological applications.

Workload
360 hours consisting of attendance time (90 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (270 hours).

Recommendation
Useful is knowledge on quantum field theory and the Standard Model of particle physics (e.g. from the lecture „Introduction to Theoretical Particle Physics“ - 4026021). It is useful to attend in parallel the lecture „Theoretical Particle Physics I“.

Literature
Will be announced in the lecture.

M 4.189 Module: Supersymmetry and Exotics at Colliders, with Exercises (Minor) [M-PHYS-106849]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	1 term	German/English	4	2

Mandatory			
T-PHYS-113735	Supersymmetry and Exotics at Colliders, with Exercises (Minor)	12 CR	Mühlleitner

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106848 - Supersymmetry and Exotics at Colliders, with Exercises must not have been started.
2. The module M-PHYS-106850 - Supersymmetry and Exotics at Colliders, without Exercises must not have been started.

Competence Goal
The students get to know the theoretical concepts and methodology of supersymmetric as well as exotic extensions of the Standard Model. They get to know the phenomenology of the simplest and more complex supersymmetric extensions and of exotic field theories at present and future colliders. The students will apply the concepts and techniques they have learned to solve selected problems in supersymmetry.

Content
The following topics will be covered: supersymmetry algebra and its representations, supersymmetric field theories and superfield formalism, supersymmetric gauge theories, the minimal supersymmetric Standard Model (MSSM), the next-to-minimal supersymmetric Standard Model (NMSSM), their phenomenological applications; exotic extensions of the Standard Model and their phenomenological applications.

Workload
360 hours consisting of attendance time (90 hours), follow-up of the lecture incl. preparation of the exercises (270 hours).

Recommendation
Useful is knowledge on quantum field theory and the Standard Model of particle physics (e.g. from the lecture „Introduction to Theoretical Particle Physics“ - 4026021). It is useful to attend in parallel the lecture „Theoretical Particle Physics I“.

Literature
Will be announced in the lecture.

M 4.190 Module: Supersymmetry and Exotics at Colliders, without Exercises [M-PHYS-106850]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-PHYS-113736	Supersymmetry and Exotics at Colliders, without Exercises	8 CR	Mühlleitner

Competence Certificate
Oral examination. As part of the major subject of the MSc Physics, the module is examined together with other modules taken. The duration of the oral examination is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106848 - Supersymmetry and Exotics at Colliders, with Exercises must not have been started.
2. The module M-PHYS-106849 - Supersymmetry and Exotics at Colliders, with Exercises (Minor) must not have been started.

Competence Goal
The students get to know the theoretical concepts and methodology of supersymmetric as well as exotic extensions of the Standard Model. They get to know the phenomenology of the simplest and more complex supersymmetric extensions and of exotic field theories at present and future colliders.

Content
The following topics will be covered: supersymmetry algebra and its representations, supersymmetric field theories and superfield formalism, supersymmetric gauge theories, the minimal supersymmetric Standard Model (MSSM), the next-to-minimal supersymmetric Standard Model (NMSSM), their phenomenological applications; exotic extensions of the Standard Model and their phenomenological applications.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation (180 hours).

Recommendation
Useful is knowledge on quantum field theory and the Standard Model of particle physics (e.g. from the lecture „Introduction to Theoretical Particle Physics“ - 4026021). It is useful to attend in parallel the lecture „Theoretical Particle Physics I“.

Literature
Will be announced in the lecture.

M 4.191 Module: Supplementary Studies on Science, Technology and Society [M-FORUM-106753]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
16	Grade to a tenth	Each term	3 terms	German	3	1

Election notes
Students have to self-record the achievements obtained in the Supplementary Studies on Science, Technology and Society in their study plan. FORUM (formerly ZAK) records the achievements as "non-assigned" under "ÜQ/SQ-Leistungen". Further instructions on self-recording of achievements can be found in the FAQ at https://campus.studium.kit.edu/ and on the FORUM homepage at https://www.forum.kit.edu/english/. The title of the examination and the amount of credits override the modules placeholders.

If you want to use FORUM achievements for both your Interdisciplinary Qualifications and for the Supplementary Studies, please record them in the Interdisciplinary Qualifications first. You can then get in contact with the FORUM study services (stg@forum.kit.edu) to also record them in your Supplementary Studies.

In the Advanced Unit you can choose examinations from three subject areas: "About Knowledge and Science", "Science in Society" and "Science in Social Debates". It is advised to complete courses from each of the three subject areas in the Advanced Unit.

To self-record achievements in the Advanced Unit, you have to select a free placeholder partial examination first. The placeholders' title do *not* affect which achievements the placeholder can be used for!

Mandatory			
T-FORUM-113578	Lecture Series Supplementary Studies on Science, Technology and Society - Self Registration	2 CR	Mielke, Myglas
T-FORUM-113579	Basic Seminar Supplementary Studies on Science, Technology and Society - Self Registration	2 CR	Mielke, Myglas
Advanced Unit Supplementary Studies on Science, Technology and Society (Election: at least 12 credits)			
T-FORUM-113580	Elective Specialization Supplementary Studies on Science, Technology and Society / About Knowledge and Science - Self-Registration	3 CR	Mielke, Myglas
T-FORUM-113581	Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Society - Self-Registration	3 CR	Mielke, Myglas
T-FORUM-113582	Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Public Debates - Self Registration	3 CR	Mielke, Myglas
Mandatory			
T-FORUM-113587	Registration for Certificate Issuance - Supplementary Studies on Science, Technology and Society	0 CR	Mielke, Myglas

Competence Certificate
The monitoring is explained in the respective partial achievement.

They are composed of:
- Protocols
- Reflection reports
- Presentations
- Preparation of a project work
- An individual term paper
- An oral examination
- A written exam

Upon successful completion of the supplementary studies, graduates receive a graded report and a certificate issued by the FORUM.

Prerequisites

The course is offered during the course of study and does not have to be completed within a defined period. Enrollment is required for all assessments of the modules in the supplementary studies.

Participation in the supplementary studies is regulated by § 3 of the statutes. KIT students register for the supplementary studies by selecting this module in the student portal and booking a performance themselves. Registration for courses, assessments, and exams is regulated by § 8 of the statutes and is usually possible shortly before the start of the semester.

The course catalog, module description (module manual), statutes (study regulations), and guidelines for creating the various written performance requirements can be downloaded from the FORUM homepage at **https://www.forum.kit.edu/begleitstudium-wtg.php**.

Registration and exam modalities

PLEASE NOTE:

Registration on the FORUM, i.e. additionally via the module selection in the student portal, enables students to receive up-to-date information about courses or study modalities. In addition, registering on the FORUM ensures that you have proof of the credits you have earned. As it is currently (as of winter semester 24-25) not yet possible to continue additional credits acquired in the Bachelor's programme electronically in the Master's programme, we strongly advise you to digitally secure the credits you have earned by archiving the Bachelor's transcript of records yourself and by registering on FORUM.

In the event that a transcript of records of the Bachelor's certificate is no longer available - we can only assign the achievements of registered students and thus take them into account when issuing the certificate.

Competence Goal

Graduates of the Supplementary Studies on Science, Technology, and Society gain a solid foundation in understanding the interplay between science, the public, business, and politics. They develop practical skills essential for careers in media, political consulting, or research management. The program prepares them to foster innovation, influence social processes, and engage in dialogue with political and societal entities. Participants are introduced to interdisciplinary perspectives, encompassing social sciences and humanities, to enhance their understanding of science, technology, and society. The teaching objectives of this supplementary degree program include equipping participants with both subject-specific knowledge and insights from epistemological, economic, social, cultural, and psychological perspectives on scientific knowledge and its application in various sectors. Students are trained to critically assess and balance the implications of their actions at the intersection of science and society. This training prepares them for roles as students, researchers, future decision-makers, and active members of society.

Through the program, participants learn to contextualize in-depth content within broader frameworks, independently analyze and evaluate selected course materials, and communicate their findings effectively in both written and oral formats. Graduates are adept at analyzing social issues and problem areas, reflecting on them critically from a socially responsible and sustainable standpoint.

Content

The Supplementary Studies on Science, Technology and Society can be started in the 1st semester of the enrolled degree programme and is not limited in time. The wide range of courses offered by FORUM makes it possible to complete the program usually within three semesters. The supplementary studies comprises 16 or more credit points (LP). It consists of **two modules: the Basic Module (4 LP) and the Advanced Module (12 LP)**.

The **basic Module** comprises the compulsory courses 'Lecture Series Supplementary Studies on Science, Technology and Society' and a basic seminar with a total of 4 LP.

The **Advanced Module** comprises courses totalling 12 LP in the humanities and social sciences subject areas 'On Knowledge and Science', 'Science in Society' and 'Science in Public Debates'. The allocation of courses to the accompanying study programme can be found on the homepage https://www.forum.kit.edu/wtg-aktuelland in the printed FORUM course catalogue.

The 3 thematic subject areas:

Subject area 1: About Knowledge and Science

This is about the internal perspective of science: students explore the creation of knowledge, distinguishing between scientific and non-scientific statements (e.g., beliefs, pseudo-scientific claims, ideological statements), and examining the prerequisites, goals, and methods of knowledge generation. They investigate how researchers address their own biases, analyze the structure of scientific explanatory and forecasting models in various disciplines, and learn about the mechanisms of scientific quality assurance.

After completing courses in the "Knowledge and Science" area, students can critically reflect on the ideals and realities of contemporary science. They will be able to address questions such as: How robust is scientific knowledge? What are the capabilities and limitations of predictive models? How effective is quality assurance in science, and how can it be improved? What types of questions can science answer, and what questions remain beyond its scope?

Subject area 2: Science in Society

This focuses on the interactions between science and different areas of society, such as how scientific knowledge influences social decision-making and how social demands impact scientific research. Students learn about the specific functional logics of various societal sectors and, based on this understanding, estimate where conflicts of goals and actions might arise in transfer processes—for example, between science and business, science and politics, or science and journalism. Typical questions in this subject area include: How and under what conditions does an innovation emerge from a scientific discovery? How does scientific policy advice work? How do business and politics influence science, and when is this problematic? According to which criteria do journalists incorporate scientific findings into media reporting? Where does hostility towards science originate, and how can social trust in science be strengthened?

After completing courses in the "Sciene in Society" area, students can understand and assess the goals and constraints of actors in different societal sectors. This equips them to adopt various perspectives of communication and action partners in transfer processes and to act competently at various social interfaces with research in their professional lives.

Subject area 3: Science in Public Debates

The courses in this subject area provide insights into current debates on major social issues such as sustainability, digitalization, artificial intelligence, gender equality, social justice, and educational opportunities. Public debates on complex challenges are often polarized, leading to oversimplifications, defamation, or ideological thinking. This can hinder effective social solution-finding processes and alienate people from the political process and from science. Debates about sustainable development are particularly affected, as they involve a wide range of scientific and technological knowledge in both problem diagnosis (e.g., loss of biodiversity, climate change, resource consumption) and solution development (e.g., nature conservation, CCS, circular economy).

By attending courses in "Science in Public Debates," students are trained in an application-oriented way to engage in factual debates—exchanging arguments, addressing their own prejudices, and handling contradictory information. They learn that factual debates can often be conducted more deeply and with more nuance than is often seen in public discourse. This training enables them to handle specific factual issues in their professional lives independently of their own biases and to be open to differentiated, fact-rich arguments.

Supplementary credits:

Additional LP (supplementary work) totalling a maximum of 12 LP can also be acquired from the complementary study programme (see statutes for the WTG complementary study programme § 7). § 4 and § 5 of the statutes remain unaffected by this. These supplementary credits are not included in the overall grade of the accompanying study programme. At the request of the participant, the supplementary work will be included in the certificate of the accompanying study programme and marked as such. Supplementary coursework is listed with the grades provided for in § 9.

Module grade calculation

The overall grade of the supplementary course is calculated as a credit-weighted average of the grades that were achieved in the advanced module.

Annotation
Climate change, biodiversity crisis, antibiotic resistance, artificial intelligence, carbon capture and storage, and gene editing are just a few areas where science and technology can diagnose and address numerous social and global challenges. The extent to which scientific findings are considered in politics and society depends on various factors, such as public understanding and trust, perceived opportunities and risks, and ethical, social, or legal considerations.
To enable students to use their expertise as future decision-makers in solving social and global challenges, we aim to equip them with the skills to navigate the interfaces between science, business, and politics competently and reflectively. In the Supplementary Studies, they acquire foundational knowledge about the interactions between science, technology, and society.

They learn:
- How reliable scientific knowledge is produced,
- how social expectations and demands influence scientific research, and
- how scientific knowledge is adopted, discussed, and utilized by society.

The program integrates essential insights from psychology, philosophy, economics, social sciences, and cultural studies into these topics. After completing the supplementary studies programme, students can place the content of their specialized studies within a broader social context. This prepares them, as future decision-makers, to navigate competently and reflectively at the intersections between science and various sectors of society, such as politics, business, or journalism, and to contribute effectively to innovation processes, public debates, or political decision-making.

Workload
The workload is made up of the number of hours of the individual modules:

- Basic Module approx. 120 hours
- Advanced Module approx. 390 hours

> Total: approx. 510 hours

In the form of supplementary services, up to approximately 390 hours of work can be added.

Recommendation
It is recommended to complete the supplementary study program in three or more semesters, beginning with the lecture series on science, technology, and society in the summer semester. Alternatively, you can start with the basic seminar in the winter semester and then attend the lecture series in the summer semester.

Courses in the Advanced Module can be taken simultaneously. It is also advised to complete courses from each of the three subject areas in the advanced unit.

Learning type
- Lectures
- Seminars/Project Seminars
- Workshops

4.192 Module: Surface Science, with Exercises [M-PHYS-106482]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113098	Surface Science, with Exercises	10 CR	Willke, Wulfhekel, Zakeri-Lori

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106483 - Surface Science, without Exercises must not have been started.
2. The module M-PHYS-106484 - Surface Science, with Exercises (Minor) must not have been started.

Competence Goal
Students are introduced to the basic concepts of surface science, they master the relevant theoretical concepts and understand the concepts and measurement methods of surface science as well as their application. In groups they solve concrete problems of surface science using the factual knowledge acquired in the lecture.

Content
In the lecture, physics at surfaces and interfaces as well as the physical chemistry at surfaces are discussed. Starting with the two-dimensional space group, the structure of surfaces is discussed as well as effects arising from symmetry breaking at surfaces and interfaces. Furthermore, layer growth and modification of layer growth using various techniques will be discussed. The main part of the lecture deals with the electronic structure of two-dimensional systems and nanostructures as well as the experimental techniques of surface science.

Workload
300 hours consisting of attendance time (75 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (225 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- K. Oura, V.G. Lifshits, A.A. Saranin, A.V. Zotov, M. Katayama, Surface Science: An Introduction, Springer
- H. Ibach, Physics of Surfaces and Interfaces, Springer

4.193 Module: Surface Science, with Exercises (Minor) [M-PHYS-106484]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
10	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113100	Surface Science, with Exercises (Minor)	10 CR	Willke, Wulfhekel, Zakeri-Lori

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106482 - Surface Science, with Exercises must not have been started.
2. The module M-PHYS-106483 - Surface Science, without Exercises must not have been started.

Competence Goal
Students are introduced to the basic concepts of surface science, they master the relevant theoretical concepts and understand the concepts and measurement methods of surface science as well as their application. In groups they solve concrete problems of surface science using the factual knowledge acquired in the lecture.

Content
In the lecture, physics at surfaces and interfaces as well as the physical chemistry at surfaces are discussed. Starting with the two-dimensional space group, the structure of surfaces is discussed as well as effects arising from symmetry breaking at surfaces and interfaces. Furthermore, layer growth and modification of layer growth using various techniques will be discussed. The main part of the lecture deals with the electronic structure of two-dimensional systems and nanostructures as well as the experimental techniques of surface science.

Workload
300 hours consisting of attendance time (75 hours), wrap-up of lecture and preparation of exercises (225 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- K. Oura, V.G. Lifshits, A.A. Saranin, A.V. Zotov, M. Katayama, Surface Science: An Introduction, Springer
- H. Ibach, Physics of Surfaces and Interfaces, Springer

4.194 Module: Surface Science, without Exercises [M-PHYS-106483]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Required Elective Nanophysics)
Second Major in Physics: Condensed Matter (Required Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113099	Surface Science, without Exercises	8 CR	Willke, Wulfhekel, Zakeri-Lori

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106482 - Surface Science, with Exercises must not have been started.
2. The module M-PHYS-106484 - Surface Science, with Exercises (Minor) must not have been started.

Competence Goal
Students are introduced to the basic concepts of surface science, master the relevant theoretical concepts, and understand the concepts and measurement methods of surface science and their applications.

Content
In the lecture, physics at surfaces and interfaces as well as the physical chemistry at surfaces are discussed. Starting with the two-dimensional space group, the structure of surfaces is discussed as well as effects arising from symmetry breaking at surfaces and interfaces. Furthermore, layer growth and modification of layer growth using various techniques will be discussed. The main part of the lecture deals with the electronic structure of two-dimensional systems and nanostructures as well as the experimental techniques of surface science.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of lecture incl. exam preparation (180 hours).

Recommendation
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- K. Oura, V.G. Lifshits, A.A. Saranin, A.V. Zotov, M. Katayama, Surface Science: An Introduction, Springer
- H. Ibach, Physics of Surfaces and Interfaces, Springer

4.195 Module: Symmetries and Groups [M-PHYS-102317]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-PHYS-104596	Symmetries and Groups	8 CR	Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102315 - Symmetries, Groups and Extended Gauge Theories must not have been started.
2. The module M-PHYS-102316 - Symmetries, Groups and Extended Gauge Theories (Minor) must not have been started.
3. The module M-PHYS-102318 - Symmetries and Groups (Minor) must not have been started.

Competence Goal
Learning the methodology of group theory Ability to solve complex mathematical problems such as the classification of Lie groups.

Content
Lie groups and their representations, Lie algebras, Poincaré group, discrete groups, left-right symmetry, grand unified theories.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
Good knowledge of quantum mechanics I. For the last third, "extended gauge theories", previous knowledge of theoretical particle physics is required.

Literature
To be stated in the lecture.

M 4.196 Module: Symmetries and Groups (Minor) [M-PHYS-102318]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	German	4	1

Mandatory			
T-PHYS-104597	Symmetries and Groups (Minor)	8 CR	Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102315 - Symmetries, Groups and Extended Gauge Theories must not have been started.
2. The module M-PHYS-102316 - Symmetries, Groups and Extended Gauge Theories (Minor) must not have been started.
3. The module M-PHYS-102317 - Symmetries and Groups must not have been started.

Competence Goal
Learning the methodology of group theory Ability to solve complex mathematical problems such as the classification of Lie groups.

Content
Lie groups and their representations, Lie algebras, Poincaré group, discrete groups, left-right symmetry, grand unified theories.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
Good knowledge of quantum mechanics I. For the last third, "extended gauge theories", previous knowledge of theoretical particle physics is required.

Literature
To be stated in the lecture.

M 4.197 Module: Symmetries, Groups and Extended Gauge Theories [M-PHYS-102315]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-PHYS-102393	Symmetries, Groups and Extended Gauge Theories	12 CR	Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102316 - Symmetries, Groups and Extended Gauge Theories (Minor) must not have been started.
2. The module M-PHYS-102317 - Symmetries and Groups must not have been started.
3. The module M-PHYS-102318 - Symmetries and Groups (Minor) must not have been started.

Competence Goal
Learning the methodology of group theory Ability to solve complex mathematical problems such as classification of Lie groups, understanding the concepts of extended gauge theories.

Content
Lie groups and their representations, Lie algebras, Poincaré group, discrete groups, left-right symmetry, grand unified theories.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (270 hours)

Recommendation
Good knowledge of quantum mechanics I. For the last third, "extended gauge theories", previous knowledge of theoretical particle physics is required.

Literature
To be stated in the lecture.

4.198 Module: Symmetries, Groups and Extended Gauge Theories (Minor) [M-PHYS-102316]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	1 term	German	4	1

Mandatory			
T-PHYS-102444	Symmetries, Groups and Extended Gauge Theories (Minor)	12 CR	Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102315 - Symmetries, Groups and Extended Gauge Theories must not have been started.
2. The module M-PHYS-102317 - Symmetries and Groups must not have been started.
3. The module M-PHYS-102318 - Symmetries and Groups (Minor) must not have been started.

Competence Goal
Learning the methodology of group theory Ability to solve complex mathematical problems such as classification of Lie groups, understanding the concepts of extended gauge theories.

Content
Lie groups and their representations, Lie algebras, Poincaré group, discrete groups, left-right symmetry, grand unified theories.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture and preparation of the exercises (270 hours).

Recommendation
Good knowledge of quantum mechanics I. For the last third, "extended gauge theories", previous knowledge of theoretical particle physics is required.

Literature
To be stated in the lecture.

M 4.199 Module: The ABC of DFT [M-PHYS-102984]

Responsible: Prof. Dr. Carsten Rockstuhl
Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-105960	The ABC of DFT	6 CR	Rockstuhl, Wenzel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
Understanding of basic numerical methods in density functional theory and the ability to apply them to solve physical problems in solid state physics such as the description of charge transport or magnetism. Emphasis is placed on acquiring the skills for independent simulation execution, subsequent data analysis, physical interpretation and, if possible, linkage with experimental investigations.

Content
With ever advancing computational power, it becomes possible to determine the electronic structure of increasingly complex systems relevant to solid state physics and materials science. Here we introduce Density Functional Theory (DFT) by explaining the basic underlying concepts, present examples of its application and its shortcomings and outline the most promising improvement paths. DFT will be applied to charge transport and magnetism related problems. As DFT makes it possible to treat fairly large systems (up to a few thousand of electrons) it enables direct comparison to experiment for many important applications. Both periodic, crystalline systems and localized single molecule in vacuum will be addressed with a special focus on systems with reduced dimensionality, such as surfaces and interfaces. Where applicable, comparisons to experiment and possible deployments will be presented. Some of the topics that will be addressed are:

- Basic concepts underpinning the DFT
- Calculations of band structure and density of states (DOS) of (hybrid) graphene materials.
- Treatment of magnetism within DFT, with examples of both bulk and molecular magnetism.
- Charge transport, with examples of both ballistic and disordered hopping transport.
- Beyond ground state DFT: Time Dependent DFT, GW, ...

Workload
180 h consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and working on the exercises (120 h)

Recommendation
Basic knowledge of solid state theory, quantum mechanics, and thermodynamics is assumed.

Literature
Will be mentioned in the lecture.

M 4.200 Module: Theoretical Cosmology, with Exercises [M-PHYS-106845]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-113731	Theoretical Cosmology, with Exercises	12 CR	Kahlhöfer, Schwetz-Mangold

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104855 - Introduction to Theoretical Cosmology must not have been started.
2. The module M-PHYS-104856 - Introduction to Theoretical Cosmology (Minor) must not have been started.
3. The module M-PHYS-106846 - Theoretical Cosmology, with Exercises (Minor) must not have been started.
4. The module M-PHYS-106847 - Theoretical Cosmology, without Exercises must not have been started.

Competence Goal
Students are familiar with different aspects of the Big Bang theory. They understand the basic physical concepts and can apply relevant methods of theoretical physics to cosmology. They know about selected advanced topics in cosmology. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in Cosmology.

Content
The lecture gives an introduction to the standard model of cosmology, the so-called LCDM model. The fundamental physics principles of the model are discussed. Starting from fundamental theories such as general relativity, particle physics, thermodynamics and statistical physics, we derive the properties and predictions of the LCDM model. We consider the expansion of the Universe, dark matter, dark energy, thermodynamics in the early Universe, Big Bang nucleosynthesis, cosmic structure formation, cosmic microwave background radiation. Selected advanced topics include the theory of cosmic inflation, cosmological phase transitions, baryogenesis, neutrino cosmology, cosmological gravitational waves, dark matter candidates.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. preparation of the exercises and exam preparation (270 hours).

Recommendation
Basic knowledge of General Relativity is recommended, but all required concepts will be introduced. Basic knowledge of particle physics and quantum field theory is helpful.

Literature

- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Hot Big Bang Theory
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Cosmological Perturbations and Inflationary Theory
- D. Baumann, Cosmology
- S. Dodelson, Modern Cosmology
- S. Weinberg, Cosmology
- V. Mukhanov, Physical Foundations of Cosmology

4.201 Module: Theoretical Cosmology, with Exercises (Minor) [M-PHYS-106846]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: Minor in Physics: Theoretical Cosmology and Astroparticle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-113732	Theoretical Cosmology, with Exercises (Minor)	12 CR	Kahlhöfer, Schwetz-Mangold

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104855 - Introduction to Theoretical Cosmology must not have been started.
2. The module M-PHYS-104856 - Introduction to Theoretical Cosmology (Minor) must not have been started.
3. The module M-PHYS-106845 - Theoretical Cosmology, with Exercises must not have been started.
4. The module M-PHYS-106847 - Theoretical Cosmology, without Exercises must not have been started.

Competence Goal
Students are familiar with different aspects of the Big Bang theory. They understand the basic physical concepts and can apply relevant methods of theoretical physics to cosmology. They know about selected advanced topics in cosmology. Participants of the course can apply the concepts and techniques they have learned to solve selected problems in Cosmology.

Content
The lecture gives an introduction to the standard model of cosmology, the so-called LCDM model. The fundamental physics principles of the model are discussed. Starting from fundamental theories such as general relativity, particle physics, thermodynamics and statistical physics, we derive the properties and predictions of the LCDM model. We consider the expansion of the Universe, dark matter, dark energy, thermodynamics in the early Universe, Big Bang nucleosynthesis, cosmic structure formation, cosmic microwave background radiation. Selected advanced topics include the theory of cosmic inflation, cosmological phase transitions, baryogenesis, neutrino cosmology, cosmological gravitational waves, dark matter candidates.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. preparation of the exercises (270 hours).

Recommendation
Basic knowledge of General Relativity is recommended, but all required concepts will be introduced. Basic knowledge of particle physics and quantum field theory is helpful.

Literature

- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Hot Big Bang Theory
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Cosmological Perturbations and Inflationary Theory
- D. Baumann, Cosmology
- S. Dodelson, Modern Cosmology
- S. Weinberg, Cosmology
- V. Mukhanov, Physical Foundations of Cosmology

M 4.202 Module: Theoretical Cosmology, without Exercises [M-PHYS-106847]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Required: Theoretical Cosmology and Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-113733	Theoretical Cosmology, without Exercises	8 CR	Kahlhöfer, Schwetz-Mangold

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104855 - Introduction to Theoretical Cosmology must not have been started.
2. The module M-PHYS-104856 - Introduction to Theoretical Cosmology (Minor) must not have been started.
3. The module M-PHYS-106845 - Theoretical Cosmology, with Exercises must not have been started.
4. The module M-PHYS-106846 - Theoretical Cosmology, with Exercises (Minor) must not have been started.

Competence Goal
Students are familiar with different aspects of the Big Bang theory. They understand the basic physical concepts and can apply relevant methods of theoretical physics to cosmology. They know about selected advanced topics in cosmology.

Content
The lecture gives an introduction to the standard model of cosmology, the so-called LCDM model. The fundamental physics principles of the model are discussed. Starting from fundamental theories such as general relativity, particle physics, thermodynamics and statistical physics, we derive the properties and predictions of the LCDM model. We consider the expansion of the Universe, dark matter, dark energy, thermodynamics in the early Universe, Big Bang nucleosynthesis, cosmic structure formation, cosmic microwave background radiation. Selected advanced topics include the theory of cosmic inflation, cosmological phase transitions, baryogenesis, neutrino cosmology, cosmological gravitational waves, dark matter candidates.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation (180 hours).

Recommendation
Basic knowledge of General Relativity is recommended, but all required concepts will be introduced. Basic knowledge of particle physics and quantum field theory is helpful.

Literature

- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Hot Big Bang Theory
- D. Gorbunov, V. Rubakov, Introduction to the Theory of the Early Universe: Cosmological Perturbations and Inflationary Theory
- D. Baumann, Cosmology
- S. Dodelson, Modern Cosmology
- S. Weinberg, Cosmology
- V. Mukhanov, Physical Foundations of Cosmology

4.203 Module: Theoretical Molecular Biophysics, with Seminar [M-PHYS-102169]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-102365	Theoretical Molecular Biophysics, with Seminar	8 CR	Wenzel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102170 - Theoretical Molecular Biophysics, with Seminar (Minor) must not have been started.
2. The module M-PHYS-102171 - Theoretical Molecular Biophysics, without Seminar must not have been started.
3. The module M-PHYS-102172 - Theoretical Molecular Biophysics, without Seminar (Minor) must not have been started.

Competence Goal
The students:

- can describe the structure of biopolymers based on their components
- understand the physical interactions that determine the structure and function of biopolymers
- know models for structure formation and function of biopolymers, especially proteins and DNA.
- know methods for the simulation of structure formation and function of biopolymers, especially molecular dynamics and their technical implementation
- can apply these methods to simple problems of the teaching content
- know methods for computer-aided drug development
- know basic bioinformatics methods for protein and DNA structure prediction
- are able to critically evaluate the procedures in the context of their application
- can understand a special topic within the teaching content on the basis of scientific literature and present it in a lecture or a paper
- can critically evaluate the scientific results of this special topic

Content
The students are introduced to current issues in molecular biophysics in the border area between biology, chemistry and physics. After an introduction to the composition and structure of biopolymers, especially proteins and DNA, the physical principles of structure formation and function are presented. Afterwards biophysical basics and biochemical models for the modelling of proteins and DNA in their physiological environment are introduced. A central teaching content is the introduction to simulation methods for biopolymers (molecular dynamics, Monte Carlo method) and the biophysical models used for this (force fields) and their application in the exercises. In addition to the basic methods, modern extensions (Free-Energy-Perturbation Theory, Umbrella-Sampling, Metadynamics) are discussed. Students will be introduced to the application of these methods to important questions in molecular biophysics, including protein folding, protein structure prediction, DNA structure prediction and computer-aided drug development.

Workload
240 hours composed of attendance time (60), wrap-up of the lectures incl. preparation of the oral exam and solving the exercises (120), preparation of the seminar or writing a report (60)

Recommendation
Knowledge of thermodynamics

Literature

- Daune: Molecular Biophysics
- Branden, Tooze: Introduction to Protein Structure

Further literature will be given in the lecture

M 4.204 Module: Theoretical Molecular Biophysics, with Seminar (Minor) [M-PHYS-102170]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-102420	Theoretical Molecular Biophysics, with Seminar (Minor)	8 CR	Wenzel

Competence Certificate
50% of the points attainable in the exercise sheets, presentation and short lectures within the framework of the lecture/exercise.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102169 - Theoretical Molecular Biophysics, with Seminar must not have been started.
2. The module M-PHYS-102171 - Theoretical Molecular Biophysics, without Seminar must not have been started.
3. The module M-PHYS-102172 - Theoretical Molecular Biophysics, without Seminar (Minor) must not have been started.

Competence Goal
The students:

- can describe the structure of biopolymers based on their components
- understand the physical interactions that determine the structure and function of biopolymers
- know models for structure formation and function of biopolymers, especially proteins and DNA.
- know methods for the simulation of structure formation and function of biopolymers, especially molecular dynamics and their technical implementation
- can apply these methods to simple problems of the teaching content
- know methods for computer-aided drug development
- know basic bioinformatics methods for protein and DNA structure prediction
- are able to critically evaluate the procedures in the context of their application
- can understand a special topic within the teaching content on the basis of scientific literature and present it in a lecture or a paper
- can critically evaluate the scientific results of this special topic

Content
The students are introduced to current issues in molecular biophysics in the border area between biology, chemistry and physics. After an introduction to the composition and structure of biopolymers, especially proteins and DNA, the physical principles of structure formation and function are presented. Afterwards biophysical basics and biochemical models for the modelling of proteins and DNA in their physiological environment are introduced. A central teaching content is the introduction to simulation methods for biopolymers (molecular dynamics, Monte Carlo method) and the biophysical models used for this (force fields) and their application in the exercises. In addition to the basic methods, modern extensions (Free-Energy-Perturbation Theory, Umbrella-Sampling, Metadynamics) are discussed. Students will be introduced to the application of these methods to important questions in molecular biophysics, including protein folding, protein structure prediction, DNA structure prediction and computer-aided drug development.

Workload
240 hours composed of attendance time (60 hours), wrap-up of the lectures and solving the exercises (120 hours), preparation of the seminar or writing a report (60 hours)

Recommendation
Knowledge of thermodynamics

Literature

- Daune: Molecular Biophysics
- Branden, Tooze: Introduction to Protein Structure

Further literature will be given in the lecture

M 4.205 Module: Theoretical Molecular Biophysics, without Seminar [M-PHYS-102171]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104473	Theoretical Molecular Biophysics, without Seminar	6 CR	Wenzel

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102169 - Theoretical Molecular Biophysics, with Seminar must not have been started.
2. The module M-PHYS-102170 - Theoretical Molecular Biophysics, with Seminar (Minor) must not have been started.
3. The module M-PHYS-102172 - Theoretical Molecular Biophysics, without Seminar (Minor) must not have been started.

Competence Goal
The students:

- can describe the structure of biopolymers based on their components
- understand the physical interactions that determine the structure and function of biopolymers
- know models for structure formation and function of biopolymers, especially proteins and DNA.
- know methods for the simulation of structure formation and function of biopolymers, especially molecular dynamics and their technical implementation
- can apply these methods to simple problems of the teaching content
- know methods for computer-aided drug development
- know basic bioinformatics methods for protein and DNA structure prediction
- are able to critically evaluate the procedures in the context of their application

Content
The students are introduced to current issues in molecular biophysics in the border area between biology, chemistry and physics. After an introduction to the composition and structure of biopolymers, especially proteins and DNA, the physical principles of structure formation and function are presented. Afterwards biophysical basics and biochemical models for the modelling of proteins and DNA in their physiological environment are introduced. A central teaching content is the introduction to simulation methods for biopolymers (molecular dynamics, Monte Carlo method) and the biophysical models used for this (force fields) and their application in the exercises. In addition to the basic methods, modern extensions (Free-Energy-Perturbation Theory, Umbrella-Sampling, Metadynamics) are discussed. Students will be introduced to the application of these methods to important questions in molecular biophysics, including protein folding, protein structure prediction, DNA structure prediction and computer-aided drug development.

Workload
180 hours composed of attendance time (60), wrap-up of the lectures incl. preparation of the oral exam and solving the exercises (120)

Recommendation
Knowledge of thermodynamics

Literature

- Daune: Molecular Biophysics
- Branden, Tooze: Introduction to Protein Structure

Further literature will be given in the lecture

M 4.206 Module: Theoretical Molecular Biophysics, without Seminar (Minor) [M-PHYS-102172]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: Minor in Physics: Nanophysics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104474	Theoretical Molecular Biophysics, without Seminar (Minor)	6 CR	Wenzel

Competence Certificate
50% of the points achievable in the exercise sheets

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102169 - Theoretical Molecular Biophysics, with Seminar must not have been started.
2. The module M-PHYS-102170 - Theoretical Molecular Biophysics, with Seminar (Minor) must not have been started.
3. The module M-PHYS-102171 - Theoretical Molecular Biophysics, without Seminar must not have been started.

Competence Goal
The students:

- can describe the structure of biopolymers based on their components
- understand the physical interactions that determine the structure and function of biopolymers
- know models for structure formation and function of biopolymers, especially proteins and DNA.
- know methods for the simulation of structure formation and function of biopolymers, especially molecular dynamics and their technical implementation
- can apply these methods to simple problems of the teaching content
- know methods for computer-aided drug development
- know basic bioinformatics methods for protein and DNA structure prediction
- are able to critically evaluate the procedures in the context of their application

Content
The students are introduced to current issues in molecular biophysics in the border area between biology, chemistry and physics. After an introduction to the composition and structure of biopolymers, especially proteins and DNA, the physical principles of structure formation and function are presented. Afterwards biophysical basics and biochemical models for the modelling of proteins and DNA in their physiological environment are introduced. A central teaching content is the introduction to simulation methods for biopolymers (molecular dynamics, Monte Carlo method) and the biophysical models used for this (force fields) and their application in the exercises. In addition to the basic methods, modern extensions (Free-Energy-Perturbation Theory, Umbrella-Sampling, Metadynamics) are discussed. Students will be introduced to the application of these methods to important questions in molecular biophysics, including protein folding, protein structure prediction, DNA structure prediction and computer-aided drug development.

Workload
180 hours composed of attendance time (60), wrap-up of the lectures and solving the exercises (120)

Recommendation
Knowledge of thermodynamics

Literature

- Daune: Molecular Biophysics
- Branden, Tooze: Introduction to Protein Structure

Further literature will be given in the lecture

4.207 Module: Theoretical Nanooptics [M-PHYS-102295]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104587	Theoretical Nanooptics	6 CR	Garst, Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-103177 - Theoretical Nanooptics (Minor) must not have been started.

Competence Goal
The properties of light at the nanoscale can be controlled by various means. The aim of this lecture is to familiarize the students with the different possibilities that rely on nanostructured dielectric or metallic materials and to outline on solid mathematical grounds the analytical description of observable effects. The lecture is meant as a complementary source of education to experimental lecture. It shall provide the students with the necessary skills to work themselves in the field of theoretical nanooptics.

Content

- Dispersion relation to describe light in extended systems such as free space, interfaces, planar waveguides and waveguides with complicated geometrical cross sections.
- Description of the interaction of light with isolated objects such as spheres, cylinders, ellipsoids and prolates and oblates.
- Properties of plasmonic nanoparticles and the ability to tune their properties
- Notion of optical antennas and the discussion of their basic characteristics
- Description of the dynamics of wave propagation by perturbed eigenstates, i.e. coupled mode theory. Application to optical waveguide arrays.
- Discussion of metamaterials (unit cells, homogenization, light propagation, applications)
- Transformation optics
- Analytical modeling and phenomenological tools to describe nanooptical systems

Workload
180 hours composed of active time (45), wrap-up of the lecture incl. preparation of the examination and the excercises (135)

Recommendation
Solid mathematical background, good knowledge of classical electromagnetism and theoretical optics.

Literature

- L. Novotny and B. Hecht, Principle of Nano-Optics, Cambridge
- S. A. Maier, Plasmonics, Springer
- J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals: Molding the Flow of Light, University Press

M 4.208 Module: Theoretical Nanooptics (Minor) [M-PHYS-103177]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-106311	Theoretical Nanooptics (Minor)	6 CR	Garst, Rockstuhl

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102295 - Theoretical Nanooptics must not have been started.

Competence Goal
The properties of light at the nanoscale can be controlled by various means. The aim of this lecture is to familiarize the students with the different possibilities that rely on nanostructured dielectric or metallic materials and to outline on solid mathematical grounds the analytical description of observable effects. The lecture is meant as a complementary source of education to experimental lecture. It shall provide the students with the necessary skills to work themselves in the field of theoretical nanooptics.

Content

- Dispersion relation to describe light in extended systems such as free space, interfaces, planar waveguides and waveguides with complicated geometrical cross sections.
- Description of the interaction of light with isolated objects such as spheres, cylinders, ellipsoids and prolates and oblates.
- Properties of plasmonic nanoparticles and the ability to tune their properties
- Notion of optical antennas and the discussion of their basic characteristics
- Description of the dynamics of wave propagation by perturbed eigenstates, i.e. coupled mode theory. Application to optical waveguide arrays.
- Discussion of metamaterials (unit cells, homogenization, light propagation, applications)
- Transformation optics
- Analytical modeling and phenomenological tools to describe nanooptical systems

Workload
180 hours composed of active time (45), wrap-up of the lecture and the excercises (135)

Recommendation
Solid mathematical background, good knowledge of classical electromagnetism and theoretical optics.

Literature

- L. Novotny and B. Hecht, Principle of Nano-Optics, Cambridge
- S. A. Maier, Plasmonics, Springer
- J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals: Molding the Flow of Light, University Press

M 4.209 Module: Theoretical Optics [M-PHYS-102277]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (mandatory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104578	Theoretical Optics	6 CR	Narozhnyy, Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102279 - Theoretical Optics (Minor) must not have been started.

Competence Goal
The students deepen their knowledge about the theory and the mathematical tools in optics and photonics. They learn how to apply these tools to describe fundamental phenomena and how to predict observable quantities that reflect the actual physics from the theory by way of a corresponding purposeful mathematical analyses. They learn how to solve problems of both, interpretative and predictive nature with regards to model systems and real life situations.

Content

- Review of Electromagnetism (Maxwell's Equations, Stress Tensor, Material Properties, Kramers-Kronig Relation, Wave Propagation, Poynting's Theorem)
- Diffraction Theory (The Principles of Huygens and Fresnel, Scalar Diffraction Theory: Green's Function, Helmholtz-Kirchhoff Theorem, Kirchhoff Formulation of Diffraction, Fresnel-Kirchhoff Diffraction Formula, Rayleigh-Sommerfeld Formulation of Diffraction, Angular Spectrum Method, Fresnel and Fraunhofer Diffraction, Method of Stationary Phases, Basics og Holography)
- Crystal Optics (Polarization, Anisotropic Media, Fresnel Equation, Applications)
- Classical Coherence Theory (Elementary Coherence Phenomena, Theory of Stochastic Processes, Correlation Functions)
- Quantum Optics and Quantum Optical Coherence Theory (Review of Quantum Mechanics, Quantization of the EM Field, Quantum Coherence Functions)

Annotation
For students of the KIT Faculty of Computer Science: The exams in this module have to be registered via admissions from ISS (KIT Faculty of Computer Science). For this, an e-mail with matriculation numbers and name of the desired exam to Beratung-informatik@informatik.kit.edu is sufficient.

Workload
180 hours composed of active time (45 hours), wrap-up of the lecture incl. preparation of the examination (135 hours)

Recommendation
Solid mathematical background, good knowledge of classical electromagnetism and basic knowledge of quantum mechanics.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- "Introduction to Fourier Optics" Joseph W. Goodman
- "Introduction to the Theory of Coherence and Polarization of Light" Emil Wolf
- "The Quantum Theory of Light " Rodney Loudon

M 4.210 Module: Theoretical Optics (Minor) [M-PHYS-102279]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102305	Theoretical Optics - Unit	6 CR	Narozhnyy, Rockstuhl

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102277 - Theoretical Optics must not have been started.

Competence Goal
The students deepen their knowledge about the theory and the mathematical tools in optics and photonics. They learn how to apply these tools to describe fundamental phenomena and how to predict observable quantities that reflect the actual physics from the theory by way of a corresponding purposeful mathematical analyses. They learn how to solve problems of both, interpretative and predictive nature with regards to model systems and real life situations.

Content

- Review of Electromagnetism (Maxwell's Equations, Stress Tensor, Material Properties, Kramers-Kronig Relation, Wave Propagation, Poynting's Theorem)
- Diffraction Theory (The Principles of Huygens and Fresnel, Scalar Diffraction Theory: Green's Function, Helmholtz-Kirchhoff Theorem, Kirchhoff Formulation of Diffraction, Fresnel-Kirchhoff Diffraction Formula, Rayleigh-Sommerfeld Formulation of Diffraction, Angular Spectrum Method, Fresnel and Fraunhofer Diffraction, Method of Stationary Phases, Basics og Holography)
- Crystal Optics (Polarization, Anisotropic Media, Fresnel Equation, Applications)
- Classical Coherence Theory (Elementary Coherence Phenomena, Theory of Stochastic Processes, Correlation Functions)
- Quantum Optics and Quantum Optical Coherence Theory (Review of Quantum Mechanics, Quantization of the EM Field, Quantum Coherence Functions)

Workload
180 hours composed of active time (45 hours), wrap-up of the lecture and the examination (135 hours)

Recommendation
Solid mathematical background, good knowledge of classical electromagnetism and basic knowledge of quantum mechanics.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- "Introduction to Fourier Optics" Joseph W. Goodman
- "Introduction to the Theory of Coherence and Polarization of Light" Emil Wolf
- "The Quantum Theory of Light " Rodney Loudon

M 4.211 Module: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises [M-PHYS-102033]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Required Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102544	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises	12 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises must not have been started.
2. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.
3. The module M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises must not have been started.
4. The module M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) must not have been started.
5. The module M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The student applies his/her knowledge to physical problems and can calculate simple processes of QED. The students deepen their knowledge in the exercises coordinated with the lecture.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum FField Theory
- L. Ryder, Quantum Field Theory

M 4.212 Module: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) [M-PHYS-102037]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102540	Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor)	12 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.
2. The module M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises must not have been started.
3. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.
4. The module M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises must not have been started.
5. The module M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The student applies his/her knowledge to physical problems and can calculate simple processes of QED. The students deepen their knowledge in the exercises coordinated with the lecture.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture and working on the exercises (270 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum FField Theory.
- L. Ryder, Quantum Field Theory

M 4.213 Module: Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises [M-PHYS-102035]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Required Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102546	Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises	8 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.
2. The module M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises must not have been started.
3. The module M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises must not have been started.
4. The module M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) must not have been started.
5. The module M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The student applies his/her knowledge to physical problems and can calculate simple processes of QED.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
240 h consisting of attendance time (60 h), wrap-up of lecture incl. exam preparation (180 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum FField Theory.
- L. Ryder, Quantum Field Theory

4.214 Module: Theoretical Particle Physics I, Fundamentals, with Exercises [M-PHYS-102034]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Required Theoretical Particle Physics)
Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102545	Theoretical Particle Physics I, Fundamentals, with Exercises	8 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.
2. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.
3. The module M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises must not have been started.
4. The module M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) must not have been started.
5. The module M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The students deepen their knowledge in the exercises coordinated with the lecture.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
240 h consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and working on the exercises (180 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum Field Theory
- L. Ryder, Quantum Field Theory

4.215 Module: Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) [M-PHYS-102038]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102541	Theoretical Particle Physics I, Fundamentals, with Exercises (Minor)	8 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.
2. The module M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises must not have been started.
3. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.
4. The module M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises must not have been started.
5. The module M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The students deepen their knowledge in the exercises coordinated with the lecture.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
240 h consisting of attendance time (60 h), wrap-up of the lecture and working on the exercises (180 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum FField Theory
- L. Ryder, Quantum Field Theory

4.216 Module: Theoretical Particle Physics I, Fundamentals, without Exercises [M-PHYS-102036]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)
Second Major in Physics: Theoretical Particle Physics
Second Major in Physics: Theoretical Cosmology and Astroparticle Physics (Elective: Theoretical Cosmology an Astroparticle Physics)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102547	Theoretical Particle Physics I, Fundamentals, without Exercises	6 CR	Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.
2. The module M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises must not have been started.
3. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.
4. The module M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) must not have been started.
5. The module M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) must not have been started.

Competence Goal
The student will be introduced to the basic concepts of Relativistic Quantum Field Theory, master the relevant theoretical concepts, and be able to apply the computational methods.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
180 h consisting of attendance time (45 h), wrap-up of lecture incl. exam preparation (135 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum FField Theory
- L. Ryder, Quantum Field Theory

4.217 Module: Theoretical Particle Physics II, with Exercises [M-PHYS-102046]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102552	Theoretical Particle Physics II, with Exercises	12 CR	Heinrich, Melnikov, Mühlleitner, Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102044 - Theoretical Particle Physics II, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102048 - Theoretical Particle Physics II, without Exercises must not have been started.

Competence Goal
Students know the basic concepts of non-Abelian gauge theories and their application in particle physics. They understand the underlying theoretical concepts and their interrelationships. The students know the standard model of particle physics and can handle the relevant computational methods. The students solve concrete problems of theoretical particle physics using the factual knowledge conveyed in the lecture.

Content
In the main part of the lecture, non-Abelian gauge theories and their application in elementary particle physics are discussed. The subject area includes the Lagrangian densities of QCD and the
electroweak Standard Model as well as the Higgs mechanism. The Feynman rules that follow from the Lagrangian densities are introduced and applied in perturbation-theoretic calculations of rates for
processes involving quarks and gluons. Regularization and renormalization of ultraviolet divergences are also treated, as well as applications of the renormalization group, the QCD beta function, and asymptotic freedom. Infrared divergences, parton distribution functions, and
splitting functions are introduced.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (270 hours)

Recommendation
Theoretical Particle Physics I

M 4.218 Module: Theoretical Particle Physics II, with Exercises (Minor) [M-PHYS-102044]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Minor in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102548	Theoretical Particle Physics II, with Exercises (Minor)	12 CR	Heinrich, Melnikov, Mühlleitner, Nierste

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102046 - Theoretical Particle Physics II, with Exercises must not have been started.
2. The module M-PHYS-102048 - Theoretical Particle Physics II, without Exercises must not have been started.

Competence Goal
The students know the basic concepts of non-Abelian gauge theories and their application in particle physics. They understand the underlying theoretical concepts and their interrelationships. The students know the standard model of particle physics and can handle the relevant computational methods. The students solve concrete problems of theoretical particle physics using the factual knowledge conveyed in the lecture.

Content
In the main part of the lecture, non-Abelian gauge theories and their application in elementary particle physics are discussed. The subject area includes the Lagrangian densities of QCD and the
electroweak Standard Model as well as the Higgs mechanism. The Feynman rules that follow from the Lagrangian densities are introduced and applied in perturbation-theoretic calculations of rates for
processes involving quarks and gluons. Regularization and renormalization of ultraviolet divergences are also treated, as well as applications of the renormalization group, the QCD beta function, and asymptotic freedom. Infrared divergences, parton distribution functions, and
splitting functions are introduced.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture and preparation of the exercises (270 hours).

Recommendation
Theoretical Particle Physics I

M 4.219 Module: Theoretical Particle Physics II, without Exercises [M-PHYS-102048]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: Major in Physics: Theoretical Particle Physics (Elective Theoretical Particle Physics)
Second Major in Physics: Theoretical Particle Physics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102554	Theoretical Particle Physics II, without Exercises	8 CR	Heinrich, Melnikov, Mühlleitner, Nierste

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102044 - Theoretical Particle Physics II, with Exercises (Minor) must not have been started.
2. The module M-PHYS-102046 - Theoretical Particle Physics II, with Exercises must not have been started.

Competence Goal
The students know the basic concepts of non-Abelian gauge theories and their application in particle physics. They understand the underlying theoretical concepts and their interrelationships. The students know the standard model of particle physics and can handle the relevant calculation methods.

Content
In the main part of the lecture, non-Abelian gauge theories and their application in elementary particle physics are discussed. The subject area includes the Lagrangian densities of QCD and the
electroweak Standard Model as well as the Higgs mechanism. The Feynman rules that follow from the Lagrangian densities are introduced and applied in perturbation-theoretic calculations of rates for
processes involving quarks and gluons. Regularization and renormalization of ultraviolet divergences are also treated, as well as applications of the renormalization group, the QCD beta function, and asymptotic freedom. Infrared divergences, parton distribution functions, and
splitting functions are introduced.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation (180 hours)

Recommendation
Theoretical Particle Physics I

M 4.220 Module: Theoretical Quantum Optics [M-PHYS-105094]

Responsible: Prof. Dr. Anja Metelmann
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-110303	Theoretical Quantum Optics	6 CR	Metelmann, Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105395 - Theoretical Quantum Optics (Minor) must not have been started.

Competence Goal
The students of quantum optics comprehend the physics of quantum optical phenomena, the necessary theoretical means for their description, and the application of quantum optical resources in different applications and technologies. They learn how to express quantum optical phenomena in a mathematical language and can apply routinely different techniques to study quantum optical phenomena in specific situations. They are trained to solve basic problems in quantum optics.

The students

- learn about the quantisation of electromagnetic fields,
- understands the details of different quantum states of light,
- get an overview over experiments that were important in the development of quantum optics,
- develop an understanding for the quantum optical description of the first and second order coherence functions, and
- understand and can routinely apply different means to describe the interaction of quantum states of light with quantum emitters.

Content

- Quantization of the electromagnetic field
- Various quantum states of light fields: optical photon-number, coherent, squeezed, Schrödinger's cat states
- Classical and quantum coherence theory: photon bunching and antibunching
- Quantum description of optical interferometry: Mach-Zehnder interferometer with photons
- General description of open quantum system: master equation, Heisenberg-Langevin, and stochastic approaches
- Optical test of quantum mechanics: Hong-Ou-Mandel, quantum eraser, and Bell's theorem experiments
- Interaction of a single atom with a classical field and quantum field
- From Rabi model to Jaynes-Cummings model: the most simplest model to describe the light-matter interaction
- Quantum master equation approach: description of finite life time of atoms
- Weak and strong couplings (spontaneous emission, Purcell effect, resonance fluorescence, lasers, and Rabi oscillation)
- Interaction of an ensemble of atoms with a quantum field (Dicke and Tavis-Cummings models, and superradiance)
- Quantum optical applications (quantum cryptography, quantum teleportation, quantum metrology, etc.)

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (135 hours).

Recommendation
Interest in theoretical physics, good knowledge in quantum mechanics and electrodynamics/optics

Literature

- C. Gerry and P. Knight, *Introductory Quantum Optics*.
- M. O. Scully and M. S. Zubairy, *Quantum Optics*.
- M. Fox, *Quantum Optics: An Introduction*.
- R. Loudon, *The Quantum Theory of Light*.
- D.F. Walls and G. J. Milburn, *Quantum Optics*.
- P. Meystre and M. Sargent, *Elements of Quantum Optics*.
- W. Schleich, *Quantum Optics in Phase Space*.

M 4.221 Module: Theoretical Quantum Optics (Minor) [M-PHYS-105395]

Responsible: Prof. Dr. Anja Metelmann
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics
Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-110884	Theoretical Quantum Optics (Minor)	6 CR	Metelmann, Rockstuhl

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105094 - Theoretical Quantum Optics must not have been started.

Competence Goal
The students of quantum optics comprehend the physics of quantum optical phenomena, the necessary theoretical means for their description, and the application of quantum optical resources in different applications and technologies. They learn how to express quantum optical phenomena in a mathematical language and can apply routinely different techniques to study quantum optical phenomena in specific situations. They are trained to solve basic problems in quantum optics.

The students

- learn about the quantisation of electromagnetic fields,
- understands the details of different quantum states of light,
- get an overview over experiments that were important in the development of quantum optics,
- develop an understanding for the quantum optical description of the first and second order coherence functions, and
- understand and can routinely apply different means to describe the interaction of quantum states of light with quantum emitters.

Content

- Quantization of the electromagnetic field
- Various quantum states of light fields: optical photon-number, coherent, squeezed, Schrödinger's cat states
- Classical and quantum coherence theory: photon bunching and antibunching
- Quantum description of optical interferometry: Mach-Zehnder interferometer with photons
- General description of open quantum system: master equation, Heisenberg-Langevin, and stochastic approaches
- Optical test of quantum mechanics: Hong-Ou-Mandel, quantum eraser, and Bell's theorem experiments
- Interaction of a single atom with a classical field and quantum field
- From Rabi model to Jaynes-Cummings model: the most simplest model to describe the light-matter interaction
- Quantum master equation approach: description of finite life time of atoms
- Weak and strong couplings (spontaneous emission, Purcell effect, resonance fluorescence, lasers, and Rabi oscillation)
- Interaction of an ensemble of atoms with a quantum field (Dicke and Tavis-Cummings models, and superradiance)
- Quantum optical applications (quantum cryptography, quantum teleportation, quantum metrology, etc.)

Workload
180 hours consisting of attendance time (45 hours), wrap-up of lecture and completion of exercises (135 hours).

Recommendation
Interest in theoretical physics, good knowledge in quantum mechanics and electrodynamics/optics

Literature

- C. Gerry and P. Knight, *Introductory Quantum Optics*.
- M. O. Scully and M. S. Zubairy, *Quantum Optics*.
- M. Fox, *Quantum Optics: An Introduction*.
- R. Loudon, *The Quantum Theory of Light*.
- D.F. Walls and G. J. Milburn, *Quantum Optics*.
- P. Meystre and M. Sargent, *Elements of Quantum Optics*.
- W. Schleich, *Quantum Optics in Phase Space*.

M 4.222 Module: Theory and Applications of Quantum Machines [M-PHYS-105942]

Responsible: Prof. Dr. Anja Metelmann
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112018	Theory and Applications of Quantum Machines	8 CR	Metelmann

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
The students know the possible applications of quantum technologies and understand the operation of key core architectures such as superconducting circuits. Students understand the detrimental effect of dissipation on the operation and performance of quantum technologies, and they learn possible protocols to avoid dissipation. Students learn about various readout elements and protocols and understand the fundamental quantum mechanical limitations of measurements. Students understand the relevant basic concepts in the field of superconducting circuits, such as cavity, qubit, dispersive readout, fidelity, etc., as well as the basic concepts of optomechanical architectures, such as sidebands, dynamic feedback, fundamental limits on measurement accuracy, etc. Students are able to analyze, structure, and formally describe simple problems in the area of open quantum systems. Simple problems here include a two-level system or a mechanical mode coupled to the light field of a cavity. Students are able to apply the methodology of the Heisenberg-Langevin equations as well as that of the master equation. Students are able to perform the calculation of noise spectra of these example systems. Students will learn the modern methodologies of modeling open quantum systems, e.g. the formalism of quantum trajectories, feedback protocols and quasi-distributions.

Content
This module aims to provide students with the theoretical and practical aspects of modern quantum technologies. Different technological architectures will be covered, e.g. superconducting circuits as a basis for future efficient computers, optomechanical systems as a basis for increasing the sensitivity of force sensors, or spin-based quantum communication systems. The module will cover the basic concepts of theoretical modeling of open quantum systems, with a focus on quantum mechanical measurement and readout. The influence of dissipation as well as the fundamental limits of measurement accuracy will be addressed. The module will provide an overview of future applications of quantum technologies, and at the same time highlight the challenges that these technologies face.

Workload
240 hours consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 h)

Literature

1. Quantum Measurement and Control, Howard M. Wiseman und Gerard J. Milburn, Cambridge University Press,
2. Statistical Methods in Quantum Optics 1&2, Howard J. Carmichael, Springer,
3. Quantum Machines: Measurement and Control of Engineered Quantum Systems: Lecture Notes of the Les Houches Summer School: Volume 96, July 2011, Oxford University Press

M 4.223 Module: Theory and Applications of Quantum Machines (Minor) [M-PHYS-105943]

Responsible: Prof. Dr. Anja Metelmann
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112019	Theory and Applications of Quantum Machines (Minor)	8 CR	Metelmann

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Competence Goal
The Students know the possible applications of quantum technologies and understand the operation of key core architectures such as superconducting circuits. Students understand the detrimental effect of dissipation on the operation and performance of quantum technologies, and they learn possible protocols to avoid dissipation. Students learn about various readout elements and protocols and understand the fundamental quantum mechanical limitations of measurements. Students understand the relevant basic concepts in the field of superconducting circuits, such as cavity, qubit, dispersive readout, fidelity, etc., as well as the basic concepts of optomechanical architectures, such as sidebands, dynamic feedback, fundamental limits on measurement accuracy, etc. Students are able to analyze, structure, and formally describe simple problems in the area of open quantum systems. Simple problems here include a two-level system or a mechanical mode coupled to the light field of a cavity. Students are able to apply the methodology of the Heisenberg-Langevin equations as well as that of the master equation. Students are able to perform the calculation of noise spectra of these example systems. Students will learn the modern methodologies of modeling open quantum systems, e.g. the formalism of quantum trajectories, feedback protocols and quasi-distributions.

Content
This module aims to provide students with the theoretical and practical aspects of modern quantum technologies. Different technological architectures will be covered, e.g. superconducting circuits as a basis for future efficient computers, optomechanical systems as a basis for increasing the sensitivity of force sensors, or spin-based quantum communication systems. The module will cover the basic concepts of theoretical modeling of open quantum systems, with a focus on quantum mechanical measurement and readout. The influence of dissipation as well as the fundamental limits of measurement accuracy will be addressed. The module will provide an overview of future applications of quantum technologies, and at the same time highlight the challenges that these technologies face.

Workload
240 hours consisting of attendance time (60 h), wrap-up of the lecture and preparation of the exercises (180 h).

Literature

1. Quantum Measurement and Control, Howard M. Wiseman und Gerard J. Milburn, Cambridge University Press,
2. Statistical Methods in Quantum Optics 1&2, Howard J. Carmichael, Springer,
3. Quantum Machines: Measurement and Control of Engineered Quantum Systems: Lecture Notes of the Les Houches Summer School: Volume 96, July 2011, Oxford University Press

4.224 Module: Theory of Magnetism, with Exercises [M-PHYS-105381]

Responsible: Prof. Dr. Markus Garst
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-110869	Theory of Magnetism, with Exercises	8 CR	Garst

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
Students understand phenomena and concepts in classical and quantum magnetism. They master basic theoretical tools for their description, both analytically and numerically, and are able to analyze and solve problems theoretically in the field of magnetism.

Content
An introduction to the concepts of magnetism, isolated magnetic moments, crystal field effects, Hund's rules, interacting magnetic moments, the Heisenberg model, ground states and excitations, spin wave theory, classical micromagnetism, the Landau-Lifshitz-Gilbert equation, topological solitons: domain walls, vortices, skyrmions, spintronics.

Workload
240 h consisting of attendance time (60 h), wrap-up of the lecture incl. exam preparation and working on the exercises (180 h)

Recommendation
Solid mathematical background, basic knowledge of theoretical solid state physics, good knowledge of quantum mechanics and statistical physics.

Literature

- J. Stöhr & H. C. Siegmann, Magnetism.
- S. Blundell, Magnetism in Condensed Matter.
- A. Hubert & R. Schäfer, Magnetic Domains.
- K. Yosida, Theory of Magnetism.

4.225 Module: Theory of Magnetism, with Exercises (Minor) [M-PHYS-105385]

Responsible: Prof. Dr. Markus Garst
Organisation: KIT Department of Physics
Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-110873	Theory of Magnetism, with Exercises (Minor)	8 CR	Garst

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Competence Goal
Students understand phenomena and concepts in classical and quantum magnetism. They master basic theoretical tools for their description, both analytically and numerically, and are able to analyze and solve problems theoretically in the field of magnetism.

Content
An introduction to the concepts of magnetism, isolated magnetic moments, crystal field effects, Hund's rules, interacting magnetic moments, the Heisenberg model, ground states and excitations, spin wave theory, classical micromagnetism, the Landau-Lifshitz-Gilbert equation, topological solitons: domain walls, vortices, skyrmions, spintronics.

Workload
240 h consisting of attendance time (60 h), follow-up of the lecture and working on the exercises (180 h)

Recommendation
Solid mathematical background, basic knowledge of theoretical solid state physics, good knowledge of quantum mechanics and statistical physics.

Literature

- J. Stöhr & H. C. Siegmann, Magnetism.
- S. Blundell, Magnetism in Condensed Matter.
- A. Hubert & R. Schäfer, Magnetic Domains.
- K. Yosida, Theory of Magnetism.

M 4.226 Module: Theory of Seismic Waves [M-PHYS-102367]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Second Major in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-104736	Theory of Seismic Waves	6 CR	Bohlen

Competence Certificate
To pass the module, an oral exam must be passed (approx. 20 min). As prerequisites the examinations of other type must be passed, based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., stress and strain tensors, Zoeppritz equations, or rays) and is based on solving a given theoretical problem by means of calculus. In some cases equations and solutions need to be visualized using Matlab (or equivalent tools).

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102657 - Theory of Seismic Waves (Minor) must not have been started.

Competence Goal
The students know the fundamental laws and equations of linear elasticity and wave propagation. They understand wave propagation phenomena such as source effects, reflection and transmission or the effects of anisotropy, absorption, dispersion and scattering and can describe them in mathematical terms. They are able to apply the concepts and equations to theoretical problems and relate the theory to phenomena observed in field data.

Content

- Theory of elasticity, stress and strain, elastic tensor, fundamental laws and equations
- Anisotropic elastic wave equation and various simplifications
- Mathematical description of sources, near-field and far-field terms
- Boundary conditions
- Reflection and transmission of plane waves at plane interfaces, Zoeppritz equations
- Surface waves, dispersion relation, phase and group velocity
- Introduction to ray theory, eikonal and transport equations and their solutions
- Absorption and dispersion
- Wave propagation in anisotropic media
- Scattering

Workload
180 hours composed of attendance time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Literature

- Aki and Richards, "Quantitative Seismology", 2003, University Science Books.
- Ben-Menahem and Singh, "Seismic waves and sources", 1981, Springer.
- Dahlen and Tromp, "Theoretical Global Seismology", 1998, Princeton University Press.
- Frank Hadsell, "Tensors of Geophysics for Mavericks and Mongrels", 1995, Society of Exploration Geophysicists.

4.227 Module: Theory of Seismic Waves (Minor) [M-PHYS-102657]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Minor in Physics: Geophysics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each summer term	1 term	English	4	2

Mandatory			
T-PHYS-105571	Theory of Seismic Waves (Minor)	6 CR	Bohlen

Competence Certificate
To pass the module, the examinations of other type must be passed, based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., stress and strain tensors, Zoeppritz equations, or rays) and is based on solving a given theoretical problem by means of calculus. In some cases equations and solutions need to be visualized using Matlab (or equivalent tools).

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102367 - Theory of Seismic Waves must not have been started.

Competence Goal
The students know the fundamental laws and equations of linear elasticity and wave propagation. They understand wave propagation phenomena such as source effects, reflection and transmission or the effects of anisotropy, absorption, dispersion and scattering and can describe them in mathematical terms. They are able to apply the concepts and equations to theoretical problems and relate the theory to phenomena observed in field data.

Content

- Theory of elasticity, stress and strain, elastic tensor, fundamental laws and equations
- Anisotropic elastic wave equation and various simplifications
- Mathematical description of sources, near-field and far-field terms
- Boundary conditions
- Reflection and transmission of plane waves at plane interfaces, Zoeppritz equations
- Surface waves, dispersion relation, phase and group velocity
- Introduction to ray theory, eikonal and transport equations and their solutions
- Absorption and dispersion
- Wave propagation in anisotropic media
- Scattering

Workload
180 hours composed of attendance time (45 h), wrap-up of the lectures and solving the exercises (135 h)

Recommendation
Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Literature

- Aki and Richards, "Quantitative Seismology", 2003, University Science Books.
- Ben-Menahem and Singh, "Seismic waves and sources", 1981, Springer.
- Dahlen and Tromp, "Theoretical Global Seismology", 1998, Princeton University Press.
- Frank Hadsell, "Tensors of Geophysics for Mavericks and Mongrels", 1995, Society of Exploration Geophysicists.

M 4.228 Module: Theory of Strongly Correlated Electron Systems [M-PHYS-106056]

Responsible: PD Dr. Robert Eder
Organisation: KIT Department of Physics
Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-112245	Theory of Strongly Correlated Electron Systems	12 CR	Eder

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
The students acquire knowledge about strongly correlated electron systems and understand their basic principles, both on the level of atomic physics for realistic models and on the level of simplified models which are deduced from realistic models and used to discuss various effects in actual solids. The students can apply simple theoretical tools such as variational wave functions, canonical transformations, perturbation theory and Green's functions (the latter only on a very basic level). The students also learn and understand applications of the theory to some important experimental techniques in the field such as photoelectron spectroscopy, X-ray absorption spectroscopy and other types of spectroscopy.

Content
The modul is concerned with the theory of strongly correlated electron systems i.e. solids which contain 3d or 4f transition metal ions. The small radius of the 3d or 4f shells in these elements enhances the Coulomb repulsion between electrons considerably so that one faces a situation where the interaction between particles is the dominant term in the Hamiltonian. The standard theory for electrons in solids therefore looses its validity and a variety of unexpected phenomena are observed. There is no such thing as a universal theory for strongly correlated electron systems, rather there is a variety of theories for approximations to treat different phenomena. The following topics will be adressed: The method of linear combination of atomic orbitals, Coulomb repulsion in atomic shells aka multiplet theory, crystalline electric field effects, Hubbard model and `classic' approximations, Mott insulators, magnetic exchange and magnetic anisotropy, quantum spin systems, Anderson model and `classic' approximations, Kondo effekt.

Workload
360 hours consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and preparation of the exercises (270 h)

Recommendation
Good knowledge of quantum mechanics and statistical physics and basic knowledge of solid state physics is necessary.

Literature
Will be discussed in the lecture.

4.229 Module: Topology in Condensed Matter Physics: Fundamentals and Advanced Topics [M-PHYS-106586]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113258	Topology in Condensed Matter Physics: Fundamentals and Advanced Topics	8 CR	Gornyi, Mirlin

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106587 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor) must not have been started.
2. The module M-PHYS-106588 - Topology in Condensed Matter Physics: Fundamentals and Selected Topics must not have been started.

Competence Goal
Gaining understanding of basic concepts of topology in physics and of their applications to modern topics in condensed-matter physics. Mastering theoretical tools for description of topological phenomena in condensed matter physics and acquiring an ability to apply these tools to a solution of a broad class of topology-related problems.

Content
From elementary quantum mechanics lectures, we know that different states can be distinguished by their quantum numbers, such as momentum, angular momentum, etc. The appearance of these quantum numbers is closely related to symmetry-related invariance under transformations, e.g., translations or rotations. The introduction of concepts of topology into physics makes it possible to identify further, so-called "topological" quantum numbers. Topological aspects have long been known in physics, e.g., from the Dirac hypothesis of the existence of magnetic monopoles (which would explain the quantization of the electric charge), as well as from nuclear physics of the 50s ("Skyrmions"). The enormous variety of topological effects and their fundamental importance in condensed-matter physics has only become apparent in recent times. Today, an outstanding precision of the integer quantum Hall effect (QHE) is understood as a consequence of its topological nature. Furthermore, extraordinary properties of graphene and of other novel materials---topological insulators and superconductors, Weyl semimetals, etc.---are also due to their topological nature. Fractional charges and exotic statistics of low-lying excitations in fractional QHE are topologically imposed and stabilized, as is also the case for quantum spin liquids. Realizations of Majorana excitations in topological systems are of great interest, especially in connection with their potential application for topological quantum computing. Modern solid-state physics would be deprived of many of its most fascinating and intrinsic aspects without topological concepts.

The following topics will be covered in the lecture course:

1. Fundamental topological concepts: winding numbers and homotopy groups, Berry connection, curvature, and phase; Chern numbers; topological (Thouless) pumping.
2. Models of 1D topological matter: Su–Schrieffer–Heeger model; Kitaev chain with Majorana edge states (1D topological superconductor); Haldane quantum spin chains.
3. Quantum Hall Effects (QHEs). Integer QHE; Fractional QHE: fractional charge and exotic (Abelian and non-Abelian) quantum statistics; physics of edge states.
4. Gapless topological matter. Graphene, Weyl/Dirac semimetals
5. Topological insulators and superconductors, Quantum Spin Hall Effect.
6. Classification of topological quantum matter; “periodic table” of topological insulators and superconductors; bulk-boundary correspondence
7. Topology and Anderson localization. Field theories of disordered topological matter.
8. Topology in strongly interacting systems. Topologically ordered phases of matter with fractionalized or non-abelian excitations.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- D. Thouless, Topological Quantum Numbers in Non-Relativistic Physics
- A. Altland and B. Simons, Condensed Matter Field Theory
- R. Moessner and J. E. Moore, Topological Phases of Matter
- B. A. Bernevig (with T.L. Hughes), Topological Insulators and Topological Superconductors
- M. A. N. Araujo and P. Sacramento, Topology in Condensed Matter: An Introduction
- Xiao-Gang Wen, Quantum Field Theory of Many-Body Systems
- S. M. Girvin and Kun Yang, Modern Condensed Matter Physics
- Somendra M. Bhattacharjee et al., Topology and Condensed Matter Physics
- Online course on topology in condensed matter: https://topocondmat.org/
  Topological Quantum Matter -- Weizmann online course: https://www.youtube.com/@topologicalquantummatter-w4105

M 4.230 Module: Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor) [M-PHYS-106587]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113259	Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor)	8 CR	Gornyi, Mirlin

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106586 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-106588 - Topology in Condensed Matter Physics: Fundamentals and Selected Topics must not have been started.

Competence Goal
Gaining understanding of basic concepts of topology in physics and of their applications to modern topics in condensed-matter physics. Mastering theoretical tools for description of topological phenomena in condensed matter physics and acquiring an ability to apply these tools to a solution of a broad class of topology-related problems.

Content
From elementary quantum mechanics lectures, we know that different states can be distinguished by their quantum numbers, such as momentum, angular momentum, etc. The appearance of these quantum numbers is closely related to symmetry-related invariance under transformations, e.g., translations or rotations. The introduction of concepts of topology into physics makes it possible to identify further, so-called "topological" quantum numbers. Topological aspects have long been known in physics, e.g., from the Dirac hypothesis of the existence of magnetic monopoles (which would explain the quantization of the electric charge), as well as from nuclear physics of the 50s ("Skyrmions"). The enormous variety of topological effects and their fundamental importance in condensed-matter physics has only become apparent in recent times. Today, an outstanding precision of the integer quantum Hall effect (QHE) is understood as a consequence of its topological nature. Furthermore, extraordinary properties of graphene and of other novel materials---topological insulators and superconductors, Weyl semimetals, etc.---are also due to their topological nature. Fractional charges and exotic statistics of low-lying excitations in fractional QHE are topologically imposed and stabilized, as is also the case for quantum spin liquids. Realizations of Majorana excitations in topological systems are of great interest, especially in connection with their potential application for topological quantum computing. Modern solid-state physics would be deprived of many of its most fascinating and intrinsic aspects without topological concepts.

The following topics will be covered in the lecture course:

1. Fundamental topological concepts: winding numbers and homotopy groups, Berry connection, curvature, and phase; Chern numbers; topological (Thouless) pumping.
2. Models of 1D topological matter: Su–Schrieffer–Heeger model; Kitaev chain with Majorana edge states (1D topological superconductor); Haldane quantum spin chains.
3. Quantum Hall Effects (QHEs). Integer QHE; Fractional QHE: fractional charge and exotic (Abelian and non-Abelian) quantum statistics; physics of edge states.
4. Gapless topological matter. Graphene, Weyl/Dirac semimetals
5. Topological insulators and superconductors, Quantum Spin Hall Effect.
6. Classification of topological quantum matter; “periodic table” of topological insulators and superconductors; bulk-boundary correspondence
7. Topology and Anderson localization. Field theories of disordered topological matter.
8. Topology in strongly interacting systems. Topologically ordered phases of matter with fractionalized or non-abelian excitations.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture and preparation of the exercises (180 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- D. Thouless, Topological Quantum Numbers in Non-Relativistic Physics
- A. Altland and B. Simons, Condensed Matter Field Theory
- R. Moessner and J. E. Moore, Topological Phases of Matter
- B. A. Bernevig (with T.L. Hughes), Topological Insulators and Topological Superconductors
- M. A. N. Araujo and P. Sacramento, Topology in Condensed Matter: An Introduction
- Xiao-Gang Wen, Quantum Field Theory of Many-Body Systems
- S. M. Girvin and Kun Yang, Modern Condensed Matter Physics
- Somendra M. Bhattacharjee et al., Topology and Condensed Matter Physics
- Online course on topology in condensed matter: https://topocondmat.org/
  Topological Quantum Matter -- Weizmann online course: https://www.youtube.com/@topologicalquantummatter-w4105

M 4.231 Module: Topology in Condensed Matter Physics: Fundamentals and Selected Topics [M-PHYS-106588]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter Theory (Elective Condensed Matter Theory)
Second Major in Physics: Condensed Matter Theory

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-113260	Topology in Condensed Matter Physics: Fundamentals and Selected Topics	2 CR	Gornyi, Mirlin

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-106586 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics must not have been started.
2. The module M-PHYS-106587 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor) must not have been started.

Competence Goal
Gaining understanding of basic concepts of topology in physics and of their applications to selected topics in modern condensed-matter physics.

Content
From elementary quantum mechanics lectures, we know that different states can be distinguished by their quantum numbers, such as momentum, angular momentum, etc. The appearance of these quantum numbers is closely related to symmetry-related invariance under transformations, e.g., translations or rotations. The introduction of concepts of topology into physics makes it possible to identify further, so-called "topological" quantum numbers. Topological aspects have long been known in physics, e.g., from the Dirac hypothesis of the existence of magnetic monopoles (which would explain the quantization of the electric charge), as well as from nuclear physics of the 50s ("Skyrmions"). The enormous variety of topological effects and their fundamental importance in condensed-matter physics has only become apparent in recent times. Today, an outstanding precision of the integer quantum Hall effect (QHE) is understood as a consequence of its topological nature. Furthermore, extraordinary properties of graphene and of other novel materials---topological insulators and superconductors, Weyl semimetals, etc.---are also due to their topological nature. Fractional charges and exotic statistics of low-lying excitations in fractional QHE are topologically imposed and stabilized, as is also the case for quantum spin liquids. Realizations of Majorana excitations in topological systems are of great interest, especially in connection with their potential application for topological quantum computing. Modern solid-state physics would be deprived of many of its most fascinating and intrinsic aspects without topological concepts.

The following topics will be covered in the lecture course:

1. Fundamental topological concepts: winding numbers and homotopy groups, Berry connection, curvature, and phase; Chern numbers; topological (Thouless) pumping.
2. Models of 1D topological matter: Su–Schrieffer–Heeger model; Kitaev chain with Majorana edge states (1D topological superconductor); Haldane quantum spin chains.
3. Quantum Hall Effects (QHEs). Integer QHE; Fractional QHE: fractional charge and exotic (Abelian and non-Abelian) quantum statistics; physics of edge states.

Workload
60 hours consisting of attendance time (15 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (45 hours).

Recommendation
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- D. Thouless, Topological Quantum Numbers in Non-Relativistic Physics
- A. Altland and B. Simons, Condensed Matter Field Theory
- R. Moessner and J. E. Moore, Topological Phases of Matter
- B. A. Bernevig (with T.L. Hughes), Topological Insulators and Topological Superconductors
- M. A. N. Araujo and P. Sacramento, Topology in Condensed Matter: An Introduction
- Xiao-Gang Wen, Quantum Field Theory of Many-Body Systems
- S. M. Girvin and Kun Yang, Modern Condensed Matter Physics
- Somendra M. Bhattacharjee et al., Topology and Condensed Matter Physics
- Online course on topology in condensed matter: https://topocondmat.org/
  Topological Quantum Matter -- Weizmann online course: https://www.youtube.com/@topologicalquantummatter-w4105

M 4.232 Module: Wildcard Non-Physics Elective, Module with 1 Brick [M-PHYS-102091]

Organisation: KIT Department of Physics
Part of: Non-Physics Elective

Credits	Grading scale	Language	Level	Version
8	Grade to a tenth	German	4	1

Mandatory			
T-PHYS-104384	Wildcard Non-Physics Elective, Module with 1 Brick, 8 CP graded	8 CR	

Prerequisites
none

M 4.233 Module: Wildcard Non-Physics Elective, Module with 2 Bricks [M-PHYS-103129]

Organisation: KIT Department of Physics
Part of: Non-Physics Elective

Credits	Grading scale	Language	Level	Version
8	Grade to a tenth	German	4	1

Mandatory			
T-PHYS-106221	Wildcard Non-Physics Elective, Module with 2 Bricks, 4 CP graded	4 CR	
T-PHYS-106222	Wildcard Non-Physics Elective, Module with 2 Bricks, 4 CP graded	4 CR	

Prerequisites
none

M 4.234 Module: Wildcard Non-Physics Elective, Module with 3 Bricks [M-PHYS-103130]

Organisation: KIT Department of Physics
Part of: Non-Physics Elective

Credits	Grading scale	Language	Level	Version
8	Grade to a tenth	German	4	1

Mandatory			
T-PHYS-106223	Wildcard Non-Physics Elective, Module with 3 Bricks, 3 CP graded	3 CR	
T-PHYS-106224	Wildcard Non-Physics Elective, Module with 3 Bricks, 3 CP graded	3 CR	
T-PHYS-106225	Wildcard Non-Physics Elective, Module with 3 Bricks, 2 CP graded	2 CR	

Prerequisites
none

M 4.235 Module: Wildcard Non-Physics Elective, Module with 4 Bricks [M-PHYS-103131]

Organisation: KIT Department of Physics
Part of: Non-Physics Elective

Credits	Grading scale	Language	Level	Version
8	Grade to a tenth	German	4	1

Mandatory			
T-PHYS-106226	Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded	2 CR	
T-PHYS-106227	Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded	2 CR	
T-PHYS-106228	Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded	2 CR	
T-PHYS-106229	Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded	2 CR	

Prerequisites
none

M 4.236 Module: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab [M-PHYS-105555]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-111156	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab	8 CR	Baumbach, Stankov

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105556 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab must not have been started.
2. The module M-PHYS-105557 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor) must not have been started.

Competence Goal
Students are introduced to the basic concepts of X-ray physics and its applications to characterize the structure and dynamics of crystalline solids and nanostructures as an extension to topics in wave optics, quantum mechanical scattering theory, crystallography and solid state physics. They understand and are able to apply the physical principles of modern X-ray experimental methods in spatial, frequency and momentum spaces at laboratory sources and large-scale facilities (synchrotron radiation sources, free electron lasers). The lecture, exercises and practical courses at the KIT Light Source combine theory, experiments and high-tech instrumentation with state-of-the-art research applications in the nanoscience. The exercises and practical courses enable the students to prepare and perform X-ray experiments at laboratory X-ray sources and at synchrotron radiation beamlines.

Content
Introduction to modern X-ray physics. The lecture bridges the gap from basic physics to modern X-ray methods for students of physics, chemistry, materials science, crystallography & mineralogy, and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray physics, optics and analysis, esp. X-ray scattering, diffraction and spectroscopy.
- Modern instrumentation in the X-ray laboratory and at large-scale facilities (synchrotron radiation sources, free electron lasers).
- Application examples from crystallography and nanoscience.
- The exercises optionally include the possibility of supervised performance of three experiments on state-of-the-art X-ray equipment of the KIT Light Source.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation, preparation and follow-up of the exercises and the internship (180 hours).

Recommendation
Fundamentals of classical electrodynamics, optics, quantum mechanics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- H. Kuzmany; Solid-State Spectroscopy, Springer (2009)
- E. Jaeschke, S. Khan, J. R. Schneider and J. B. Hastings: Synchrotron Light Sources and Free-Electron Lasers, Springer (2019)

M 4.237 Module: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor) [M-PHYS-105557]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Minor in Physics: Condensed Matter
Minor in Physics: Nanophysics
Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-111158	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor)	8 CR	Baumbach, Stankov

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105555 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab must not have been started.
2. The module M-PHYS-105556 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab must not have been started.

Competence Goal
Students are introduced to the basic concepts of X-ray physics and its applications to characterize the structure and dynamics of crystalline solids and nanostructures as an extension to topics in wave optics, quantum mechanical scattering theory, crystallography and solid state physics. They understand and are able to apply the physical principles of modern X-ray experimental methods in spatial, frequency and momentum spaces at laboratory sources and large-scale facilities (synchrotron radiation sources, free electron lasers). The lecture, exercises and practical courses at the KIT Light Source combine theory, experiments and high-tech instrumentation with state-of-the-art research applications in the nanoscience. The exercises and practical courses enable the students to prepare and perform X-ray experiments at laboratory X-ray sources and at synchrotron radiation beamlines.

Content
Introduction to modern X-ray physics. The lecture bridges the gap from basic physics to modern X-ray methods for students of physics, chemistry, materials science, crystallography & mineralogy, and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray physics, optics and analysis, esp. X-ray scattering, diffraction and spectroscopy.
- Modern instrumentation in the X-ray laboratory and at large-scale facilities (synchrotron radiation sources, free electron lasers).
- Application examples from crystallography and nanoscience.
- The exercises optionally include the possibility of supervised performance of three experiments on state-of-the-art X-ray equipment of the KIT Light Source.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture, preparation and follow-up of the exercises and the internship (180 hours).

Recommendation
Fundamentals of classical electrodynamics, optics, quantum mechanics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- H. Kuzmany; Solid-State Spectroscopy, Springer (2009)
- E. Jaeschke, S. Khan, J. R. Schneider and J. B. Hastings: Synchrotron Light Sources and Free-Electron Lasers, Springer (2019)

M 4.238 Module: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab [M-PHYS-105556]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Major in Physics: Condensed Matter (Elective Condensed Matter)
Major in Physics: Nanophysics (Elective Nanophysics)
Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Condensed Matter (Elective Condensed Matter)
Second Major in Physics: Nanophysics (Elective Nanophysics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-PHYS-111157	X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab	4 CR	Baumbach, Stankov

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105555 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab must not have been started.
2. The module M-PHYS-105557 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor) must not have been started.

Competence Goal
Students are introduced to the basic concepts of X-ray physics and their application to characterize the structure and dynamics of crystalline solids and nanostructures as an extension to topics in wave optics, quantum mechanical scattering theory, crystallography and solid state physics. They understand the physical principles of modern X-ray measurement methods imaging in spatial, frequency and momentum spaces at laboratory sources and large-scale facilities (synchrotron radiation sources, free electron lasers) and can apply them.

Content
Introduction to modern X-ray physics. The lecture bridges the gap from basic physics to modern X-ray methods for students of physics, chemistry, materials science, crystallography & mineralogy, and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray physics, optics and analysis, esp. X-ray scattering, diffraction and spectroscopy.
- Modern instrumentation in the X-ray laboratory and at large facilities (synchrotron facilities, free electron lasers).
- Application examples from crystallography and nanosciences.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation (90 hours).

Recommendation
Fundamentals of classical electrodynamics, optics, quantum mechanics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- H. Kuzmany; Solid-State Spectroscopy, Springer (2009)
- E. Jaeschke, S. Khan, J. R. Schneider and J. B. Hastings: Synchrotron Light Sources and Free-Electron Lasers, Springer (2019)

M 4.239 Module: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab [M-PHYS-105558]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	German/English	4	2

Mandatory			
T-PHYS-111159	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab	8 CR	Baumbach, Stankov

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105559 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab must not have been started.
2. The module M-PHYS-105560 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor) must not have been started.

Competence Goal
Students acquire the experimental and theoretical basis for performing data acquisition and interpretation of 2D and 3D X-ray imaging in real and reciprocal space. This includes microscopic absorption and (non-) interferometric phase contrast imaging, diffraction-enhanced imaging, and scattering methods. The lecture makes connections to routine applications of these methods in life sciences and solid state research at the KIT Light Source. Students apply the knowledge gained in the lecture in experimental group work.

Content
The lecture bridges the gap from basic physics to modern X-ray methods for physicists, chemists and materials scientists and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray optics and X-ray analysis, especially computed tomography, X-ray microscopy, diffraction and scattering.
- Modern instrumentation in the X-ray laboratory and at large-scale facilities (synchrotron storage rings, free electron lasers).
- Application examples from crystallography, nanoscience and life science.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation, preparation and follow-up of the exercises and the internship (180 hours).

Recommendation
Fundamentals of classical electrodynamics, optics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- D. M. Paganin, Coherent X-ray Optics, Oxford Science Publications (2006)
- U. Pietsch, V. Holy, T. Baumbach, High-resolution X-ray scattering, Springer NY (2004)

4.240 Module: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor) [M-PHYS-105560]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Minor in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	pass/fail	Each summer term	1 term	German/English	4	2

Mandatory			
T-PHYS-111161	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor)	8 CR	Baumbach, Stankov

Competence Certificate
The course credit is achieved through successful participation in the exercises. The details will be announced in the first lecture or at the first tutorial.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105558 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab must not have been started.
2. The module M-PHYS-105559 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab must not have been started.

Competence Goal
Students acquire the experimental and theoretical basis for performing data acquisition and interpretation of 2D and 3D X-ray imaging in real and reciprocal space. This includes microscopic absorption and (non-) interferometric phase contrast imaging, diffraction-enhanced imaging, and scattering methods. The lecture makes connections to routine applications of these methods in life sciences and solid state research at the KIT Light Source. Students apply the knowledge gained in the lecture in experimental group work.

Content
The lecture bridges the gap from basic physics to modern X-ray methods for physicists, chemists and materials scientists and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray optics and X-ray analysis, especially computed tomography, X-ray microscopy, diffraction and scattering.
- Modern instrumentation in the X-ray laboratory and at large-scale facilities (synchrotron storage rings, free electron lasers).
- Application examples from crystallography, nanoscience and life science.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation, preparation and follow-up of the exercises and the internship (180 hours).

Recommendation
Fundamentals of classical electrodynamics, optics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- D. M. Paganin, Coherent X-ray Optics, Oxford Science Publications (2006)
- U. Pietsch, V. Holy, T. Baumbach, High-resolution X-ray scattering, Springer NY (2004)

M 4.241 Module: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab [M-PHYS-105559]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: Major in Physics: Optics and Photonics (Elective Optics and Photonics)
Second Major in Physics: Optics and Photonics

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German/English	4	2

Mandatory			
T-PHYS-111160	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab	4 CR	Baumbach, Stankov

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105558 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab must not have been started.
2. The module M-PHYS-105560 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor) must not have been started.

Competence Goal
Students acquire the experimental and theoretical basis for performing data acquisition and interpretation of 2D and 3D X-ray imaging in real and reciprocal space. This includes microscopic absorption and (non-) interferometric phase contrast imaging, diffraction-enhanced imaging, and scattering methods. The lecture makes connections to routine applications of these methods in life sciences and solid state research at the KIT Light Source.

Content
The lecture bridges the gap from basic physics to modern X-ray methods for physicists, chemists and materials scientists and gives an overview of important current application fields:

- Theoretical and experimental foundations of X-ray optics and X-ray analysis, especially computed tomography, X-ray microscopy, diffraction and scattering.
- Modern instrumentation in the X-ray laboratory and at large-scale physical facilities (synchrotron storage rings, free electron lasers).
- Application examples from crystallography, nanosciences and life sciences.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation (90 hours).

Recommendation
Fundamentals of classical electrodynamics, optics and basic knowledge of solid state physics.

Literature

- J. Als-Nielsen, D. McMorrow: Elements of Modern X-Ray Physics, John Wiley & Sons, Ltd (2011)
- M. Born und E. Wolf; Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, Cambridge University Press (2006, 7th edition)
- J. M. Cowley; Diffraction physics, Elsevier (1995)
- D. M. Paganin, Coherent X-ray Optics, Oxford Science Publications (2006)
- U. Pietsch, V. Holy, T. Baumbach, High-resolution X-ray scattering, Springer NY (2004)

5 Courses

T 5.1 Course: Accelerator Physics, with ext. Exercises [T-PHYS-109904]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: M-PHYS-104869 - Accelerator Physics, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Each winter term	1 terms	1

Events					
WT 22/23	4028011	Accelerator physics	4 SWS	Lecture / 🗣	Reißig, Müller, Bernhard, Härer
WT 22/23	4028012	Praktische Übungen an KARA zur Beschleunigerphysik	1 SWS	Practice / 🗣	Müller, Härer
WT 23/24	4028011	Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Noll
WT 23/24	4028012	Practical Exercises at KARA for Accelerator Physics	1 SWS	Practice / 🗣	Müller, Härer
WT 24/25	4028011	Particle Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Ray
WT 24/25	4028012	Practical Exercises at KARA for Accelerator Physics	1 SWS	Practice / 🗣	Müller, Härer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.2 Course: Accelerator Physics, with ext. exercises (Minor) [T-PHYS-109903]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller
Organisation: KIT Department of Physics
Part of: M-PHYS-104870 - Accelerator Physics, with ext. exercises (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	8	pass/fail	Each winter term	1 terms	1

Events					
WT 22/23	4028011	Accelerator physics	4 SWS	Lecture / 🗣	Reißig, Müller, Bernhard, Härer
WT 22/23	4028012	Praktische Übungen an KARA zur Beschleunigerphysik	1 SWS	Practice / 🗣	Müller, Härer
WT 23/24	4028011	Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Noll
WT 23/24	4028012	Practical Exercises at KARA for Accelerator Physics	1 SWS	Practice / 🗣	Müller, Härer
WT 24/25	4028011	Particle Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Ray
WT 24/25	4028012	Practical Exercises at KARA for Accelerator Physics	1 SWS	Practice / 🗣	Müller, Härer

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.3 Course: Accelerator Physics, without ext. Exercises [T-PHYS-109905]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller
Organisation: KIT Department of Physics
Part of: M-PHYS-104871 - Accelerator Physics, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Each winter term	1 terms	1

Events					
WT 22/23	4028011	Accelerator physics	4 SWS	Lecture / 🗣	Reißig, Müller, Bernhard, Härer
WT 23/24	4028011	Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Noll
WT 24/25	4028011	Particle Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Ray

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.4 Course: Accelerator Physics, without ext. exercises (Minor) [T-PHYS-109906]

Responsible: Dr. Axel Bernhard
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: M-PHYS-104872 - Accelerator Physics, without ext. exercises (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	6	pass/fail	Each winter term	1 terms	1

Events					
WT 22/23	4028011	Accelerator physics	4 SWS	Lecture / 🗣	Reißig, Müller, Bernhard, Härer
WT 23/24	4028011	Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Noll
WT 24/25	4028011	Particle Accelerator Physics	4 SWS	Lecture / 🗣	Müller, Bernhard, Härer, Krasch, Ray

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.5 Course: Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training [T-PHYS-112943]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Prof. Dr. Anke-Susanne Müller
Dr. Anton Plech
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-106399 - Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	1

Events					
WT 23/24	4028101	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	5 SWS	Block / 🗣	Schuh, Baumbach, Müller, Härer, Plech, Stankov
WT 24/25	4028101	Accelerators and Synchrotron Radiation for Materials Research with Tutorials and a Practical Training	5 SWS	Block / 🗣	Schuh, Baumbach, Müller, Härer, Plech, Stankov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.6 Course: Advanced Numerical Weather Prediction [T-PHYS-111429]

Responsible: Prof. Dr. Peter Knippertz
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	4	pass/fail	Each summer term	1 terms	3

Events					
ST 2023	4052051	Advanced Numerical Weather Prediction	2 SWS	Lecture / 🗣	Knippertz
ST 2023	4052052	Exercises to Advanced Numerical Weather Prediction	1 SWS	Practice / 🗣	Oertel, Knippertz, Pickl
ST 2024	4052051	Advanced Numerical Weather Prediction	2 SWS	Lecture / 🗣	Knippertz
ST 2024	4052052	Exercises to Advanced Numerical Weather Prediction	1 SWS	Practice / 🗣	Oertel, Knippertz, Nguyen
ST 2025	4052051	Advanced Numerical Weather Prediction	2 SWS	Lecture / 🗣	Knippertz
ST 2025	4052052	Exercises to Advanced Numerical Weather Prediction	1 SWS	Practice / 🗣	Oertel, Knippertz

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Students must achieve 50% of the points on the exercise sheets.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.7 Course: Advanced Physics Laboratory Course [T-PHYS-102479]

Responsible: Dr. Gernot Guigas
PD Dr. Andreas Naber
Dr. Christoph Sürgers
Dr. Joachim Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-101395 - Advanced Physics Laboratory Course

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
WT 22/23	4011333	Advanced lab course for Master students	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
WT 22/23	4011349	Vorbesprechung zum Praktikum Moderne Physik und zum Physikalischen Fortgeschrittenenpraktikum für Masterstudenten		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2023	4011353	Physikalisches Fortgeschrittenenpraktikum für Masterstudenten (Kurs 1)	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2023	4011369	Vorbesprechung zum Praktikum Moderne Physik und zum Physikalischen Fortgeschrittenenpraktikum für Masterstudenten		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
WT 23/24	4011333	Advanced lab course for Master students	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
WT 23/24	4011349	Preliminary meeting for the Advanced lab course for Master students		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2024	4011353	Advanced lab course for Master students	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2024	4011369	Preliminary meeting for the Advanced lab course for Master students		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
WT 24/25	4011333	Advanced lab course for Master students	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
WT 24/25	4011349	Preliminary meeting for the Advanced lab course for Master students		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2025	4011353	Advanced lab course for Master students	4 SWS	Practical course / 🗣	Naber, Guigas, Sürgers, Wolf
ST 2025	4011369	Preliminary meeting for the Advanced lab course for Master students		Practical course / 🗣	Naber, Guigas, Sürgers, Wolf

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.8 Course: Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine [T-PHYS-112801]

Responsible: Prof. Dr. Bernhard Holzapfel
Prof. Dr. Ulrich Husemann
Prof. Dr. Anke-Susanne Müller
Prof. Dr.-Ing. Maria Francesca Spadea

Organisation: KIT Department of Physics

Part of: M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics
M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013214	Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine	2 SWS	Advanced seminar (/ 🗣	Husemann, Holzapfel, Müller
ST 2024	4013214	Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine	2 SWS	Advanced seminar (/ 🗣	Schwarz, Husemann, Holzapfel, Müller, Fuchs, Spadea, Bernhard
ST 2025	4013214	Advanced Seminar: Accelerators and Detectors - Future Technologies for Research and Medicine	2 SWS	Advanced seminar (/ 🗣	Schwarz, Husemann, Holzapfel, Müller, Spadea, Bernhard

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.9 Course: Advanced Seminar: Advanced Quantum Mechanics: Fundamentals and Technology [T-PHYS-113446]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Anja Metelmann
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2024	4013414	Advanced Seminar: Advanced Quantum Mechanics: Fundamentals and Technology	2 SWS	Advanced seminar (/ 🗣	Garst, Metelmann, Shnirman

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.10 Course: Advanced Seminar: Astroparticle Physics [T-PHYS-110293]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013224	Hauptseminar: Astroteilchenphysik	2 SWS	Advanced seminar (/ 🗣	Drexlin, Engel, Roth, Valerius
WT 23/24	4013224	Advanced Seminar: Astroparticle Physics	2 SWS	Advanced seminar (/ 🗣	Drexlin, Engel, Valerius, Hiller
WT 24/25	4013224	Advanced Seminar: Astroparticle Physics	2 SWS	Advanced seminar (/ 🗣	Drexlin, Engel, Valerius, Hiller

Legend: 📱 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 5.11 Course: Advanced Seminar: Astroparticle Physics – Modern Experiments [T-PHYS-114241]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2025	4013234	Advanced Seminar: Astroparticle Physics – Modern Experiments	2 SWS	Advanced seminar (/ 🗣	Drexlin, Lokhov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.12 Course: Advanced Seminar: Astroparticle Physics and Cosmology [T-PHYS-112800]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013224	Hauptseminar: Astroteilchenphysik und Kosmologie	2 SWS	Advanced seminar (/ 🗣	Drexlin, Engel, Valerius, Hiller
ST 2024	4013224	Advanced Seminar: Astroparticle Physics and Cosmology	2 SWS	Advanced seminar (/ 🗣	Drexlin, Engel, Valerius, Schlösser, Hiller
ST 2025	4013224	Advanced Seminar: Astroparticle Physics and Cosmology	2 SWS	Advanced seminar (/ 🗣	Engel, Valerius, Hiller

Legend: 📱 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.13 Course: Advanced Seminar: Conformational Dynamics in Biomolecules [T-PHYS-104544]

Responsible: Prof. Dr. Ulrich Nienhaus
Prof. Dr. Wolfgang Wenzel

Organisation: KIT Department of Physics

Part of: M-PHYS-102204 - Advanced Seminar in the Area Nanophysics
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics
M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013014	Hauptseminar: Konformationsdynamik in Biomolekülen: Experiment und Theorie	2 SWS	Advanced seminar (/ 🗣	Kobitski, Nienhaus, Wenzel
ST 2024	4013014	Advanced Seminar: Conformational Dynamics in Biomolecules: Experiment and Theory	2 SWS	Advanced seminar (/ 🗣	Kobitski, Nienhaus, Wenzel
ST 2025	4013014	Advanced Seminar: Conformational Dynamics in Biomolecules: Experiment and Theory	2 SWS	Advanced seminar (/ 🗣	Kobitski, Nienhaus, Wenzel

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.14 Course: Advanced Seminar: Experimental and Theoretical Methods in Particle Physics [T-PHYS-106525]

Responsible: Prof. Dr. Torben Ferber
PD Dr. Stefan Gieseke
Prof. Dr. Gudrun Heinrich
Prof. Dr. Günter Quast

Organisation: KIT Department of Physics

Part of: M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics
M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013644	Hauptseminar: Experimentelle und Theoretische Methoden der Teilchenphysik	2 SWS	Advanced seminar (/ 🗣	Ferber, Heinrich, Rabbertz
ST 2024	4013644	Advanced Seminar: Experimental and Theoretical Methods in Particle Physics	2 SWS	Advanced seminar (/ 🗣	Gieseke, Quast, Rabbertz
ST 2025	4013644	Advanced Seminar: Experimental and Theoretical Methods in Particle Physics	2 SWS	Advanced seminar (/ 🗣	Gieseke, Quast, Rabbertz

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.15 Course: Advanced Seminar: Flavor Physics [T-PHYS-112804]

Responsible: Dr. Monika Blanke
Prof. Dr. Felix Kahlhöfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013534	Hauptseminar: Flavourphysik	2 SWS	Advanced seminar (/ 🗣	Blanke, Kahlhöfer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.16 Course: Advanced Seminar: Flavour Physics [T-PHYS-113448]

Responsible: Dr. Monika Blanke
Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2024	4013514	Advanced Seminar: Flavour Physics	2 SWS	Advanced seminar (/ 🗣	Blanke, Nierste
WT 24/25	4013514	Advanced Seminar: Flavour Physics	2 SWS	Advanced seminar (/ 🗣	Blanke, Nierste

Legend: 🖥 Online, ⚹ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.17 Course: Advanced Seminar: Gravitational Waves and Black Holes - Selected Topics [T-PHYS-114093]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-106829 - Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2025	4013624	Advanced Seminar: Gravitational Waves and Black Holes - Selected Topics	2 SWS	Advanced seminar (/ 🗣	Schwetz-Mangold, Mühlleitner

Legend: 📱 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.18 Course: Advanced Seminar: Light-optical Nanoscopy [T-PHYS-104560]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: M-PHYS-102204 - Advanced Seminar in the Area Nanophysics
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013014	Hauptseminar: Lichtoptische Nanoskopie	2 SWS	Advanced seminar (	Kobitski, Nienhaus
WT 24/25	4013014	Advanced Seminar: Light-optical Nanoscopy	2 SWS	Advanced seminar (	Kobitski, Nienhaus

Prerequisites
none

T 5.19 Course: Advanced Seminar: Modern Particle Accelerators and Research with Photons [T-PHYS-106129]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Prof. Dr. Anke-Susanne Müller

Organisation: KIT Department of Physics

Part of: M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics
M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics
M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013814	Hauptseminar: Moderne Teilchenbeschleuniger und Forschung mit Photonen	2 SWS	Advanced seminar (	Schwarz, Baumbach, Müller, Bernhard, Stankov, Plech
WT 23/24	4013814	Advanced Seminar: Modern Accelerators and Research with Photons	2 SWS	Advanced seminar (	Bernhard, Stankov, Plech, Müller, Baumbach
WT 24/25	4013814	Advanced Seminar: Modern Accelerators and Research with Photons	2 SWS	Advanced seminar (	Bernhard, Stankov, Plech, Müller, Baumbach

Prerequisites
none

T 5.20 Course: Advanced Seminar: Nano-Optics [T-PHYS-111862]

Responsible: PD Dr. Andreas Naber
Prof. Dr. Carsten Rockstuhl
Prof. Dr. Martin Wegener

Organisation: KIT Department of Physics

Part of: M-PHYS-102204 - Advanced Seminar in the Area Nanophysics
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2025	4013024	Advanced Seminar: Nano-Optics	2 SWS	Advanced seminar (/ 🗣	Meretska, Naber, Rockstuhl, Wegener

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.21 Course: Advanced Seminar: Nanophotonics [T-PHYS-113683]

Responsible: PD Dr. Andreas Naber
Prof. Dr. Carsten Rockstuhl
Prof. Dr. Martin Wegener

Organisation: KIT Department of Physics

Part of: M-PHYS-102204 - Advanced Seminar in the Area Nanophysics
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics
M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 24/25	4013124	Advanced Seminar: Nanophotonics	2 SWS	Advanced seminar (/ 🗣	Rockstuhl, Wegener, Meretska, Naber

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.22 Course: Advanced Seminar: Neutrons and X-rays in Solid State Physics [T-PHYS-109977]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Organisation: KIT Department of Physics
Part of: M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013814	Hauptseminar: Neutronen und Röntgenstrahlung in der Festkörperphysik	2 SWS	Advanced seminar (/ 🗣	Baumbach, Plech
ST 2024	4013814	Advanced Seminar: Neutrons and X-rays in Solid State Physics	2 SWS	Advanced seminar (/ 🗣	Baumbach, Stankov
ST 2025	4013814	Advanced Seminar: Neutrons and X-rays in Solid State Physics	2 SWS	Advanced seminar (/ 🗣	Baumbach, Stankov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.23 Course: Advanced Seminar: Particle Physics [T-PHYS-112235]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013214	Hauptseminar: Teilchenphysik	2 SWS	Advanced seminar (/ 🗣	Husemann, Ferber, Klute
WT 23/24	4013214	Advanced Seminar: Particle Physics	2 SWS	Advanced seminar (/ 🗣	Klute, Ferber, Rabbertz
WT 24/25	4013214	Advanced Seminar: Particle Physics	2 SWS	Advanced seminar (/ 🗣	Husemann, Ferber, Klute, Müller

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.24 Course: Advanced Seminar: Particle Physics beyond the Standard Model [T-PHYS-111863]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102206 - Advanced Seminar in the Area Experimental Particle Physics

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2023	4013244	Hauptseminar: Teilchenphysik jenseits des Standardmodells	2 SWS	Advanced seminar (/ 🗣	Klute
ST 2024	4013244	Advanced Seminar: Particle Physics beyond the Standard Model	2 SWS	Advanced seminar (/ 🗣	Ferber, Klute
ST 2025	4013244	Advanced Seminar: Particle Physics beyond the Standard Model	2 SWS	Advanced seminar (/ 🗣	Ferber, Klute

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.25 Course: Advanced Seminar: Phenomena of the Quantum World [T-PHYS-112802]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Jörg Schmalian
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013414	Advanced Seminar: Phenomena of the Quantum World	2 SWS	Advanced seminar (/ 🗣	Garst, Schmalian, Shnirman

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.26 Course: Advanced Seminar: Physics of Electrons in a Magnetic Field: Quantum Hall Effects [T-PHYS-114092]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Jörg Schmalian
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2025	4013414	Advanced Seminar: Physics of Electrons in a Magnetic Field: Quantum Hall Effects	2 SWS	Advanced seminar (/ 🗣	Garst, Schmalian, Shnirman

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.27 Course: Advanced Seminar: Quantum Mechanics: Selected Chapters [T-PHYS-113133]

Responsible: PD Dr. Robert Eder
Organisation: KIT Department of Physics
Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 23/24	4013424	Advanced Seminar: Quantum Mechanics: Selected chapters	2 SWS	Advanced seminar (/ 🗣	Eder

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.28 Course: Advanced Seminar: Quantum Science at the Atomic Scale: Advanced Scanning Probe Techniques [T-PHYS-113684]

Responsible: Prof. Dr. Wolfgang Wernsdorfer
TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter
M-PHYS-102204 - Advanced Seminar in the Area Nanophysics

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Irregular	1

Events					
WT 24/25	4013134	Advanced Seminar: Quantum Science at the Atomic Scale: Advanced Scanning Probe Techniques	2 SWS	Advanced seminar (/ 🗣	Willke, Wernsdorfer, Wulfhekel

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.29 Course: Advanced Seminar: Recent Experiments in Quantum Physics [T-PHYS-109971]

Responsible: Prof. Dr. David Hunger
Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
TT-Prof. Dr. Philip Willke
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter
M-PHYS-102204 - Advanced Seminar in the Area Nanophysics

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Irregular	1

Events					
ST 2023	4013114	Hauptseminar: Aktuelle Experimente in der Quantenphysik	2 SWS	Advanced seminar (/ 🗣	Hunger, Wernsdorfer, Willke, Le Tacon
ST 2024	4013114	Advanced Seminar: Recent Experiments in Quantum Physics	2 SWS	Advanced seminar (/ 🗣	Hunger, Wernsdorfer, Willke, Wulfhekel, Le Tacon
ST 2025	4013114	Advanced Seminar: Recent Experiments in Quantum Physics	2 SWS	Advanced seminar (/ 🗣	Wernsdorfer, Willke, Wulfhekel, Le Tacon

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 5.30 Course: Advanced Seminar: The Dark Universe [T-PHYS-113447]

Responsible: Prof. Dr. Felix Kahlhöfer
Organisation: KIT Department of Physics
Part of: M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics
M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-106829 - Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
ST 2024	4013624	Advanced Seminar: The Dark Universe	2 SWS	Advanced seminar (/ 🗣	Kahlhöfer, Benso

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.31 Course: Advanced Seminar: The Matter Puzzle - Baryon Asymmetry, Dark Matter and Particle Physics [T-PHYS-112803]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Milada Margarete Mühlleitner

Organisation: KIT Department of Physics

Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-106829 - Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4013624	Advanced Seminar: The Matter Puzzle - Baryon Asymmetry, Dark Matter and Particle Physics	2 SWS	Advanced seminar (/ 🖥	Mühlleitner, Kahlhöfer

Legend: 🖥 Online, Blended (On-Site/Online), On-Site, × Cancelled

Prerequisites
none

T 5.32 Course: Advanced Seminar: Theoretical Challenges in Precision Standard Model Physics [T-PHYS-113686]

Responsible: Prof. Dr. Kirill Melnikov
Organisation: KIT Department of Physics
Part of: M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 24/25	4013524	Advanced Seminar: Theoretical Challenges in Precision Standard Model Physics	2 SWS	Advanced seminar (/ 🗣	Melnikov, Novikov, Pikelner

Legend: 📱 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.33 Course: Advanced Seminar: Topology in Condensed Matter Systems [T-PHYS-110829]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013414	Hauptseminar: Topology in Condensed Matter Physics	2 SWS	Advanced seminar (	Gornyi, Mirlin, Narozhnyy

Prerequisites
none

5.34 Course: Advanced Seminar: Topology in Quantum Condensed Matter Systems [T-PHYS-113685]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 24/25	4013414	Advanced Seminar: Topology in Quantum Condensed Matter Physics	2 SWS	Advanced seminar (	Poboiko, Gornyi, Mirlin

Prerequisites
none

T 5.35 Course: Advanced Seminar: Units of Measurement and Metrology: No Guessing but Precise Measurement! [T-PHYS-111451]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: M-PHYS-102203 - Advanced Seminar in the Area Condensed Matter
M-PHYS-102205 - Advanced Seminar in the Area Optics and Photonics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013114	Hauptseminar: Basisgrößen und Basiseinheiten: Nicht Raten - Messen!	2 SWS	Advanced seminar (/ 🗣	Wulfhekel, Gozlinski

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.36 Course: Advanced Seminar: Unraveling the Puzzle of Dark Matter [T-PHYS-112236]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: M-PHYS-102207 - Advanced Seminar in the Area Experimental Astroparticle Physics
M-PHYS-102208 - Advanced Seminar in the Area Theoretical Particle Physics
M-PHYS-106829 - Advanced Seminar in the Area Theoretical Cosmology and Astroparticle Physics

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4013624	Hauptseminar: Unraveling the Puzzle of Dark Matter / Dem Rätsel der Dunklen Materie auf der Spur	2 SWS	Advanced seminar (	Mühlleitner, Schwetz-Mangold

Prerequisites
none

5.37 Course: Advanced Seminar: Virtual Design of Materials [T-PHYS-111865]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102204 - Advanced Seminar in the Area Nanophysics
M-PHYS-102209 - Advanced Seminar in the Area Condensed Matter Theory

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	4	pass/fail	Irregular	1 terms	1

Events					
WT 22/23	4013314	Hauptseminar: Virtuelles Materialdesign	2 SWS	Advanced seminar (	Wenzel
ST 2023	4013324	Hauptseminar: Virtual Materials Design	2 SWS	Advanced seminar (/ 🗣	Wenzel
WT 23/24	4013314	Advanced Seminar: Virtual Materials Design	2 SWS	Advanced seminar (	Wenzel
ST 2024	4013324	Advanced Seminar: Virtual Materials Design	2 SWS	Advanced seminar (/ 🗣	Wenzel
WT 24/25	4013314	Advanced Seminar: Virtual Materials Design	2 SWS	Advanced seminar (	Wenzel
ST 2025	4013324	Advanced Seminar: Virtual Materials Design	2 SWS	Advanced seminar (/ 🗣	Wenzel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.38 Course: Advanced Topics in Quantum Field Theory [T-PHYS-113728]

Responsible: Prof. Dr. Ulrich Nierste
Dr. Robert Ziegler

Organisation: KIT Department of Physics

Part of: M-PHYS-106842 - Advanced Topics in Quantum Field Theory

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
WT 24/25	4025051	Advanced Topics in Quantum Field Theory	2 SWS	Lecture / 🗣	Ziegler, Nierste

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.39 Course: Arctic Climate System [T-PHYS-111273]

Responsible: Prof. Dr. Björn-Martin Sinnhuber
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	2	pass/fail	Each winter term	1 terms	3

Events					
WT 22/23	4052101	Arctic Climate System	2 SWS	Lecture / Blended	Sinnhuber
WT 23/24	4052101	Arctic Climate System	2 SWS	Lecture / Blended	Sinnhuber
WT 24/25	4052101	Arctic Climate System	2 SWS	Lecture / Blended	Sinnhuber

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The assessment consists of a coursework according to §4 (3) SPO MSc Meteorology and Climate Physics in the form of a short lecture (approx. 10 minutes) on a topic relevant to the llecture . The detailled conditions will be discussed in the lecture.

Prerequisites
None

Annotation
Serreze, M., & Barry, R. (2014). The Arctic Climate System (2nd ed., Cambridge Atmospheric and Space Science Series). Cambridge: Cambridge University Press. doi:10.1017/CBO9781139583817

Workload
30 hours

T 5.40 Course: Array Techniques in Seismology, graded [T-PHYS-112590]

Responsible: apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-106196 - Array Techniques in Seismology (Graded)

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	1

Events					
WT 22/23	4060261	Array Techniques in Seismology	1 SWS	Lecture / 🗣	Ritter
WT 22/23	4060262	Exercises to Array Techniques in Seismology	1 SWS	Practice / 🗣	Ritter, NN
WT 23/24	4060261	Array Techniques in Seismology	1 SWS	Lecture / 🗣	Ritter
WT 23/24	4060262	Exercises to Array Techniques in Seismology	1 SWS	Practice / 🗣	Ritter, NN
WT 24/25	4060261	Array Techniques in Seismology	1 SWS	Lecture / 🗣	Ritter
WT 24/25	4060262	Exercises on Array Techniques in Seismology	1 SWS	Practice / 🗣	Ritter, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Grading is based on written reports on exercises. A detailed rating scheme is distributed during the first lecture together with information on the required length of the reports and rating criteria.

Recommendation
Participants need to know the basics of seismology.

Workload
120 hours

T 5.41 Course: Astroparticle Physics I [T-PHYS-102432]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: M-PHYS-102075 - Astroparticle Physics I

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 22/23	4022011	Astroteilchenphysik I: Dunkle Materie	3 SWS	Lecture / 🗣	Drexlin, Schlösser, Huber, Valerius
WT 22/23	4022012	Übungen zur Astroteilchenphysik I: Dunkle Materie	1 SWS	Practice / 🗣	Drexlin, Schlösser, Huber, Valerius
WT 23/24	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov
WT 23/24	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Drexlin, Valerius, Huber
WT 24/25	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Drexlin, Schlösser
WT 24/25	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Drexlin, Heyns, Kovac

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.42 Course: Astroparticle Physics I (Minor) [T-PHYS-104379]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102076 - Astroparticle Physics I (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 22/23	4022011	Astroteilchenphysik I: Dunkle Materie	3 SWS	Lecture / 🗣	Drexlin, Schlösser, Huber, Valerius
WT 22/23	4022012	Übungen zur Astroteilchenphysik I: Dunkle Materie	1 SWS	Practice / 🗣	Drexlin, Schlösser, Huber, Valerius
WT 23/24	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov
WT 23/24	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Drexlin, Valerius, Huber
WT 24/25	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Drexlin, Schlösser
WT 24/25	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Drexlin, Heyns, Kovac

Legend: 🖥 Online, ✣ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.43 Course: Astroparticle Physics II - Cosmic Rays, with ext. Exercises [T-PHYS-105108]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: M-PHYS-102525 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 22/23	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Unger
WT 22/23	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Fitoussi
WT 23/24	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 23/24	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Hahn, Engel
WT 24/25	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 24/25	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.44 Course: Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor) [T-PHYS-106317]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: M-PHYS-103184 - Astroparticle Physics II - Cosmic Rays, with ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 22/23	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Unger
WT 22/23	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Fitoussi
WT 23/24	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 23/24	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Hahn, Engel
WT 24/25	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 24/25	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.45 Course: Astroparticle Physics II - Cosmic Rays, without ext. Exercises [T-PHYS-102382]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth
Organisation: KIT Department of Physics
Part of: M-PHYS-102078 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 22/23	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Unger
WT 22/23	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Fitoussi
WT 23/24	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 23/24	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Hahn, Engel
WT 24/25	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 24/25	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.46 Course: Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor) [T-PHYS-104380]

Responsible: Prof. Dr. Ralph Engel
Dr. Markus Roth

Organisation: KIT Department of Physics

Part of: M-PHYS-102082 - Astroparticle Physics II - Cosmic Rays, without ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
WT 22/23	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Unger
WT 22/23	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Fitoussi
WT 23/24	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 23/24	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Hahn, Engel
WT 24/25	4022041	Astroparticle Physics II: Cosmic Rays	2 SWS	Lecture / 🗣	Engel, Schmidt
WT 24/25	4022042	Exercises to Astroparticle Physics II: Cosmic Rays	1 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.47 Course: Astroparticle Physics II - Gamma Rays and Neutrinos [T-PHYS-111343]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel

Organisation: KIT Department of Physics

Part of: M-PHYS-105683 - Astroparticle Physics II - Gamma Rays and Neutrinos

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2023	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2023	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2024	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2024	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2025	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Unger
ST 2025	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.48 Course: Astroparticle Physics II - Gamma Rays and Neutrinos (Minor) [T-PHYS-111344]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel

Organisation: KIT Department of Physics

Part of: M-PHYS-105684 - Astroparticle Physics II - Gamma Rays and Neutrinos (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
ST 2023	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2023	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2024	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2024	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2025	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Unger
ST 2025	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.49 Course: Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises [T-PHYS-111346]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel
Organisation: KIT Department of Physics
Part of: M-PHYS-105686 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2023	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2023	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2024	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2024	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2025	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Unger
ST 2025	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.50 Course: Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor) [T-PHYS-111345]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Ralph Engel

Organisation: KIT Department of Physics

Part of: M-PHYS-105685 - Astroparticle Physics II - Gamma Rays and Neutrinos, with ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2023	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2023	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2024	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Veberic
ST 2024	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Veberic
ST 2025	4022131	Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Lecture / 🗣	Engel, Unger
ST 2025	4022132	Exercises to Astroparticle Physics II - Gamma-Ray Astronomy and Neutrinos	2 SWS	Practice / 🗣	Engel, Varsi

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.51 Course: Astroparticle Physics II - Particles and Stars, with ext. Exercises [T-PHYS-105110]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: M-PHYS-102527 - Astroparticle Physics II - Particles and Stars, with ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2023	4022111	Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov, Huber
ST 2023	4022112	Übungen zu Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Practice / 🗣	Drexlin, Huber
ST 2024	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Schlösser
ST 2024	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Schlösser
ST 2025	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Biondi
ST 2025	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Kovac, Heyns

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.52 Course: Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor) [T-PHYS-106319]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-103186 - Astroparticle Physics II - Particles and Stars, with ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2023	4022111	Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov, Huber
ST 2023	4022112	Übungen zu Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Practice / 🗣	Drexlin, Huber
ST 2024	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Schlösser
ST 2024	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Schlösser
ST 2025	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Biondi
ST 2025	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Kovac, Heyns

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.53 Course: Astroparticle Physics II - Particles and Stars, without ext. Exercises [T-PHYS-102498]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102081 - Astroparticle Physics II - Particles and Stars, without ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2023	4022111	Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov, Huber
ST 2023	4022112	Übungen zu Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Practice / 🗣	Drexlin, Huber
ST 2024	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Schlösser
ST 2024	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Schlösser
ST 2025	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Biondi
ST 2025	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Kovac, Heyns

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.54 Course: Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor) [T-PHYS-104383]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102086 - Astroparticle Physics II - Particles and Stars, without ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
ST 2023	4022111	Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov, Huber
ST 2023	4022112	Übungen zu Astroteilchenphysik II - Teilchen und Sterne	2 SWS	Practice / 🗣	Drexlin, Huber
ST 2024	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Schlösser
ST 2024	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Schlösser
ST 2025	4022111	Astroparticle Physics II - Particles and Stars	2 SWS	Lecture / 🗣	Drexlin, Biondi
ST 2025	4022112	Exercises to Astroparticle Physics II - Particles and Stars	2 SWS	Practice / 🗣	Drexlin, Kovac, Heyns

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.55 Course: Atmospheric Aerosols [T-PHYS-111418]

Responsible: Dr. Ottmar Möhler
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	3

Events					
WT 22/23	4052041	Atmospheric Aerosols	2 SWS	Lecture / Blended	Möhler
WT 22/23	4052042	Exercises to Atmospheric Aerosols	1 SWS	Practice / On-Site	Möhler, Böhmländer
WT 23/24	4052041	Atmospheric Aerosols	2 SWS	Lecture / Blended	Möhler
WT 23/24	4052042	Exercises to Atmospheric Aerosols	1 SWS	Practice / On-Site	Möhler, Bogert
WT 24/25	4052041	Atmospheric Aerosols	2 SWS	Lecture / Blended	Möhler
WT 24/25	4052042	Exercises to Atmospheric Aerosols	1 SWS	Practice / On-Site	Möhler, Bogert

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
The students participating in the lecture on Atmospheric Aerosols with Exercises are expected to regularly participate in the Exercises. To pass the course, each student has to submit a solution for at least 50% of all exercises, and to present at least one solution to the tutor and the other participants.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.56 Course: Atmospheric Radiation [T-PHYS-111419]

Responsible: PD Dr. Michael Höpfner
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	3

Events					
WT 22/23	4052071	Atmospheric Radiation	2 SWS	Lecture / Blended	Höpfner, Johansson
WT 23/24	4052071	Atmospheric Radiation	2 SWS	Lecture / Blended	Höpfner, Johansson
WT 24/25	4052071	Atmospheric Radiation	2 SWS	Lecture / Blended	Höpfner

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Short presentation at the end of the semester

Prerequisites
None

Recommendation
None

Annotation
None

Workload
30 hours

T 5.57 Course: Basic Seminar Supplementary Studies on Science, Technology and Society - Self Registration [T-FORUM-113579]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	2	pass/fail	Each summer term	1 terms	1

Competence Certificate
Study achievement in the form of a presentation or a term paper or project work in the selected course.

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendation
It is recommended that the basic seminar be completed during the same semester as the lecture series "Science in Society". If it is not possible to attend the lecture series and the basic seminar in the same semester, the basic seminar can also be attended in the semesters before the lecture series.
However, attending courses in the advanced unit before attending the basic seminar should be avoided.

Annotation

T 5.58 Course: Basics of Nanotechnology I [T-PHYS-102529]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102097 - Basics of Nanotechnology I

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
WT 22/23	4021041	Grundlagen der Nanotechnologie I	2 SWS	Lecture / 🗣	Goll
WT 23/24	4021041	Nanotechnology I	2 SWS	Lecture / 🗣	Goll
WT 24/25	4021041	Basics of Nanotechnology I	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.59 Course: Basics of Nanotechnology I (Minor) [T-PHYS-102528]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102096 - Basics of Nanotechnology I (Minor)

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4021041	Grundlagen der Nanotechnologie I	2 SWS	Lecture / 🗣	Goll
WT 23/24	4021041	Nanotechnology I	2 SWS	Lecture / 🗣	Goll
WT 24/25	4021041	Basics of Nanotechnology I	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.60 Course: Basics of Nanotechnology II [T-PHYS-102531]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102100 - Basics of Nanotechnology II

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2023	4021151	Grundlagen der Nanotechnologie II	2 SWS	Lecture / 🗣	Goll
ST 2024	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll
ST 2025	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.61 Course: Basics of Nanotechnology II (Minor) [T-PHYS-102530]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102099 - Basics of Nanotechnology II (Minor)

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
ST 2023	4021151	Grundlagen der Nanotechnologie II	2 SWS	Lecture / 🗣	Goll
ST 2024	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll
ST 2025	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, ⚭ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.62 Course: Block Practical Course: ETP Data Science [T-PHYS-113159]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-106530 - Block Practical Course: ETP Data Science

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	1

Events					
WT 23/24	4032194	Block Practical Course: ETP Data Science	4 SWS	Practical course / 🗣	Klute, Ferber, Kieseler
WT 24/25	4032194	Block Practical Course: ETP Data Science	4 SWS	Practical course / 🗣	Klute, Ferber, Kieseler

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.63 Course: Climate Modeling & Dynamics with ICON [T-PHYS-111412]

Responsible: Prof. Dr. Joaquim José Ginete Werner Pinto
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	3

Events					
WT 22/23	4052151	Climate Modeling & Dynamics with ICON	2 SWS	Lecture / Blended	Ludwig, Ginete Werner Pinto
WT 22/23	4052152	Exercises to Climate Modeling & Dynamics with ICON	1 SWS	Practice / Blended	Ludwig, Ginete Werner Pinto, Pothapakula
WT 23/24	4052151	Climate Modeling & Dynamics with ICON	2 SWS	Lecture / Blended	Ludwig, Ginete Werner Pinto
WT 23/24	4052152	Exercises to Climate Modeling & Dynamics with ICON	1 SWS	Practice / Blended	Braun, Ginete Werner Pinto, Lemburg
WT 24/25	4052151	Climate Modeling & Dynamics with ICON	2 SWS	Lecture / Blended	Ginete Werner Pinto, Ludwig
WT 24/25	4052152	Exercises to Climate Modeling & Dynamics with ICON	1 SWS	Practice / Blended	Ginete Werner Pinto, Braun, Keshtgar

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Successful participation in the exrcises.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.64 Course: Cloud Physics [T-PHYS-111416]

Responsible: Prof. Dr. Corinna Hoose
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	3

Events					
WT 22/23	4052081	Cloud Physics	2 SWS	Lecture / Blended	Oertel, Hoose, Le Roy de Bonneville, Frey
WT 22/23	4052082	Exercises to Cloud Physics	1 SWS	Practice / Blended	Wallentin, Hoose
WT 23/24	4052081	Cloud Physics	2 SWS	Lecture / Blended	Oertel, Hoose
WT 23/24	4052082	Exercises to Cloud Physics	1 SWS	Practice / Blended	Hoose, Wallentin
WT 24/25	4052081	Cloud Physics	2 SWS	Lecture / Blended	Hoose, Oertel, Le Roy de Bonneville
WT 24/25	4052082	Exercises to Cloud Physics	1 SWS	Practice / Blended	Hoose, Meusel

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
At least 50% of the points of the exercises have to be reached. At least once, a solution to one of the exercises has to be presented in class.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.65 Course: Computational Condensed Matter Physics [T-PHYS-109895]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-104862 - Computational Condensed Matter Physics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	12	Grade to a third	Irregular	1 terms	1

Events					
ST 2023	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2023	4023162	Übungen zu Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel
ST 2024	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2024	4023162	Übungen zu Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel
ST 2025	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2025	4023162	Exercises to Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.66 Course: Computational Condensed Matter Physics (Minor) [T-PHYS-109894]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-104863 - Computational Condensed Matter Physics (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	12	pass/fail	Irregular	1 terms	1

Events					
ST 2023	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2023	4023162	Übungen zu Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel
ST 2024	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2024	4023162	Übungen zu Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel
ST 2025	4023161	Computational Condensed Matter Physics	4 SWS	Lecture / 🗣	Wenzel
ST 2025	4023162	Exercises to Computational Condensed Matter Physics	2 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.67 Course: Computational Methods for Particle Physics and Cosmology [T-PHYS-112378]

Responsible: Prof. Dr. Felix Kahlhöfer
Organisation: KIT Department of Physics
Part of: M-PHYS-106117 - Computational Methods for Particle Physics and Cosmology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 22/23	4025061	Computational Methods for Particle Physics and Cosmology	2 SWS	Lecture / 🗣	Kahlhöfer
WT 22/23	4025062	Exercises to Computational methods for particle physics and cosmology	1 SWS	Practice / 🗣	Gonzálo Velasco, Kahlhöfer, Morandini

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.68 Course: Computational Methods for Particle Physics and Cosmology (Minor) [T-PHYS-112379]

Responsible: Prof. Dr. Felix Kahlhöfer
Organisation: KIT Department of Physics
Part of: M-PHYS-106118 - Computational Methods for Particle Physics and Cosmology (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 22/23	4025061	Computational Methods for Particle Physics and Cosmology	2 SWS	Lecture / 🗣	Kahlhöfer
WT 22/23	4025062	Exercises to Computational methods for particle physics and cosmology	1 SWS	Practice / 🗣	Gonzálo Velasco, Kahlhöfer, Morandini

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.69 Course: Computational Photonics, with ext. Exercises [T-PHYS-103633]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-101933 - Computational Photonics, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2023	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2023	4023022	Exercises to Computational Photonics	1 SWS	Practice / 🗣	Nyman, Rockstuhl
ST 2024	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2024	4023022	Exercises to Computational Photonics		Practice / 🗣	Nyman, Rockstuhl

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Workload
240 hours

T 5.70 Course: Computational Photonics, with ext. Exercises (Minor) [T-PHYS-106132]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-103090 - Computational Photonics, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2023	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2023	4023022	Exercises to Computational Photonics	1 SWS	Practice / 🗣	Nyman, Rockstuhl
ST 2024	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2024	4023022	Exercises to Computational Photonics		Practice / 🗣	Nyman, Rockstuhl

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Workload
240 hours

T 5.71 Course: Computational Photonics, without ext. Exercises [T-PHYS-106131]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-103089 - Computational Photonics, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	2

Events					
ST 2023	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2023	4023022	Exercises to Computational Photonics	1 SWS	Practice / 🗣	Nyman, Rockstuhl
ST 2024	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2024	4023022	Exercises to Computational Photonics		Practice / 🗣	Nyman, Rockstuhl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.72 Course: Computational Photonics, without ext. Exercises (Minor) [T-PHYS-106326]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-103193 - Computational Photonics, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
ST 2023	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2023	4023022	Exercises to Computational Photonics	1 SWS	Practice / 🗣	Nyman, Rockstuhl
ST 2024	4023021	Computational Photonics	2 SWS	Lecture / 🗣	Nyman, Rockstuhl
ST 2024	4023022	Exercises to Computational Photonics		Practice / 🗣	Nyman, Rockstuhl

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Workload
240 hours

T 5.73 Course: Computational Physics [T-PHYS-114137]

Responsible: Prof. Dr. Matthias Steinhauser
Organisation: KIT Department of Physics
Part of: M-PHYS-107092 - Computational Physics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Events					
ST 2025	4026231	Computational Physics	2 SWS	Lecture / 🗣	Steinhauser
ST 2025	4026232	Exercises to Computational Physics	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.74 Course: Computational Physics (Minor) [T-PHYS-114138]

Responsible: Prof. Dr. Matthias Steinhauser
Organisation: KIT Department of Physics
Part of: M-PHYS-107093 - Computational Physics (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	8	pass/fail	Irregular	1 terms	1

Events					
ST 2025	4026231	Computational Physics	2 SWS	Lecture / 🗣	Steinhauser
ST 2025	4026232	Exercises to Computational Physics	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.75 Course: Condensed Matter Theory I, Fundamentals [T-PHYS-102559]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102054 - Condensed Matter Theory I, Fundamentals

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4024011	Theorie der Kondensierten Materie I	4 SWS	Lecture / 🗣	Shnirman
WT 22/23	4024012	Übungen zu Theorie der Kondensierten Materie I	2 SWS	Practice / 🗣	Shnirman, Shapiro, Perrin
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell
WT 24/25	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Eder
WT 24/25	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Eder, NN

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.76 Course: Condensed Matter Theory I, Fundamentals (Minor) [T-PHYS-102557]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102052 - Condensed Matter Theory I, Fundamentals (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4024011	Theorie der Kondensierten Materie I	4 SWS	Lecture / 🗣	Shnirman
WT 22/23	4024012	Übungen zu Theorie der Kondensierten Materie I	2 SWS	Practice / 🗣	Shnirman, Shapiro, Perrin
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell
WT 24/25	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Eder
WT 24/25	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Eder, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.77 Course: Condensed Matter Theory I, Fundamentals and Advanced Topics [T-PHYS-102558]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Each winter term	1

Events					
WT 22/23	4024011	Theorie der Kondensierten Materie I	4 SWS	Lecture / 🗣	Shnirman
WT 22/23	4024012	Übungen zu Theorie der Kondensierten Materie I	2 SWS	Practice / 🗣	Shnirman, Shapiro, Perrin
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell
WT 24/25	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Eder
WT 24/25	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Eder, NN

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.78 Course: Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor) [T-PHYS-102556]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102051 - Condensed Matter Theory I, Fundamentals and Advanced Topics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Each winter term	1

Events					
WT 22/23	4024011	Theorie der Kondensierten Materie I	4 SWS	Lecture / 🗣	Shnirman
WT 22/23	4024012	Übungen zu Theorie der Kondensierten Materie I	2 SWS	Practice / 🗣	Shnirman, Shapiro, Perrin
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell
WT 24/25	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Eder
WT 24/25	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Eder, NN

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.79 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals [T-PHYS-104591]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Mathematics
KIT Department of Physics

Part of: M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2023	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Gornyi
ST 2023	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Gornyi, Pöpperl, Ojajärvi
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Poboiko, Scoquart, Gornyi
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.80 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals (Minor) [T-PHYS-104592]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-102314 - Condensed Matter Theory II: Many-Body Theory, Fundamentals (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2023	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Gornyi
ST 2023	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Gornyi, Pöpperl, Ojajärvi
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Poboiko, Scoquart, Gornyi
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.81 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics [T-PHYS-102560]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics

Type	Credits	Grading scale	Version
Oral examination	12	Grade to a third	1

Events					
ST 2023	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Gornyi
ST 2023	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Gornyi, Pöpperl, Ojajärvi
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Poboiko, Scoquart, Gornyi
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.82 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics (Minor) [T-PHYS-102562]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-102312 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics (Minor)

Type	Credits	Grading scale	Version
Completed coursework	12	pass/fail	1

Events					
ST 2023	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Gornyi
ST 2023	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Gornyi, Pöpperl, Ojajärvi
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Poboiko, Scoquart, Gornyi
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.83 Course: Condensed Matter Theory II: Many-Body Systems, selected topics [T-PHYS-106676]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-103331 - Condensed Matter Theory II: Many-Body Theory, selected topics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	2	Grade to a third	Each summer term	1

Events					
ST 2023	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Gornyi
ST 2023	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Gornyi, Pöpperl, Ojajärvi
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Poboiko, Scoquart, Gornyi
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.84 Course: Detectors for Particle and Astroparticle Physics, with ext. Exercises [T-PHYS-102378]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102121 - Detectors for Particle and Astroparticle Physics, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4022071	Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Lecture / 🗣	Hartmann, Klute
WT 22/23	4022072	Übungen zu Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Practice / 🗣	Hartmann, Klute
WT 23/24	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 23/24	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller
WT 24/25	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 24/25	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.85 Course: Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor) [T-PHYS-102431]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102122 - Detectors for Particle and Astroparticle Physics, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4022071	Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Lecture / 🗣	Hartmann, Klute
WT 22/23	4022072	Übungen zu Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Practice / 🗣	Hartmann, Klute
WT 23/24	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 23/24	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller
WT 24/25	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 24/25	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 5.86 Course: Detectors for Particle and Astroparticle Physics, without ext. Exercises [T-PHYS-104453]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102119 - Detectors for Particle and Astroparticle Physics, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 22/23	4022071	Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Lecture / 🗣	Hartmann, Klute
WT 22/23	4022072	Übungen zu Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Practice / 🗣	Hartmann, Klute
WT 23/24	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 23/24	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller
WT 24/25	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 24/25	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.87 Course: Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor) [T-PHYS-104454]

Responsible: PD Dr. Frank Hartmann
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute

Organisation: KIT Department of Physics

Part of: M-PHYS-102120 - Detectors for Particle and Astroparticle Physics, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each winter term	1

Events					
WT 22/23	4022071	Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Lecture / 🗣	Hartmann, Klute
WT 22/23	4022072	Übungen zu Detektoren für Teilchen- und Astroteilchenphysik	2 SWS	Practice / 🗣	Hartmann, Klute
WT 23/24	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 23/24	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller
WT 24/25	4022071	Detectors for Particle and Astroparticle Physics	2 SWS	Lecture / 🗣	Hartmann, Müller
WT 24/25	4022072	Exercises to Detectors for Particle and Astroparticle Physics	2 SWS	Practice / 🗣	Hartmann, Müller

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.88 Course: Effective Field Theories [T-PHYS-114136]

Responsible: Jun.-Prof. Dr. Anke Biekötter
Organisation: KIT Department of Physics
Part of: M-PHYS-107091 - Effective Field Theories

Type	Credits	Grading scale	Expansion	Version
Oral examination	4	Grade to a third	1 terms	1

Events					
ST 2025	4025161	Effective Field Theories	1 SWS	Lecture / 🗣	Biekötter
ST 2025	4025162	Exercises to Effective Field Theories	1 SWS	Practice / 🗣	Biekötter, Anisha

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.89 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / About Knowledge and Science - Self-Registration [T-FORUM-113580]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each term	1

Competence Certificate
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendation
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Annotation
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

In the Advanced Module, students can choose their own individual focus, e.g. sustainable development, data literacy, etc. The focus should be discussed with the module coordinator at the FORUM.

T 5.90 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Public Debates - Self Registration [T-FORUM-113582]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each term	1

Competence Certificate
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendation
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Annotation
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

5.91 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Society - Self-Registration [T-FORUM-113581]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each term	1

Competence Certificate
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendation
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Annotation
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

T 5.92 Course: Electron Microscopy I, with Exercises [T-PHYS-105965]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-102989 - Electron Microscopy I, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
WT 22/23	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 22/23	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler
WT 23/24	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 23/24	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler
WT 24/25	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 24/25	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.93 Course: Electron Microscopy I, with Exercises (Minor) [T-PHYS-105968]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-102991 - Electron Microscopy I, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
WT 22/23	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 22/23	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler
WT 23/24	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 23/24	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler
WT 24/25	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 24/25	4027012	Exercises to Electron Microscopy I	2 SWS	Practice / 🗣	Eggeler

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.94 Course: Electron Microscopy I, without Exercises [T-PHYS-105967]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-102990 - Electron Microscopy I, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
WT 22/23	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 23/24	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler
WT 24/25	4027011	Electron Microscopy I	2 SWS	Lecture / 🗣	Eggeler

Legend: 🖥 Online, ⚭ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.95 Course: Electron Microscopy II, with Exercises [T-PHYS-102349]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-102227 - Electron Microscopy II, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2023	4027021	Elektronenmikroskopie II	2 SWS	Lecture / 🗣	Eggeler
ST 2023	4027022	Übungen zu Elektronenmikroskopie II	2 SWS	Practice / 🗣	Eggeler
ST 2024	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler
ST 2024	4027022	Exercises to Electron Microscopy II	2 SWS	Practice / 🗣	Eggeler
ST 2025	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler
ST 2025	4027022	Exercises to Electron Microscopy II	2 SWS	Practice / 🗣	Eggeler

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.96 Course: Electron Microscopy II, with Exercises (Minor) [T-PHYS-106306]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-103172 - Electron Microscopy II, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2023	4027021	Elektronenmikroskopie II	2 SWS	Lecture / 🗣	Eggeler
ST 2023	4027022	Übungen zu Elektronenmikroskopie II	2 SWS	Practice / 🗣	Eggeler
ST 2024	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler
ST 2024	4027022	Exercises to Electron Microscopy II	2 SWS	Practice / 🗣	Eggeler
ST 2025	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler
ST 2025	4027022	Exercises to Electron Microscopy II	2 SWS	Practice / 🗣	Eggeler

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.97 Course: Electron Microscopy II, without Exercises [T-PHYS-105817]

Responsible: TT-Prof. Dr. Yolita Eggeler
Organisation: KIT Department of Physics
Part of: M-PHYS-102844 - Electron Microscopy II, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2023	4027021	Elektronenmikroskopie II	2 SWS	Lecture / 🗣	Eggeler
ST 2024	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler
ST 2025	4027021	Electron Microscopy II	2 SWS	Lecture / 🗣	Eggeler

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.98 Course: Electronic Properties of Solids I, with Exercises [T-PHYS-102577]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102089 - Electronic Properties of Solids I, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	10	Grade to a third	Each winter term	1

Events					
WT 22/23	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 22/23	4021012	Übungen zu Elektronische Eigenschaften von Festkörpern I	1 SWS	Practice / 🗣	Le Tacon, Willke
WT 23/24	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 23/24	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Willke
WT 24/25	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 24/25	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Willke

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.99 Course: Electronic Properties of Solids I, with Exercises (Minor) [T-PHYS-102575]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102087 - Electronic Properties of Solids I, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	10	pass/fail	Each winter term	1

Events					
WT 22/23	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 22/23	4021012	Übungen zu Elektronische Eigenschaften von Festkörpern I	1 SWS	Practice / 🗣	Le Tacon, Willke
WT 23/24	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 23/24	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Willke
WT 24/25	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 24/25	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Willke

Legend: 🖥 Online, ⚃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.100 Course: Electronic Properties of Solids I, without Exercises [T-PHYS-102578]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102090 - Electronic Properties of Solids I, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 23/24	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 24/25	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.101 Course: Electronic Properties of Solids II, with Exercises [T-PHYS-104422]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102108 - Electronic Properties of Solids II, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2023	4021111	Elektronische Eigenschaften von Festkörpern II	2 SWS	Lecture / 🗣	Ustinov
ST 2023	4021112	Übungen zu Elektronische Eigenschaften von Festkörpern II	2 SWS	Practice / 🗣	Ustinov, Fischer
ST 2024	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2024	4021112	Exercises to Electronic Properties of Solids II	2 SWS	Practice / 🗣	Ustinov, Fischer
ST 2025	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2025	4021112	Exercises to Electronic Properties of Solids II	2 SWS	Practice / 🗣	Ustinov, Fischer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.102 Course: Electronic Properties of Solids II, with Exercises (Minor) [T-PHYS-104420]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102106 - Electronic Properties of Solids II, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2023	4021111	Elektronische Eigenschaften von Festkörpern II	2 SWS	Lecture / 🗣	Ustinov
ST 2023	4021112	Übungen zu Elektronische Eigenschaften von Festkörpern II	2 SWS	Practice / 🗣	Ustinov, Fischer
ST 2024	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2024	4021112	Exercises to Electronic Properties of Solids II	2 SWS	Practice / 🗣	Ustinov, Fischer
ST 2025	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2025	4021112	Exercises to Electronic Properties of Solids II	2 SWS	Practice / 🗣	Ustinov, Fischer

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.103 Course: Electronic Properties of Solids II, without Exercises [T-PHYS-104423]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102109 - Electronic Properties of Solids II, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Events					
ST 2023	4021111	Elektronische Eigenschaften von Festkörpern II	2 SWS	Lecture / 🗣	Ustinov
ST 2024	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2025	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.104 Course: Electronics for Physicists [T-PHYS-104479]

Responsible: PD Dr. Klaus Rabbertz
Prof. Dr. Frank Simon

Organisation: KIT Department of Physics

Part of: M-PHYS-102184 - Electronics for Physicists

Type	Credits	Grading scale	Recurrence	Version
Oral examination	10	Grade to a third	Each winter term	1

Events					
WT 22/23	4022061	Elektronik für Physiker (Analogelektronik)	2 SWS	Lecture / 🗣	Simon
WT 22/23	4022066	Elektronik für Physiker (Digitalelektronik)	2 SWS	Lecture / 🗣	Feldbusch, Simon
WT 22/23	4022067	Praktische Übungen zur Elektronik für Physiker	4 SWS	Practical course / 🗣	Rabbertz
WT 23/24	4022061	Electronics for Physicists (Analog Electronics)	2 SWS	Lecture / 🗣	Simon, Feldbusch
WT 23/24	4022066	Electronics for Physicists (Digital Electronics)	2 SWS	Lecture / 🗣	Simon, Feldbusch
WT 23/24	4022067	Practical Exercises to Electronics for Physicists	4 SWS	Practical course / 🗣	Rabbertz
WT 24/25	4022061	Electronics for Physicists	4 SWS	Lecture / 🗣	Simon, Feldbusch
WT 24/25	4022062	Practical Exercises to Electronics for Physicists	4 SWS	Practical course / 🗣	Simon, Feldbusch, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.105 Course: Electronics for Physicists (Minor) [T-PHYS-104480]

Responsible: PD Dr. Klaus Rabbertz
Prof. Dr. Frank Simon

Organisation: KIT Department of Physics

Part of: M-PHYS-102185 - Electronics for Physicists (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	10	pass/fail	Each winter term	1

Events					
WT 22/23	4022061	Elektronik für Physiker (Analogelektronik)	2 SWS	Lecture / 🗣	Simon
WT 22/23	4022066	Elektronik für Physiker (Digitalelektronik)	2 SWS	Lecture / 🗣	Feldbusch, Simon
WT 22/23	4022067	Praktische Übungen zur Elektronik für Physiker	4 SWS	Practical course / 🗣	Rabbertz
WT 23/24	4022061	Electronics for Physicists (Analog Electronics)	2 SWS	Lecture / 🗣	Simon, Feldbusch
WT 23/24	4022066	Electronics for Physicists (Digital Electronics)	2 SWS	Lecture / 🗣	Simon, Feldbusch
WT 23/24	4022067	Practical Exercises to Electronics for Physicists	4 SWS	Practical course / 🗣	Rabbertz
WT 24/25	4022061	Electronics for Physicists	4 SWS	Lecture / 🗣	Simon, Feldbusch
WT 24/25	4022062	Practical Exercises to Electronics for Physicists	4 SWS	Practical course / 🗣	Simon, Feldbusch, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.106 Course: Energetics [T-PHYS-111417]

Responsible: Prof. Dr. Andreas Fink
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	3

Events					
WT 22/23	4052131	Energetics	2 SWS	Lecture / Blended	Fink
WT 23/24	4052131	Energetics	2 SWS	Lecture / Blended	Fink
WT 24/25	4052131	Energetics	2 SWS	Lecture / Blended	Fink

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
Active participation

Prerequisites
None

Recommendation
None

Annotation
None

Workload
30 hours

T 5.107 Course: Energy Meteorology [T-PHYS-111428]

Responsible: apl. Prof. Dr. Stefan Emeis
Prof. Dr. Joaquim José Ginete Werner Pinto

Organisation: KIT Department of Physics

Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each summer term	3

Events					
ST 2023	4052191	Energy Meteorology	2 SWS	Lecture / 🗣	Emeis, Schroedter-Homscheidt, Ginete Werner Pinto, Grams
ST 2024	4052191	Energy Meteorology	2 SWS	Lecture / 🗣	Emeis, Schroedter-Homscheidt, Ginete Werner Pinto
ST 2025	4052191	Energy Meteorology	2 SWS	Lecture / 🗣	Emeis, Schroedter-Homscheidt, Ginete Werner Pinto

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The students work in small groups on a task chosen at the beginning of the course on the topics of wind, solar or electricity grids. At the end, each student presents his or her results in a short presentation (max. 5 slides) followed by a discussion.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
30 hours

T 5.108 Course: Exam on Selected Topics in Meteorology (Second Major) [T-PHYS-109380]

Responsible: Prof. Dr. Corinna Hoose
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each term	4

Competence Certificate
Oral examination on the lectures chosen from the electives.

Prerequisites
Prerequisites totalling at least 10 ECTS from the module's electives must be passed in order to be admitted to the examination.

Modeled Conditions
You have to fulfill one of 4 conditions:

1. The following conditions have to be fulfilled:
    1. You have to fulfill one of 8 conditions:
        1. The course T-PHYS-111411 - Tropical Meteorology must have been passed.
        2. The course T-PHYS-111412 - Climate Modeling & Dynamics with ICON must have been passed.
        3. The course T-PHYS-111416 - Cloud Physics must have been passed.
        4. The course T-PHYS-111418 - Atmospheric Aerosols must have been passed.
        5. The course T-PHYS-111424 - Remote Sensing of Atmosphere and Ocean must have been passed.
        6. The course T-PHYS-111426 - Methods of Data Analysis must have been passed.
        7. The course T-PHYS-111427 - Turbulent Diffusion must have been passed.
        8. The course T-PHYS-111429 - Advanced Numerical Weather Prediction must have been passed.
    2. The following conditions have to be fulfilled:
        1. The course T-PHYS-111410 - Seminar on IPCC Assessment Report must have been passed.
        2. The course T-PHYS-111413 - Middle Atmosphere in the Climate System must have been passed.
        3. The course T-PHYS-111414 - Ocean-Atmosphere Interactions must have been passed.
        4. The course T-PHYS-111417 - Energetics must have been passed.
        5. The course T-PHYS-111419 - Atmospheric Radiation must have been passed.
        6. The course T-PHYS-111428 - Energy Meteorology must have been passed.
        7. The course T-PHYS-111273 - Arctic Climate System must have been passed.
2. The following conditions have to be fulfilled:
    1. You have to fulfill 2 of 8 conditions:
        1. The course T-PHYS-111412 - Climate Modeling & Dynamics with ICON must have been passed.
        2. The course T-PHYS-111411 - Tropical Meteorology must have been passed.
        3. The course T-PHYS-111416 - Cloud Physics must have been passed.
        4. The course T-PHYS-111418 - Atmospheric Aerosols must have been passed.
        5. The course T-PHYS-111424 - Remote Sensing of Atmosphere and Ocean must have been passed.
        6. The course T-PHYS-111426 - Methods of Data Analysis must have been passed.
        7. The course T-PHYS-111427 - Turbulent Diffusion must have been passed.
        8. The course T-PHYS-111429 - Advanced Numerical Weather Prediction must have been passed.
    2. You have to fulfill 4 of 7 conditions:
        1. The course T-PHYS-111410 - Seminar on IPCC Assessment Report must have been passed.
        2. The course T-PHYS-111413 - Middle Atmosphere in the Climate System must have been passed.
        3. The course T-PHYS-111414 - Ocean-Atmosphere Interactions must have been passed.
        4. The course T-PHYS-111417 - Energetics must have been passed.
        5. The course T-PHYS-111419 - Atmospheric Radiation must have been passed.
        6. The course T-PHYS-111428 - Energy Meteorology must have been passed.
        7. The course T-PHYS-111273 - Arctic Climate System must have been passed.
3. The following conditions have to be fulfilled:
    1. You have to fulfill 3 of 8 conditions:
        1. The course T-PHYS-111411 - Tropical Meteorology must have been passed.
        2. The course T-PHYS-111412 - Climate Modeling & Dynamics with ICON must have been passed.
        3. The course T-PHYS-111416 - Cloud Physics must have been passed.
        4. The course T-PHYS-111418 - Atmospheric Aerosols must have been passed.
        5. The course T-PHYS-111424 - Remote Sensing of Atmosphere and Ocean must have been passed.
        6. The course T-PHYS-111426 - Methods of Data Analysis must have been passed.
        7. The course T-PHYS-111427 - Turbulent Diffusion must have been passed.
        8. The course T-PHYS-111429 - Advanced Numerical Weather Prediction must have been passed.
    2. You have to fulfill one of 7 conditions:
        1. The course T-PHYS-111410 - Seminar on IPCC Assessment Report must have been passed.
        2. The course T-PHYS-111413 - Middle Atmosphere in the Climate System must have been passed.
        3. The course T-PHYS-111414 - Ocean-Atmosphere Interactions must have been passed.
        4. The course T-PHYS-111417 - Energetics must have been passed.
        5. The course T-PHYS-111419 - Atmospheric Radiation must have been passed.
        6. The course T-PHYS-111428 - Energy Meteorology must have been passed.
        7. The course T-PHYS-111273 - Arctic Climate System must have been passed.
4. The following conditions have to be fulfilled:
    1. You have to fulfill 4 of 8 conditions:
        1. The course T-PHYS-111411 - Tropical Meteorology must have been passed.
        2. The course T-PHYS-111412 - Climate Modeling & Dynamics with ICON must have been passed.
        3. The course T-PHYS-111416 - Cloud Physics must have been passed.
        4. The course T-PHYS-111418 - Atmospheric Aerosols must have been passed.
        5. The course T-PHYS-111424 - Remote Sensing of Atmosphere and Ocean must have been passed.
        6. The course T-PHYS-111426 - Methods of Data Analysis must have been passed.
        7. The course T-PHYS-111427 - Turbulent Diffusion must have been passed.
        8. The course T-PHYS-111429 - Advanced Numerical Weather Prediction must have been passed.

Workload
120 hours

T 5.109 Course: Experimental Biophysics II, with Seminar [T-PHYS-102532]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: M-PHYS-102165 - Experimental Biophysics II, with Seminar

Type	Credits	Grading scale	Version
Oral examination	14	Grade to a third	1

Events					
ST 2023	4020121	Experimentelle Biophysik IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2023	4020122	Übungen zu Experimentelle Biophysik II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2023	4020124	Seminar zu Experimentelle Biophysik II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2023	4020125	Experimentelle Biophysik IIb	2 SWS	Lecture / On-Site	Nienhaus
ST 2024	4020121	Experimental Biophysics IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2024	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2024	4020124	Seminar to Experimental Biophysics II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2024	4020125	Experimental Biophysics IIb	2 SWS	Lecture / On-Site	Nienhaus
ST 2025	4020121	Experimental Biophysics IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2025	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2025	4020124	Seminar to Experimental Biophysics II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2025	4020125	Experimental Biophysics IIb	2 SWS	Lecture / On-Site	Nienhaus

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

T 5.110 Course: Experimental Biophysics II, with Seminar (Minor) [T-PHYS-102533]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: M-PHYS-102166 - Experimental Biophysics II, with Seminar (Minor)

Type	Credits	Grading scale	Version
Completed coursework	14	pass/fail	1

Events					
ST 2023	4020121	Experimentelle Biophysik IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2023	4020122	Übungen zu Experimentelle Biophysik II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2023	4020124	Seminar zu Experimentelle Biophysik II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2023	4020125	Experimentelle Biophysik IIb	2 SWS	Lecture / On-Site	Nienhaus
ST 2024	4020121	Experimental Biophysics IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2024	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2024	4020124	Seminar to Experimental Biophysics II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2024	4020125	Experimental Biophysics IIb	2 SWS	Lecture / On-Site	Nienhaus
ST 2025	4020121	Experimental Biophysics IIa	2 SWS	Lecture / On-Site	Nienhaus
ST 2025	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / On-Site	Nienhaus, Guigas
ST 2025	4020124	Seminar to Experimental Biophysics II	2 SWS	Seminar / On-Site	Nienhaus, Guigas
ST 2025	4020125	Experimental Biophysics IIb	2 SWS	Lecture / On-Site	Nienhaus

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Prerequisites
none

T 5.111 Course: Experimental Biophysics II, without Seminar [T-PHYS-104471]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: M-PHYS-102167 - Experimental Biophysics II, without Seminar

Type	Credits	Grading scale	Version
Oral examination	12	Grade to a third	1

Events					
ST 2023	4020121	Experimentelle Biophysik IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2023	4020122	Übungen zu Experimentelle Biophysik II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2023	4020125	Experimentelle Biophysik IIb	2 SWS	Lecture / 🗣	Nienhaus
ST 2024	4020121	Experimental Biophysics IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2024	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2024	4020125	Experimental Biophysics IIb	2 SWS	Lecture / 🗣	Nienhaus
ST 2025	4020121	Experimental Biophysics IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2025	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2025	4020125	Experimental Biophysics IIb	2 SWS	Lecture / 🗣	Nienhaus

Legend: 📱 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.112 Course: Experimental Biophysics II, without Seminar (Minor) [T-PHYS-104472]

Responsible: Prof. Dr. Ulrich Nienhaus
Organisation: KIT Department of Physics
Part of: M-PHYS-102168 - Experimental Biophysics II, without Seminar (Minor)

Type	Credits	Grading scale	Version
Completed coursework	12	pass/fail	1

Events					
ST 2023	4020121	Experimentelle Biophysik IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2023	4020122	Übungen zu Experimentelle Biophysik II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2023	4020125	Experimentelle Biophysik IIb	2 SWS	Lecture / 🗣	Nienhaus
ST 2024	4020121	Experimental Biophysics IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2024	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2024	4020125	Experimental Biophysics IIb	2 SWS	Lecture / 🗣	Nienhaus
ST 2025	4020121	Experimental Biophysics IIa	2 SWS	Lecture / 🗣	Nienhaus
ST 2025	4020122	Exercises to Experimental Biophysics II	2 SWS	Practice / 🗣	Nienhaus, Guigas
ST 2025	4020125	Experimental Biophysics IIb	2 SWS	Lecture / 🗣	Nienhaus

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.113 Course: Full-Waveform Inversion [T-PHYS-109272]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104522 - Full-Waveform Inversion (Ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each winter term	1

Events					
WT 22/23	4060181	Full-waveform inversion	2 SWS	Lecture / 🗣	Gao, Bohlen
WT 22/23	4060182	Exercises on Full-waveform inversion	1 SWS	Practice / 🗣	Gao, Bohlen
WT 23/24	4060181	Full-waveform inversion	2 SWS	Lecture / 🗣	Gao, Bohlen
WT 23/24	4060182	Exercises on Full-waveform inversion	1 SWS	Practice / 🗣	Gao, Bohlen
WT 24/25	4060181	Full-waveform inversion	2 SWS	Lecture / 🗣	Gao, Bohlen
WT 24/25	4060182	Exercises on Full-waveform inversion	1 SWS	Practice / 🗣	Gao, Rezaei Nevisi, Bohlen

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Workload
180 hours

T 5.114 Course: Fundamentals of Cryophysics, with Exercises [T-PHYS-113658]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: M-PHYS-106799 - Fundamentals of Cryophysics, with Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 24/25	4021021	Fundamentals of Cryophysics	2 SWS	Lecture / 🗣	Wulfhekel
WT 24/25	4021022	Exercises to Fundamentals of Cryophysics	1 SWS	Practice / 🗣	Wulfhekel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.115 Course: Fundamentals of Cryophysics, with Exercises (Minor) [T-PHYS-113660]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: M-PHYS-106801 - Fundamentals of Cryophysics, with Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
WT 24/25	4021021	Fundamentals of Cryophysics	2 SWS	Lecture / 🗣	Wulfhekel
WT 24/25	4021022	Exercises to Fundamentals of Cryophysics	1 SWS	Practice / 🗣	Wulfhekel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.116 Course: Fundamentals of Cryophysics, without Exercises [T-PHYS-113657]

Responsible: Prof. Dr. Wulf Wulfhekel
Organisation: KIT Department of Physics
Part of: M-PHYS-106798 - Fundamentals of Cryophysics, without Exercises

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
WT 24/25	4021021	Fundamentals of Cryophysics	2 SWS	Lecture / 🗣	Wulfhekel

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.117 Course: Geological Hazards and Risk [T-PHYS-103525]

Responsible: Dr. Andreas Schäfer
Organisation: KIT Department of Physics
Part of: M-PHYS-101833 - Geological Hazards and Risk

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	8	Grade to a third	Each winter term	2

Events					
WT 22/23	4060121	Geological Hazards and Risk	2 SWS	Lecture / 🗣	Schäfer, Rietbrock
WT 22/23	4060122	Exercises on Geological Hazards and Risk	2 SWS	Practice / 🗣	Schäfer, Rietbrock
WT 23/24	4060121	Geological Hazards and Risk	2 SWS	Lecture / 🗣	Schäfer, Rietbrock
WT 23/24	4060122	Exercises on Geological Hazards and Risk	2 SWS	Practice / 🗣	Schäfer, Rietbrock
WT 24/25	4060121	Geological Hazards and Risk	2 SWS	Lecture / 🗣	Schäfer, Rietbrock
WT 24/25	4060122	Exercises on Geological Hazards and Risk	2 SWS	Practice / 🗣	Schäfer, Rietbrock

Legend: 🖥 Online, ⚃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Workload
240 hours

T 5.118 Course: Groups, algebras and representations [T-PHYS-113541]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-106732 - Groups, Algebras and Representations

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2024	4026211	Groups, Algebras and Representations	2 SWS	Lecture / 🗣	Gonzálo Velasco, Nierste
ST 2024	4026212	Exercises to Groups, Algebras and Representations	1 SWS	Practice / 🗣	Gonzálo Velasco, Nierste

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.119 Course: Groups, Algebras and Representations (Minor) [T-PHYS-113558]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-106743 - Groups, Algebras and Representations (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
ST 2024	4026211	Groups, Algebras and Representations	2 SWS	Lecture / 🗣	Gonzálo Velasco, Nierste
ST 2024	4026212	Exercises to Groups, Algebras and Representations	1 SWS	Practice / 🗣	Gonzálo Velasco, Nierste

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.120 Course: In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region [T-PHYS-112830]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: M-PHYS-106322 - In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	6	Grade to a third	Irregular	1 terms	1

Events					
ST 2023	4060351	In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	2 SWS	Lecture / 🗣	Rietbrock, NN
ST 2023	4060352	Exercises on In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	2 SWS	Practice / 🗣	Rietbrock, NN
ST 2024	4060351	In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	2 SWS	Lecture / 🗣	Rietbrock, NN
ST 2024	4060352	Exercises on In-Situ: Tectonics and Seismic Hazard in the Mediterranean Region	2 SWS	Practice / 🗣	Rietbrock, NN

Legend: 📱 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Students solve exercise sheets, prepare and give a presentation and write a final report.

Workload
180 hours

T 5.121 Course: Introduction to Cosmology [T-PHYS-102384]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: M-PHYS-102175 - Introduction to Cosmology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 22/23	4022021	Einführung in die Kosmologie	2 SWS	Lecture / 🗣	Drexlin, Huber
WT 22/23	4022022	Übungen zur Einführung in die Kosmologie	1 SWS	Practice / 🗣	Drexlin, Huber
WT 23/24	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Drexlin, Lokhov
WT 23/24	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Drexlin, Lokhov, Huber
WT 24/25	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Drexlin, Lokhov
WT 24/25	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Drexlin, Hinz

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.122 Course: Introduction to Cosmology (Minor) [T-PHYS-102433]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: M-PHYS-102176 - Introduction to Cosmology (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each winter term	1

Events					
WT 22/23	4022021	Einführung in die Kosmologie	2 SWS	Lecture / 🗣	Drexlin, Huber
WT 22/23	4022022	Übungen zur Einführung in die Kosmologie	1 SWS	Practice / 🗣	Drexlin, Huber
WT 23/24	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Drexlin, Lokhov
WT 23/24	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Drexlin, Lokhov, Huber
WT 24/25	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Drexlin, Lokhov
WT 24/25	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Drexlin, Hinz

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.123 Course: Introduction to Flavor Physics, Fundamentals [T-PHYS-105963]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102987 - Introduction to Flavor Physics, Fundamentals

Type	Credits	Grading scale	Recurrence	Version
Oral examination	10	Grade to a third	Irregular	1

Events					
WT 24/25	4025031	Introduction to Flavour Physics	4 SWS	Lecture / 🗣	Nierste
WT 24/25	4025032	Exercises to Introduction to Flavour Physics	2 SWS	Practice / 🗣	Nierste, Gao

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.124 Course: Introduction to Flavor Physics, Fundamentals (Minor) [T-PHYS-106322]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-103189 - Introduction to Flavor Physics, Fundamentals (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	10	pass/fail	Irregular	1

Events					
WT 24/25	4025031	Introduction to Flavour Physics	4 SWS	Lecture / 🗣	Nierste
WT 24/25	4025032	Exercises to Introduction to Flavour Physics	2 SWS	Practice / 🗣	Nierste, Gao

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.125 Course: Introduction to Flavor Physics, Fundamentals and Advanced Topics [T-PHYS-105962]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102986 - Introduction to Flavor Physics, Fundamentals and Advanced Topics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Irregular	1

Events					
WT 24/25	4025031	Introduction to Flavour Physics	4 SWS	Lecture / 🗣	Nierste
WT 24/25	4025032	Exercises to Introduction to Flavour Physics	2 SWS	Practice / 🗣	Nierste, Gao

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.126 Course: Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor) [T-PHYS-106321]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-103188 - Introduction to Flavor Physics, Fundamentals and Advanced Topics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Irregular	1

Events					
WT 24/25	4025031	Introduction to Flavour Physics	4 SWS	Lecture / 🗣	Nierste
WT 24/25	4025032	Exercises to Introduction to Flavour Physics	2 SWS	Practice / 🗣	Nierste, Gao

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.127 Course: Introduction to General Relativity [T-PHYS-113186]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: M-PHYS-106532 - Introduction to General Relativity

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold
WT 23/24	4022102	Exercises to Introduction to General Relativity	1 SWS	Practice / 🗣	Ovchynnikov, Schwetz-Mangold
WT 24/25	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold
WT 24/25	4022102	Exercises to Introduction to General Relativity	1 SWS	Practice / 🗣	Schwetz-Mangold, Dalla Valle Garcia

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.128 Course: Introduction to General Relativity (Minor) [T-PHYS-113189]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: M-PHYS-106533 - Introduction to General Relativity (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 23/24	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold
WT 23/24	4022102	Exercises to Introduction to General Relativity	1 SWS	Practice / 🗣	Ovchynnikov, Schwetz-Mangold
WT 24/25	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold
WT 24/25	4022102	Exercises to Introduction to General Relativity	1 SWS	Practice / 🗣	Schwetz-Mangold, Dalla Valle Garcia

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.129 Course: Introduction to General Relativity, without Exercises [T-PHYS-113729]

Responsible: Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: M-PHYS-106843 - Introduction to General Relativity, without Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 23/24	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold
WT 24/25	4022101	Introduction to General Relativity	3 SWS	Lecture / 🗣	Schwetz-Mangold

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.130 Course: Introduction to Neutron Scattering [T-PHYS-112831]

Responsible: PD Dr. Frank Weber
Organisation: KIT Department of Physics
Part of: M-PHYS-106323 - Introduction to Neutron Scattering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2023	4021171	Introduction to Neutron Scattering	2 SWS	Lecture / 🗣	Weber
ST 2023	4021172	Exercises to Introduction to Neutron Scattering	1 SWS	Practice / 🗣	Weber
ST 2024	4021171	Introduction to Neutron Scattering	2 SWS	Lecture / 🗣	Weber
ST 2024	4021172	Exercises to Introduction to Neutron Scattering	1 SWS	Practice / 🗣	Weber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.131 Course: Introduction to Neutron Scattering (Minor) [T-PHYS-112832]

Responsible: PD Dr. Frank Weber
Organisation: KIT Department of Physics
Part of: M-PHYS-106324 - Introduction to Neutron Scattering (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
ST 2023	4021171	Introduction to Neutron Scattering	2 SWS	Lecture / 🗣	Weber
ST 2023	4021172	Exercises to Introduction to Neutron Scattering	1 SWS	Practice / 🗣	Weber
ST 2024	4021171	Introduction to Neutron Scattering	2 SWS	Lecture / 🗣	Weber
ST 2024	4021172	Exercises to Introduction to Neutron Scattering	1 SWS	Practice / 🗣	Weber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.132 Course: Introduction to Scientific Methods [T-PHYS-102480]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-101397 - Introduction to Scientific Methods

Type	Credits	Grading scale	Version
Completed coursework	15	pass/fail	1

Prerequisites
none

T 5.133 Course: Introduction to Theoretical Cosmology [T-PHYS-109887]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: M-PHYS-104855 - Introduction to Theoretical Cosmology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2023	4022201	Introduction into Theoretical Cosmology	3 SWS	Lecture / 🗣	Kahlhöfer
ST 2023	4022202	Exercises to Introduction into Theoretical Cosmology	1 SWS	Practice / 🗣	Kahlhöfer, Hemme
ST 2024	4022201	Introduction to Theoretical Cosmology	3 SWS	Lecture / 🗣	Schwetz-Mangold
ST 2024	4022202	Exercises to Introduction to Theoretical Cosmology	1 SWS	Practice / 🗣	Schwetz-Mangold, Chathirathas
ST 2025	4022201	Theoretical Cosmology	4 SWS	Lecture / 🗣	Kahlhöfer
ST 2025	4022202	Exercises to Theoretical Cosmology	2 SWS	Practice / 🗣	Kahlhöfer, Mansour, Rink

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.134 Course: Introduction to Theoretical Cosmology (Minor) [T-PHYS-109888]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: M-PHYS-104856 - Introduction to Theoretical Cosmology (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2023	4022201	Introduction into Theoretical Cosmology	3 SWS	Lecture / 🗣	Kahlhöfer
ST 2023	4022202	Exercises to Introduction into Theoretical Cosmology	1 SWS	Practice / 🗣	Kahlhöfer, Hemme
ST 2024	4022201	Introduction to Theoretical Cosmology	3 SWS	Lecture / 🗣	Schwetz-Mangold
ST 2024	4022202	Exercises to Introduction to Theoretical Cosmology	1 SWS	Practice / 🗣	Schwetz-Mangold, Chathirathas
ST 2025	4022201	Theoretical Cosmology	4 SWS	Lecture / 🗣	Kahlhöfer
ST 2025	4022202	Exercises to Theoretical Cosmology	2 SWS	Practice / 🗣	Kahlhöfer, Mansour, Rink

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.135 Course: Inversion and Tomography [T-PHYS-104737]

Responsible: Prof. Dr. Thomas Bohlen
apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-102368 - Inversion and Tomography

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2023	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Ritter
ST 2023	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Ritter
ST 2024	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Rietbrock
ST 2024	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Rietbrock
ST 2025	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Rietbrock
ST 2025	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Rietbrock

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.136 Course: Inversion and Tomography (Minor) [T-PHYS-105572]

Responsible: Prof. Dr. Thomas Bohlen
apl. Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-102658 - Inversion and Tomography (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2023	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Ritter
ST 2023	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Ritter
ST 2024	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Rietbrock
ST 2024	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Rietbrock
ST 2025	4060231	Inversion and Tomography	2 SWS	Lecture / 🗣	Rietbrock
ST 2025	4060232	Exercises to Inversion and Tomography	2 SWS	Practice / 🗣	Gao, Rietbrock

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.137 Course: Lecture Series Supplementary Studies on Science, Technology and Society - Self Registration [T-FORUM-113578]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	2	pass/fail	Each summer term	1 terms	1

Competence Certificate
Active participation, learning protocols, if applicable.

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendation
It is recommended that you complete the lecture series "Science in Society" before attending events in the advanced module and in parallel with attending the basic seminar.
If it is not possible to attend the lecture series and the basic seminar in the same semester, the lecture series can also be attended after attending the basic seminar.
However, attending events in the advanced module before attending the lecture series should be avoided.

Annotation
The basic module consists of the lecture series "Science in Society" and the basic seminar. The lecture series is only offered during the summer semester.
The basic seminar can be attended in the summer or winter semester.

5.138 Course: Macroscopic Quantum Coherence and Dissipation, with Exercises [T-PHYS-113528]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-106724 - Macroscopic Quantum Coherence and Dissipation, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2024	4024191	Macroscopic Quantum Coherence and Dissipation	3 SWS	Lecture / 🗣	Shnirman
ST 2024	4024192	Exercises to Macroscopic Quantum Coherence and Dissipation	1 SWS	Practice / 🗣	Shnirman, Reich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.139 Course: Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor) [T-PHYS-113530]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-106726 - Macroscopic Quantum Coherence and Dissipation, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2024	4024191	Macroscopic Quantum Coherence and Dissipation	3 SWS	Lecture / 🗣	Shnirman
ST 2024	4024192	Exercises to Macroscopic Quantum Coherence and Dissipation	1 SWS	Practice / 🗣	Shnirman, Reich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.140 Course: Macroscopic Quantum Coherence and Dissipation, without Exercises [T-PHYS-113529]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-106725 - Macroscopic Quantum Coherence and Dissipation, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2024	4024191	Macroscopic Quantum Coherence and Dissipation	3 SWS	Lecture / 🗣	Shnirman

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.141 Course: Master's Thesis [T-PHYS-113096]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-106481 - Master's Thesis

Type	Credits	Grading scale	Version
Final Thesis	30	Grade to a third	1

Prerequisites
none

Final Thesis
This course represents a final thesis. The following periods have been supplied:

Submission deadline	6 months
Maximum extension period	3 months
Correction period	8 weeks

This thesis requires confirmation by the examination office.

T 5.142 Course: Mathematical Methods of Theoretical Physics [T-PHYS-111116]

Responsible: Prof. Dr. Kirill Melnikov
Organisation: KIT Department of Physics
Part of: M-PHYS-105535 - Mathematical Methods of Theoretical Physics

Type	Credits	Grading scale	Version
Oral examination	12	Grade to a third	1

Events					
WT 24/25	4026151	Mathematical Methods of Theoretical Physics	4 SWS	Lecture / 🗣	Melnikov, Pikelner
WT 24/25	4026152	Exercises to Mathematical Methods of Theoretical Physics	2 SWS	Practice / 🗣	Melnikov, Pikelner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.143 Course: Mathematical Methods of Theoretical Physics (Minor) [T-PHYS-111117]

Responsible: Prof. Dr. Kirill Melnikov
Organisation: KIT Department of Physics
Part of: M-PHYS-105536 - Mathematical Methods of Theoretical Physics (Minor)

Type	Credits	Grading scale	Version
Completed coursework	12	pass/fail	1

Events					
WT 24/25	4026151	Mathematical Methods of Theoretical Physics	4 SWS	Lecture / 🗣	Melnikov, Pikelner
WT 24/25	4026152	Exercises to Mathematical Methods of Theoretical Physics	2 SWS	Practice / 🗣	Melnikov, Pikelner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.144 Course: Measurement Methods and Techniques in Experimental Physics, with ext. Exercises [T-PHYS-102376]

Responsible: Prof. Dr. Guido Drexlin
PD Dr. Frank Hartmann
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102517 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2023	4022151	Messmethoden und Techniken in der Experimentalphysik	2 SWS	Lecture / 🗣	Priester, Valerius, Röllig
ST 2023	4022152	Übungen zu Messmethoden und Techniken in der Experimentalphysik	1 SWS	Practice / 🗣	Priester, Valerius, Röllig

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.145 Course: Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor) [T-PHYS-105106]

Responsible: Prof. Dr. Guido Drexlin
PD Dr. Frank Hartmann
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102519 - Measurement Methods and Techniques in Experimental Physics, with ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2023	4022151	Messmethoden und Techniken in der Experimentalphysik	2 SWS	Lecture / 🗣	Priester, Valerius, Röllig
ST 2023	4022152	Übungen zu Messmethoden und Techniken in der Experimentalphysik	1 SWS	Practice / 🗣	Priester, Valerius, Röllig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.146 Course: Measurement Methods and Techniques in Experimental Physics, without ext. Exercises [T-PHYS-105105]

Responsible: Prof. Dr. Guido Drexlin
PD Dr. Frank Hartmann
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-102518 - Measurement Methods and Techniques in Experimental Physics, without ext. Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2023	4022151	Messmethoden und Techniken in der Experimentalphysik	2 SWS	Lecture / 🗣	Priester, Valerius, Röllig
ST 2023	4022152	Übungen zu Messmethoden und Techniken in der Experimentalphysik	1 SWS	Practice / 🗣	Priester, Valerius, Röllig

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.147 Course: Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor) [T-PHYS-106327]

Responsible: Prof. Dr. Guido Drexlin
PD Dr. Frank Hartmann
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-103194 - Measurement Methods and Techniques in Experimental Physics, without ext. Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
ST 2023	4022151	Messmethoden und Techniken in der Experimentalphysik	2 SWS	Lecture / 🗣	Priester, Valerius, Röllig
ST 2023	4022152	Übungen zu Messmethoden und Techniken in der Experimentalphysik	1 SWS	Practice / 🗣	Priester, Valerius, Röllig

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.148 Course: Methods of Data Analysis [T-PHYS-111426]

Responsible: Prof. Dr. Joaquim José Ginete Werner Pinto
Prof. Dr. Peter Knippertz

Organisation: KIT Department of Physics

Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each summer term	3

Events					
ST 2023	4052171	Methods of Data Analysis	2 SWS	Lecture / 🗣	Ginete Werner Pinto, Lerch, Ramos
ST 2023	4052172	Exercises to Methods of Data Analysis	1 SWS	Practice / 🗣	Ginete Werner Pinto, Horat, Kiefer
ST 2024	4052171	Methods of Data Analysis	2 SWS	Lecture / 🗣	Ginete Werner Pinto
ST 2024	4052172	Exercises to Methods of Data Analysis	1 SWS	Practice / 🗣	Ginete Werner Pinto, Ramos
ST 2025	4052171	Methods of Data Analysis	2 SWS	Lecture / 🗣	Ginete Werner Pinto, Quinting
ST 2025	4052172	Exercises to Methods of Data Analysis	1 SWS	Practice / 🗣	Ginete Werner Pinto, Ramos

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Successful participation in the exercises.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.149 Course: Microscale Fluid Mechanics [T-MACH-113144]

Responsible: Dr.-Ing. Philipp Marthaler
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-106539 - Microscale Fluid Mechanics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	2153451	Microscale Fluid Mechanics	2 SWS	Lecture / 🗣	Marthaler
ST 2025	2153451	Microscale Fluid Mechanics	2 SWS	Lecture / 🗣	Marthaler

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral exam, duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Prerequisites
none

Workload
120 hours

T 5.150 Course: Middle Atmosphere in the Climate System [T-PHYS-111413]

Responsible: PD Dr. Michael Höpfner
Dr. Miriam Sinnhuber

Organisation: KIT Department of Physics

Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	3

Events					
WT 22/23	4052061	Middle Atmosphere in the Climate System	2 SWS	Lecture / 🧩	Höpfner, Sinnhuber
WT 23/24	4052061	Middle Atmosphere in the Climate System	2 SWS	Lecture / 🧩	Höpfner, Sinnhuber
WT 24/25	4052061	Middle Atmosphere in the Climate System	2 SWS	Lecture / 🧩	Höpfner, Sinnhuber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Short presentation at the end of the semester

Prerequisites
None

Recommendation
None

Annotation
None

Workload
30 hours

T 5.151 Course: Modern Methods of Data Analysis, with ext. Exercises [T-PHYS-102495]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-102127 - Modern Methods of Data Analysis, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2023	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Wolf
ST 2023	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Wolf
ST 2024	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Kieseler, Ferber
ST 2024	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Ferber
ST 2025	4022141	Modern Methods of Data Analysis	2 SWS	Lecture / 🗣	Kieseler, Goldenzweig, Ferber
ST 2025	4022142	Modern Methods of Data Analysis: PC-Lab	2 SWS	Practical course / 🗣	Kieseler, Goldenzweig, Ferber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.152 Course: Modern Methods of Data Analysis, with ext. Exercises (Minor) [T-PHYS-102496]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-102128 - Modern Methods of Data Analysis, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2023	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Wolf
ST 2023	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Wolf
ST 2024	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Kieseler, Ferber
ST 2024	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Ferber
ST 2025	4022141	Modern Methods of Data Analysis	2 SWS	Lecture / 🗣	Kieseler, Goldenzweig, Ferber
ST 2025	4022142	Modern Methods of Data Analysis: PC-Lab	2 SWS	Practical course / 🗣	Kieseler, Goldenzweig, Ferber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.153 Course: Modern Methods of Data Analysis, without ext. Exercises [T-PHYS-102494]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-102125 - Modern Methods of Data Analysis, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2023	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Wolf
ST 2023	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Wolf
ST 2024	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Kieseler, Ferber
ST 2024	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Ferber
ST 2025	4022141	Modern Methods of Data Analysis	2 SWS	Lecture / 🗣	Kieseler, Goldenzweig, Ferber
ST 2025	4022142	Modern Methods of Data Analysis: PC-Lab	2 SWS	Practical course / 🗣	Kieseler, Goldenzweig, Ferber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.154 Course: Modern Methods of Data Analysis, without ext. Exercises (Minor) [T-PHYS-102497]

Responsible: Prof. Dr. Torben Ferber
Dr. rer. nat. Jan Kieseler
Prof. Dr. Günter Quast
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-102126 - Modern Methods of Data Analysis, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each summer term	1

Events					
ST 2023	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Wolf
ST 2023	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Wolf
ST 2024	4022141	Advanced statistical methods and machine learning	2 SWS	Lecture / 🗣	Goldenzweig, Kieseler, Ferber
ST 2024	4022142	Moderne Methoden der Datenanalyse: Computerpraktikum	2 SWS	Practical course / 🗣	Stefkova, Goldenzweig, Ferber
ST 2025	4022141	Modern Methods of Data Analysis	2 SWS	Lecture / 🗣	Kieseler, Goldenzweig, Ferber
ST 2025	4022142	Modern Methods of Data Analysis: PC-Lab	2 SWS	Practical course / 🗣	Kieseler, Goldenzweig, Ferber

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.155 Course: Modern Methods of Spectroscopy: Applications in Astroparticle Physics [T-PHYS-112237]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius

Organisation: KIT Department of Physics

Part of: M-PHYS-106047 - Modern Methods of Spectroscopy: Applications in Astroparticle Physics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	2	pass/fail	Each term	1 terms	1

Events					
WT 22/23	4032203	Blockpraktikum: Moderne Methoden der Spektroskopie - Anwendungen in der Astroteilchenphysik	5 SWS	Practical course / 🗣	Drexlin, Valerius, Wolf
WT 23/24	4032203	Block Practial Course: Modern Methods of Spectroscopy - Applications in Astroparticle Physics	5 SWS	Practical course / 🗣	Drexlin, Valerius, Wolf, Größle
WT 24/25	4032203	Block Practial Course: Modern Methods of Spectroscopy - Applications in Astroparticle Physics	5 SWS	Practical course / 🗣	Drexlin, Valerius, Wolf

Legend: 🖥 Online, ♲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.156 Course: Molecular Spectroscopy [T-CHEMBIO-104639]

Responsible: apl. Prof. Dr. Andreas-Neil Unterreiner
Organisation: KIT Department of Chemistry and Biosciences
KIT Department of Physics
Part of: M-PHYS-102337 - Molecular Spectroscopy

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Events					
WT 22/23	5213	Molekülspektroskopie	2 SWS	Lecture	Unterreiner, Schooss
WT 22/23	5214	Übungen zur Vorlesung Molekülspektroskopie	1 SWS	Practice	Unterreiner, Schooss
WT 23/24	5213	Molekülspektroskopie	2 SWS	Lecture	Unterreiner, Schooss
WT 23/24	5214	Übungen zur Vorlesung Molekülspektroskopie	1 SWS	Practice	Unterreiner, Schooss
WT 24/25	5213	Molekülspektroskopie	2 SWS	Lecture	Unterreiner, Schooss
WT 24/25	5214	Übungen zur Vorlesung Molekülspektroskopie	1 SWS	Practice	Unterreiner, Schooss

Prerequisites
none

T 5.157 Course: Nano-Optics [T-PHYS-102282]

Responsible: PD Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: M-PHYS-102146 - Nano-Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	2

Events					
WT 22/23	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 22/23	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber
WT 23/24	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 23/24	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber
WT 24/25	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 24/25	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.158 Course: Nano-Optics (Minor) [T-PHYS-102360]

Responsible: PD Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: M-PHYS-102147 - Nano-Optics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 22/23	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber
WT 23/24	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 23/24	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber
WT 24/25	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 24/25	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.159 Course: New Light Particles Beyond the Standard Model, without Exercises [T-PHYS-111703]

Responsible: Prof. Dr. Ulrich Nierste
Dr. Robert Ziegler

Organisation: KIT Department of Physics

Part of: M-PHYS-105833 - New Light Particles Beyond the Standard Model, without Exercises

Type	Credits	Grading scale	Expansion	Version
Oral examination	4	Grade to a third	1 terms	1

Events					
WT 23/24	4025051	Light Particles beyond the Standard Model	2 SWS	Lecture / 🗣	Ziegler, Nierste

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.160 Course: Nonlinear Optics [T-ETIT-101906]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100430 - Nonlinear Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	2

Events					
ST 2023	2309468	Nonlinear Optics	2 SWS	Lecture / 🗣	Koos
ST 2023	2309469	Nonlinear Optics (Tutorial)	2 SWS	Practice / 🗣	Koos
ST 2024	2309468	Nonlinear Optics	2 SWS	Lecture / 🗣	Koos
ST 2024	2309469	Nonlinear Optics (Tutorial)	2 SWS	Practice / 🗣	Koos
ST 2025	2309468	Nonlinear Optics	2 SWS	Lecture / 🗣	Koos
ST 2025	2309469	Nonlinear Optics (Tutorial)	2 SWS	Practice / 🗣	Koos

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.161 Course: Non-supersymmetric Extensions of the Standard Model (Minor) [T-PHYS-111277]

Responsible: Dr. Monika Blanke
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-105639 - Non-supersymmetric Extensions of the Standard Model (Minor)

Type	Credits	Grading scale	Expansion	Version
Completed coursework	4	pass/fail	1 terms	1

Events					
WT 23/24	4025081	Non-supersymmetric Extensions of the Standard Model	2 SWS	Lecture / 🗣	Blanke, Nierste

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.162 Course: Ocean-Atmosphere Interactions [T-PHYS-111414]

Responsible: Prof. Dr. Andreas Fink
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	3

Events					
WT 22/23	4052121	Ocean-Atmosphere Interactions	2 SWS	Lecture / Blended	Fink, Woodhams
WT 23/24	4052121	Ocean-Atmosphere Interactions	2 SWS	Lecture / Blended	Fink
WT 24/25	4052121	Ocean-Atmosphere Interactions	2 SWS	Lecture / Blended	Fink

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Active participation

Prerequisites
None

Recommendation
None

Annotation
None

Workload
30 hours

T 5.163 Course: Particle Physics I [T-PHYS-102369]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-102114 - Particle Physics I

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4022031	Teilchenphysik I	3 SWS	Lecture / 🗣	Ferber
WT 22/23	4022032	Praktische Übungen zur Teilchenphysik I	2 SWS	/ 🗣	Quast, Faltermann
WT 23/24	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Ferber
WT 23/24	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Ferber, Chwalek
WT 24/25	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Klute, Goldenzweig
WT 24/25	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Klute, Goldenzweig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.164 Course: Particle Physics I (Minor) [T-PHYS-102488]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-102115 - Particle Physics I (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4022031	Teilchenphysik I	3 SWS	Lecture / 🗣	Ferber
WT 22/23	4022032	Praktische Übungen zur Teilchenphysik I	2 SWS	/ 🗣	Quast, Faltermann
WT 23/24	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Ferber
WT 23/24	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Ferber, Chwalek
WT 24/25	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Klute, Goldenzweig
WT 24/25	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Klute, Goldenzweig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.165 Course: Particle Physics II - Flavour Physics, with ext. Exercises [T-PHYS-104783]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102422 - Particle Physics II - Flavour Physics, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4022081	Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 22/23	4022082	Übungen zu Flavour- Physik	2 SWS	Practice / 🗣	Stefkova, Goldenzweig
WT 23/24	4022081	Particle Physics II: Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 23/24	4022082	Exercises to Particle Physics II: Flavour-Physics	2 SWS	Practice / 🗣	Stefkova, Goldenzweig

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.166 Course: Particle Physics II - Flavour Physics, with ext. Exercises (Minor) [T-PHYS-106316]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-103183 - Particle Physics II - Flavour Physics, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4022081	Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 22/23	4022082	Übungen zu Flavour- Physik	2 SWS	Practice / 🗣	Stefkova, Goldenzweig
WT 23/24	4022081	Particle Physics II: Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 23/24	4022082	Exercises to Particle Physics II: Flavour-Physics	2 SWS	Practice / 🗣	Stefkova, Goldenzweig

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.167 Course: Particle Physics II - Flavour Physics, without ext. Exercises [T-PHYS-102371]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102154 - Particle Physics II - Flavour Physics, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 22/23	4022081	Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 22/23	4022082	Übungen zu Flavour- Physik	2 SWS	Practice / 🗣	Stefkova, Goldenzweig
WT 23/24	4022081	Particle Physics II: Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 23/24	4022082	Exercises to Particle Physics II: Flavour-Physics	2 SWS	Practice / 🗣	Stefkova, Goldenzweig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.168 Course: Particle Physics II - Flavour Physics, without ext. Exercises (Minor) [T-PHYS-102424]

Responsible: Prof. Dr. Torben Ferber
Dr. Pablo Goldenzweig
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102155 - Particle Physics II - Flavour Physics, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each winter term	1

Events					
WT 22/23	4022081	Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 22/23	4022082	Übungen zu Flavour- Physik	2 SWS	Practice / 🗣	Stefkova, Goldenzweig
WT 23/24	4022081	Particle Physics II: Flavour-Physics	2 SWS	Lecture / 🗣	Goldenzweig, Ferber
WT 23/24	4022082	Exercises to Particle Physics II: Flavour-Physics	2 SWS	Practice / 🗣	Stefkova, Goldenzweig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.169 Course: Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises [T-PHYS-111950]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: M-PHYS-105939 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2023	4022191	Particle Physics II - Physics beyond the Statdard Model	2 SWS	Lecture / 🗣	Klute
ST 2023	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Chwalek
ST 2025	4022191	Particle Physics II - Physics beyond the Standard Model	2 SWS	Lecture / 🗣	Klute, Alimena
ST 2025	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Alimena

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.170 Course: Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor) [T-PHYS-111951]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: M-PHYS-105940 - Particle Physics II - Physics Beyond the Standard Model, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2023	4022191	Particle Physics II - Physics beyond the Statdard Model	2 SWS	Lecture / 🗣	Klute
ST 2023	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Chwalek
ST 2025	4022191	Particle Physics II - Physics beyond the Standard Model	2 SWS	Lecture / 🗣	Klute, Alimena
ST 2025	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Alimena

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.171 Course: Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises [T-PHYS-111948]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: M-PHYS-105937 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2023	4022191	Particle Physics II - Physics beyond the Statdard Model	2 SWS	Lecture / 🗣	Klute
ST 2023	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Chwalek
ST 2025	4022191	Particle Physics II - Physics beyond the Standard Model	2 SWS	Lecture / 🗣	Klute, Alimena
ST 2025	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Alimena

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.172 Course: Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor) [T-PHYS-111949]

Responsible: Prof. Dr. Markus Klute
Organisation: KIT Department of Physics
Part of: M-PHYS-105938 - Particle Physics II - Physics Beyond the Standard Model, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
ST 2023	4022191	Particle Physics II - Physics beyond the Statdard Model	2 SWS	Lecture / 🗣	Klute
ST 2023	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Chwalek
ST 2025	4022191	Particle Physics II - Physics beyond the Standard Model	2 SWS	Lecture / 🗣	Klute, Alimena
ST 2025	4022192	Exercises to Particle Physics II - Physics beyond the Standard Model	2 SWS	Practice / 🗣	Klute, Alimena

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.173 Course: Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises [T-PHYS-108474]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-104088 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	4022171	Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Lecture / 🗣	Rabbertz, Müller
ST 2024	4022172	Übungen zu Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Practice / 🗣	Rabbertz, Müller

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.174 Course: Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor) [T-PHYS-108475]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-104089 - Particle Physics II - Top Quarks and Jets at the LHC, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2024	4022171	Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Lecture / 🗣	Rabbertz, Müller
ST 2024	4022172	Übungen zu Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Practice / 🗣	Rabbertz, Müller

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.175 Course: Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises [T-PHYS-108472]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-104086 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	4022171	Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Lecture / 🗣	Rabbertz, Müller
ST 2024	4022172	Übungen zu Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Practice / 🗣	Rabbertz, Müller

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.176 Course: Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor) [T-PHYS-108473]

Responsible: Prof. Dr. Thomas Müller
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-104087 - Particle Physics II - Top Quarks and Jets at the LHC, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each summer term	1

Events					
ST 2024	4022171	Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Lecture / 🗣	Rabbertz, Müller
ST 2024	4022172	Übungen zu Teilchenphysik II - Top-Quarks und Jets am LHC	2 SWS	Practice / 🗣	Rabbertz, Müller

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.177 Course: Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises [T-PHYS-108470]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-104084 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2023	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Rabbertz, Faltermann
ST 2023	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	1 SWS	Practice / 🗣	Rabbertz, Faltermann, Zuo
ST 2024	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Maier, Faltermann, Klute
ST 2024	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Practice / 🗣	Zuo, Klute

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.178 Course: Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor) [T-PHYS-108471]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-104085 - Particle Physics II - W, Z, Higgs at Colliders, with ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2023	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Rabbertz, Faltermann
ST 2023	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	1 SWS	Practice / 🗣	Rabbertz, Faltermann, Zuo
ST 2024	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Maier, Faltermann, Klute
ST 2024	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Practice / 🗣	Zuo, Klute

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.179 Course: Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises [T-PHYS-108468]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-104081 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2023	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Rabbertz, Faltermann
ST 2023	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	1 SWS	Practice / 🗣	Rabbertz, Faltermann, Zuo
ST 2024	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Maier, Faltermann, Klute
ST 2024	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Practice / 🗣	Zuo, Klute

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.180 Course: Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor) [T-PHYS-108469]

Responsible: Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz
PD Dr. Roger Wolf

Organisation: KIT Department of Physics

Part of: M-PHYS-104082 - Particle Physics II - W, Z, Higgs at Colliders, without ext. Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each summer term	1

Events					
ST 2023	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Rabbertz, Faltermann
ST 2023	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	1 SWS	Practice / 🗣	Rabbertz, Faltermann, Zuo
ST 2024	4022161	Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Lecture / 🗣	Maier, Faltermann, Klute
ST 2024	4022162	Übungen zu Teilchenphysik II - W, Z, Higgs am Collider	2 SWS	Practice / 🗣	Zuo, Klute

Legend: 📱 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.181 Course: Particle Physics with Extra Dimensions [T-PHYS-112244]

Responsible: Dr. Monika Blanke
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-106055 - Particle Physics with Extra Dimensions

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
WT 22/23	4025071	Particle Physics with Extra Dimensions	2 SWS	Lecture / 🗣	Blanke, Nierste

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.182 Course: Photovoltaics [T-ETIT-101939]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100513 - Photovoltaics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	2

Events					
ST 2023	2313737	Photovoltaics	3 SWS	Lecture / 🗣	Powalla, Lemmer
ST 2023	2313738	Tutorial 2313737 Photovoltaik	1 SWS	Practice / 🗣	Powalla, Lemmer
ST 2024	2313737	Photovoltaics	3 SWS	Lecture / 🗣	Powalla, Lemmer
ST 2024	2313738	Tutorial 2313737 Photovoltaik	1 SWS	Practice / 🗣	Powalla, Lemmer
ST 2025	2313737	Photovoltaics	3 SWS	Lecture / 🗣	Powalla, Lemmer
ST 2025	2313738	Tutorial 2313737 Photovoltaik	1 SWS	Practice / 🗣	Powalla, Lemmer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
"M-ETIT-100524 - Solar Energy" must not have started.

T 5.183 Course: Physics beyond the Standard Model, with Exercises [T-PHYS-113531]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: M-PHYS-106727 - Physics beyond the Standard Model, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2024	4026221	Physics Beyond the Standard Model	2 SWS	Lecture / 🗣	Mühlleitner
ST 2024	4026222	Exercises to Physics Beyond the Standard Model	1 SWS	Practice / 🗣	Mühlleitner

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.184 Course: Physics beyond the Standard Model, without Exercises [T-PHYS-113532]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: M-PHYS-106728 - Physics beyond the Standard Model, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2024	4026221	Physics Beyond the Standard Model	2 SWS	Lecture / 🗣	Mühlleitner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.185 Course: Physics of Planetary Atmospheres [T-PHYS-109177]

Responsible: Prof. Dr. Thomas Leisner
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each winter term	4

Events					
WT 22/23	4052161	Physics of Planetary Atmospheres	2 SWS	Lecture / 🔀	Reddmann, Leisner, Sinnhuber, Duft
WT 22/23	4052162	Exercises to Physics of Planetary Atmospheres	2 SWS	Practice / 🔀	Leisner, Duft
WT 23/24	4052161	Physics of Planetary Atmospheres	2 SWS	Lecture / 🔀	Reddmann, Leisner, Sinnhuber
WT 23/24	4052162	Exercises to Physics of Planetary Atmospheres	2 SWS	Practice / 🔀	Leisner, Duft

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate

- If this module is part of the Specialization or Compulsory Subject, credits are earned through the associated exam (oral, written or otherwise).
- Otherwise, the exercises, computer exercises, internships or, if necessary, graduation lectures must be successfully completed.

Prerequisites
None

Recommendation
Basic knowledge of physics, physical chemistry and fluid dynamics at Bachelor level.

Annotation
180 hours consisting of attendance times (42 hours), follow-up of the lecture and editing exercises (138 hours).

Workload
180 hours

T 5.186 Course: Physics of Seismic Instruments [T-PHYS-104727]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: M-PHYS-102358 - Physics of Seismic Instruments

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 22/23	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 22/23	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Toularoud, Forbriger, Rietbrock
WT 23/24	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 23/24	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Sharia, Forbriger, Rietbrock
WT 24/25	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 24/25	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Sharia, Forbriger, Rietbrock

Legend: 📱 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.187 Course: Physics of Seismic Instruments (Minor) [T-PHYS-105567]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: M-PHYS-102653 - Physics of Seismic Instruments (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
WT 22/23	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 22/23	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Toularoud, Forbriger, Rietbrock
WT 23/24	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 23/24	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Sharia, Forbriger, Rietbrock
WT 24/25	4060051	Physics of seismic instruments	2 SWS	Lecture / 🗣	Forbriger, Rietbrock
WT 24/25	4060052	Exercise on physics of seismic instruments	1 SWS	Practice / 🗣	Sharia, Forbriger, Rietbrock

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.188 Course: Physics of Semiconductors, with Exercises [T-PHYS-102343]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: M-PHYS-102131 - Physics of Semiconductors, with Exercises

Type	Credits	Grading scale	Version
Oral examination	10	Grade to a third	1

T 5.189 Course: Physics of Semiconductors, with Exercises (Minor) [T-PHYS-102301]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: M-PHYS-102130 - Physics of Semiconductors, with Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	10	pass/fail	1

T 5.190 Course: Physics of Semiconductors, without Exercises [T-PHYS-104590]

Responsible: Prof. Dr. Heinz Kalt
Organisation: KIT Department of Physics
Part of: M-PHYS-102301 - Physics of Semiconductors, without Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

T 5.191 Course: Plasma Physics I [T-PHYS-114146]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Physics
Part of: M-PHYS-107114 - Plasma Physics I

Type	Credits	Grading scale	Expansion	Version
Oral examination	8	Grade to a third	1 terms	1

Events					
ST 2025	4022221	Plasmaphysics I	3 SWS	Lecture / 🗣	Scherer
ST 2025	4022222	Exercises to Plasmaphysics I	1 SWS	Practice / 🗣	Scherer, Mazzocchi

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.192 Course: Plasma Physics I (Minor) [T-PHYS-114148]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Physics
Part of: M-PHYS-107115 - Plasma Physics I (Minor)

Type	Credits	Grading scale	Expansion	Version
Completed coursework	8	pass/fail	1 terms	1

Events					
ST 2025	4022221	Plasmaphysics I	3 SWS	Lecture / 🗣	Scherer
ST 2025	4022222	Exercises to Plasmaphysics I	1 SWS	Practice / 🗣	Scherer, Mazzocchi

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.193 Course: Precision Phenomenology at Colliders and Computational Methods, with Exercises [T-PHYS-111279]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: M-PHYS-105640 - Precision Phenomenology at Colliders and Computational Methods, with Exercises

Type	Credits	Grading scale	Expansion	Version
Oral examination	8	Grade to a third	1 terms	1

Events					
ST 2023	4025151	Precision Phenomenology at Colliders and Computational Methods	2 SWS	Lecture / 🗣	Heinrich
ST 2023	4025152	Exercises to Precision Phenomenology at Colliders and Computational Methods	2 SWS	Practice / 🗣	Heinrich, Kerner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.194 Course: Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor) [T-PHYS-111281]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: M-PHYS-105642 - Precision Phenomenology at Colliders and Computational Methods, with Exercises (Minor)

Type	Credits	Grading scale	Expansion	Version
Completed coursework	8	pass/fail	1 terms	1

Events					
ST 2023	4025151	Precision Phenomenology at Colliders and Computational Methods	2 SWS	Lecture / 🗣	Heinrich
ST 2023	4025152	Exercises to Precision Phenomenology at Colliders and Computational Methods	2 SWS	Practice / 🗣	Heinrich, Kerner

Legend: 🖥 Online, ⚃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.195 Course: Precision Phenomenology at Colliders and Computational Methods, without Exercises [T-PHYS-111280]

Responsible: Prof. Dr. Gudrun Heinrich
Organisation: KIT Department of Physics
Part of: M-PHYS-105641 - Precision Phenomenology at Colliders and Computational Methods, without Exercises

Type	Credits	Grading scale	Expansion	Version
Oral examination	4	Grade to a third	1 terms	1

Events					
ST 2023	4025151	Precision Phenomenology at Colliders and Computational Methods	2 SWS	Lecture / 🗣	Heinrich
ST 2024	4026201	Precision Phenomenology at Colliders and Computational Methods	2 SWS	Lecture / 🗣	Melnikov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.196 Course: Quantum Detectors and Sensors [T-PHYS-112582]

Responsible: Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Physics

Part of: M-PHYS-106193 - Quantum Detectors and Sensors

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Each winter term	1 terms	1

Events					
WT 22/23	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 22/23	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin
WT 23/24	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 23/24	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin
WT 24/25	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 24/25	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.197 Course: Quantum Detectors and Sensors (Minor) [T-PHYS-112583]

Responsible: Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Physics

Part of: M-PHYS-106194 - Quantum Detectors and Sensors (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	8	pass/fail	Each winter term	1 terms	1

Events					
WT 22/23	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 22/23	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin
WT 23/24	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 23/24	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin
WT 24/25	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 24/25	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.198 Course: Quantum Fluctuations and Dissipation far from Equilibrium [T-PHYS-114216]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-107194 - Quantum Fluctuations and Dissipation far from Equilibrium

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2025	4024201	Quantum Fluctuations and Dissipation far from Equilibrium	4 SWS	Lecture / 🗣	Gornyi, Shnirman

Legend: 🖥 Online, ❃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.199 Course: Quantum Optics at the Nano Scale, with Exercises [T-PHYS-113126]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: M-PHYS-106508 - Quantum Optics at the Nano Scale, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2023	4021161	Quantum Optics at the Nano Scale: Fundamentals and Applications	3 SWS	Lecture / 🗣	Hunger
ST 2023	4021162	Übungen zu Quantum Optics at the Nano Scale: Fundamentals and Applications	1 SWS	Practice / 🗣	Köster, Hunger
ST 2024	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger
ST 2024	4021162	Exercises to Quantum Optics at the Nano Scale	1 SWS	Practice / 🗣	Hunger, Laukó
ST 2025	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger
ST 2025	4021162	Exercises to Quantum Optics at the Nano Scale	1 SWS	Practice / 🗣	Hunger, Laukó

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 5.200 Course: Quantum Optics at the Nano Scale, with Exercises (Minor) [T-PHYS-113127]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: M-PHYS-106509 - Quantum Optics at the Nano Scale, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2023	4021161	Quantum Optics at the Nano Scale: Fundamentals and Applications	3 SWS	Lecture / 🗣	Hunger
ST 2023	4021162	Übungen zu Quantum Optics at the Nano Scale: Fundamentals and Applications	1 SWS	Practice / 🗣	Köster, Hunger
ST 2024	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger
ST 2024	4021162	Exercises to Quantum Optics at the Nano Scale	1 SWS	Practice / 🗣	Hunger, Laukó
ST 2025	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger
ST 2025	4021162	Exercises to Quantum Optics at the Nano Scale	1 SWS	Practice / 🗣	Hunger, Laukó

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.201 Course: Quantum Optics at the Nano Scale, without Exercises [T-PHYS-113128]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: M-PHYS-106510 - Quantum Optics at the Nano Scale, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2023	4021161	Quantum Optics at the Nano Scale: Fundamentals and Applications	3 SWS	Lecture / 🗣	Hunger
ST 2024	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger
ST 2025	4021161	Quantum Optics at the Nano Scale	3 SWS	Lecture / 🗣	Hunger

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.202 Course: Registration for Certificate Issuance - Supplementary Studies on Science, Technology and Society [T-FORUM-113587]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	0	pass/fail	Each term	1

Prerequisites

In order to register, it is mandatory that the basic module and the advanced module have been completed and that the grades for the partial performances in the advanced module are available.

Registration as a partial achievement means the issue of a certificate.

T 5.203 Course: Remote Sensing of Atmosphere and Ocean [T-PHYS-111424]

Responsible: Prof. Dr. Björn-Martin Sinnhuber
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	4	pass/fail	Each summer term	1 terms	3

Events					
ST 2023	4052151	Remote Sensing of Atmosphere and Ocean	2 SWS	Lecture / 🗣	Sinnhuber
ST 2023	4052152	Exercises to Remote Sensing of Atmosphere and Ocean	1 SWS	Practice / 🗣	Sinnhuber
ST 2024	4052151	Remote Sensing of Atmosphere and Ocean	2 SWS	Lecture / 🗣	Sinnhuber
ST 2024	4052152	Exercises to Remote Sensing of Atmosphere and Ocean	1 SWS	Practice / 🗣	Sinnhuber
ST 2025	4052151	Remote Sensing of Atmosphere and Ocean	2 SWS	Lecture / 🗣	Sinnhuber
ST 2025	4052152	Exercises to Remote Sensing of Atmosphere and Ocean	1 SWS	Practice / 🗣	Sinnhuber, Bartenschlager

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
More than 50% of the points from the exercises must be achieved.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.204 Course: Seismic Data Processing, Coursework [T-PHYS-108686]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104186 - Seismic Data Processing with Final Report (Graded)

Type	Credits	Grading scale	Version
Completed coursework	2	pass/fail	1

Workload
60 hours

T 5.205 Course: Seismic Data Processing, Final Report (Graded) [T-PHYS-108656]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104186 - Seismic Data Processing with Final Report (Graded)

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	1

Events					
ST 2023	4060321	Seismic Data Processing	1 SWS	Lecture / 🗣	Hertweck, Bohlen
ST 2023	4060322	Exercises to Seismic Data Processing	2 SWS	Practice / 🗣	Houpt, Hertweck, Bohlen
ST 2024	4060321	Seismic Data Processing	1 SWS	Lecture / 🗣	Hertweck, Bohlen
ST 2024	4060322	Exercises to Seismic Data Processing	2 SWS	Practice / 🗣	Houpt, Hertweck, Bohlen
ST 2025	4060321	Seismic Data Processing	1 SWS	Lecture / 🗣	Hertweck, Bohlen
ST 2025	4060322	Exercises to Seismic Data Processing	2 SWS	Practice / 🗣	Houpt, Hertweck, Bohlen

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
Successful participation on "Seismic Data Processing, course achievement"

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-108686 - Seismic Data Processing, Coursework must have been passed.

Workload
120 hours

T 5.206 Course: Seismic Modeling [T-PHYS-110605]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-105227 - Seismic Modeling

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Events					
ST 2023	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2023	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Bohlen
ST 2024	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2024	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Rezaei Nevisi, Bohlen
ST 2025	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2025	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Rezaei Nevisi, Bohlen, Keßler

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.207 Course: Seismic Modeling (Minor) [T-PHYS-110607]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-105228 - Seismic Modeling (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each summer term	1

Events					
ST 2023	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2023	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Bohlen
ST 2024	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2024	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Rezaei Nevisi, Bohlen
ST 2025	4060261	Seismic Modelling	1 SWS	Lecture / 🗣	Bohlen
ST 2025	4060262	Exercises to Seismic Modelling	1 SWS	Practice / 🗣	Rezaei Nevisi, Bohlen, Keßler

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.208 Course: Seismics [T-PHYS-112843]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-106326 - Seismics

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 22/23	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 22/23	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck
WT 23/24	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 23/24	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck
WT 24/25	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 24/25	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.209 Course: Seismics (Minor) [T-PHYS-112833]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-106325 - Seismics (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 22/23	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 22/23	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck
WT 23/24	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 23/24	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck
WT 24/25	4060111	Seismics	2 SWS	Lecture / 🗣	Bohlen, Hertweck
WT 24/25	4060112	Exercises on Seismics	2 SWS	Practice / 🗣	Houpt, Bohlen, Hertweck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.210 Course: Seismology [T-PHYS-110603]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: M-PHYS-105225 - Seismology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Kufner, Rietbrock
WT 22/23	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Kufner, Linder, Rietbrock
WT 23/24	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Rietbrock
WT 23/24	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Rietbrock
WT 24/25	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Rietbrock
WT 24/25	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Rietbrock

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.211 Course: Seismology (Minor) [T-PHYS-110604]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: M-PHYS-105226 - Seismology (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Kufner, Rietbrock
WT 22/23	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Kufner, Linder, Rietbrock
WT 23/24	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Rietbrock
WT 23/24	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Rietbrock
WT 24/25	4060171	Seismology	2 SWS	Lecture / 🗣	Gao, Rietbrock
WT 24/25	4060172	Exercises on Seismology	2 SWS	Practice / 🗣	Gao, Rietbrock

Legend: 🖥 Online, ⚭ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.212 Course: Selfassignment-MScPhysics-graded [T-PHYS-111562]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-101394 - Interdisciplinary Qualifications

Type	Credits	Grading scale	Version
Examination of another type	2	Grade to a third	1

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

T 5.213 Course: Selfassignment-MScPhysics-ungraded [T-PHYS-111565]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-101394 - Interdisciplinary Qualifications

Type	Credits	Grading scale	Version
Completed coursework	2	pass/fail	1

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

T 5.214 Course: Seminar on IPCC Assessment Report [T-PHYS-111410]

Responsible: Prof. Dr. Joaquim José Ginete Werner Pinto
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each winter term	3

Events					
WT 22/23	4052194	Seminar on IPCC Assessment Report	2 SWS	Advanced seminar (/ 🧩	Ludwig, Ginete Werner Pinto
WT 23/24	4052194	Seminar on IPCC Assessment Report	2 SWS	Advanced seminar (/ 🧩	Ludwig, Ginete Werner Pinto
WT 24/25	4052194	Seminar on IPCC Assessment Report	2 SWS	Advanced seminar (/ 🧩	Ludwig, Ginete Werner Pinto

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Study of a chapter of the current IPCC report with subsequent presentation (~ 20-25 min) and submission of a written summary (1 page).

Prerequisites
none

Recommendation
none

Annotation
none

Workload
30 hours

T 5.215 Course: Software Engineering in Condensed Matter Physics [T-PHYS-113706]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-106833 - Software Engineering in Condensed Matter Physics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 24/25	4023051	Software Engineering in Condensed Matter Physics	2 SWS	Lecture / 🗣	Wenzel
WT 24/25	4023052	Exercises to Software Engineering in Condensed Matter Physics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.216 Course: Software Engineering in Condensed Matter Physics (Minor) [T-PHYS-113707]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-106834 - Software Engineering in Condensed Matter Physics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 24/25	4023051	Software Engineering in Condensed Matter Physics	2 SWS	Lecture / 🗣	Wenzel
WT 24/25	4023052	Exercises to Software Engineering in Condensed Matter Physics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.217 Course: Solid State Quantum Technologies [T-PHYS-109889]

Responsible: Prof. Dr. Wolfgang Wernsdorfer
Organisation: KIT Department of Physics
Part of: M-PHYS-104857 - Solid State Quantum Technologies

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Events					
ST 2023	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Reisinger
ST 2023	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Reisinger
ST 2024	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Reisinger
ST 2024	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Reisinger
ST 2025	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Cubaynes
ST 2025	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Cubaynes

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.218 Course: Solid State Quantum Technologies (Minor) [T-PHYS-109890]

Responsible: Prof. Dr. Wolfgang Wernsdorfer
Organisation: KIT Department of Physics
Part of: M-PHYS-104858 - Solid State Quantum Technologies (Minor)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	8	pass/fail	Irregular	1 terms	1

Events					
ST 2023	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Reisinger
ST 2023	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Reisinger
ST 2024	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Reisinger
ST 2024	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Reisinger
ST 2025	4021131	Solid State Quantum Technologies	2 SWS	Lecture / 🗣	Wernsdorfer, Cubaynes
ST 2025	4021132	Exercises to Solid State Quantum Technologies	2 SWS	Practice / 🗣	Wernsdorfer, Cubaynes

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.219 Course: Solid-State Optics, without Exercises [T-PHYS-104773]

Responsible: PD Dr. Michael Hetterich
Organisation: KIT Department of Physics
Part of: M-PHYS-102408 - Solid-State Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	2

Events					
WT 22/23	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich, Kalt
WT 23/24	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich
WT 24/25	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.220 Course: Solid-State Optics, without Exercises (Minor) [T-PHYS-104774]

Responsible: PD Dr. Michael Hetterich
Organisation: KIT Department of Physics
Part of: M-PHYS-102409 - Solid-State Optics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich, Kalt
WT 23/24	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich
WT 24/25	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.221 Course: Specialization Phase [T-PHYS-102481]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-101396 - Specialization Phase

Type	Credits	Grading scale	Version
Completed coursework	15	pass/fail	1

Prerequisites
none

5.222 Course: Spin Transport in Nanostructures [T-PHYS-104586]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: M-PHYS-102293 - Spin Transport in Nanostructures

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2023	4021141	Spintransport in Nanostrukturen	2 SWS	Lecture / 🗣	Beckmann
ST 2023	4021142	Übungen zu Spintransport in Nanostrukturen	1 SWS	Practice / 🗣	Beckmann, Maier
ST 2024	4021141	Spin Transport in Nanostructures	2 SWS	Lecture / 🗣	Beckmann
ST 2024	4021142	Exercises to Spin Transport in Nanostructures	1 SWS	Practice / 🗣	Beckmann
ST 2025	4021141	Spin Transport in Nanostructures	2 SWS	Lecture / 🗣	Beckmann
ST 2025	4021142	Exercises to Spin Transport in Nanostructures	1 SWS	Practice / 🗣	Beckmann

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.223 Course: Spin Transport in Nanostructures (Minor) [T-PHYS-110858]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: M-PHYS-105375 - Spin Transport in Nanostructures (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
ST 2023	4021141	Spintransport in Nanostrukturen	2 SWS	Lecture / 🗣	Beckmann
ST 2023	4021142	Übungen zu Spintransport in Nanostrukturen	1 SWS	Practice / 🗣	Beckmann, Maier
ST 2024	4021141	Spin Transport in Nanostructures	2 SWS	Lecture / 🗣	Beckmann
ST 2024	4021142	Exercises to Spin Transport in Nanostructures	1 SWS	Practice / 🗣	Beckmann
ST 2025	4021141	Spin Transport in Nanostructures	2 SWS	Lecture / 🗣	Beckmann
ST 2025	4021142	Exercises to Spin Transport in Nanostructures	1 SWS	Practice / 🗣	Beckmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.224 Course: Superconducting Nanostructures [T-PHYS-104513]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: M-PHYS-102191 - Superconducting Nanostructures

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 22/23	4021031	Supraleiter-Nanostrukturen	2 SWS	Lecture / 🗣	Beckmann
WT 22/23	4021032	Übungen zu Supraleiter-Nanostrukturen	1 SWS	Practice / 🗣	Beckmann
WT 23/24	4021031	Superconducting Nanostructures	2 SWS	Lecture / 🗣	Beckmann
WT 23/24	4021032	Exercises to Superconducting Nanostructures	1 SWS	Practice / 🗣	Beckmann
WT 24/25	4021031	Superconducting Nanostructures	2 SWS	Lecture / 🗣	Beckmann
WT 24/25	4021032	Exercises to Superconducting Nanostructures	1 SWS	Practice / 🗣	Beckmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.225 Course: Superconducting Nanostructures (Minor) [T-PHYS-109621]

Responsible: apl. Prof. Dr. Detlef Beckmann
Organisation: KIT Department of Physics
Part of: M-PHYS-104723 - Superconducting Nanostructures (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 22/23	4021031	Supraleiter-Nanostrukturen	2 SWS	Lecture / 🗣	Beckmann
WT 22/23	4021032	Übungen zu Supraleiter-Nanostrukturen	1 SWS	Practice / 🗣	Beckmann
WT 23/24	4021031	Superconducting Nanostructures	2 SWS	Lecture / 🗣	Beckmann
WT 23/24	4021032	Exercises to Superconducting Nanostructures	1 SWS	Practice / 🗣	Beckmann
WT 24/25	4021031	Superconducting Nanostructures	2 SWS	Lecture / 🗣	Beckmann
WT 24/25	4021032	Exercises to Superconducting Nanostructures	1 SWS	Practice / 🗣	Beckmann

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.226 Course: Superconductivity, Josephson Effect and Applications, with Exercises [T-PHYS-111293]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-105655 - Superconductivity, Josephson Effect and Applications, with Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4024161	Superconductivity, Josephson effect and applications	3 SWS	Lecture / 🗣	Shnirman
WT 23/24	4024162	Exercises to Superconductivity, Josephson effect and applications	1 SWS	Practice / 🗣	Shnirman, Piasotski

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.227 Course: Superconductivity, Josephson Effect and Applications, with Exercises (Minor) [T-PHYS-111294]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-105656 - Superconductivity, Josephson Effect and Applications, with Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 23/24	4024161	Superconductivity, Josephson effect and applications	3 SWS	Lecture / 🗣	Shnirman
WT 23/24	4024162	Exercises to Superconductivity, Josephson effect and applications	1 SWS	Practice / 🗣	Shnirman, Piasotski

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.228 Course: Superconductivity, Josephson Effect and Applications, without Exercises [T-PHYS-113257]

Responsible: Prof. Dr. Alexander Shnirman
Organisation: KIT Department of Physics
Part of: M-PHYS-106584 - Superconductivity, Josephson Effect and Applications, without Exercises

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 23/24	4024161	Superconductivity, Josephson effect and applications	3 SWS	Lecture / 🗣	Shnirman

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.229 Course: Superconductivity, Microscopic Theory and Macroscopic Phenomena [T-PHYS-113655]

Responsible: Prof. Dr. Jörg Schmalian
Organisation: KIT Department of Physics
Part of: M-PHYS-106796 - Superconductivity, Microscopic Theory and Macroscopic Phenomena

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 24/25	4024041	Superconductivity, Microscopic Theory and Macroscopic Phenomena	2 SWS	Lecture / 🗣	Schmalian
WT 24/25	4024042	Exercises to Superconductivity, Microscopic Theory and Macroscopic Phenomena	2 SWS	Practice / 🗣	Schultz, Schmalian

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.230 Course: Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor) [T-PHYS-113656]

Responsible: Prof. Dr. Jörg Schmalian
Organisation: KIT Department of Physics
Part of: M-PHYS-106797 - Superconductivity, Microscopic Theory and Macroscopic Phenomena (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 24/25	4024041	Superconductivity, Microscopic Theory and Macroscopic Phenomena	2 SWS	Lecture / 🗣	Schmalian
WT 24/25	4024042	Exercises to Superconductivity, Microscopic Theory and Macroscopic Phenomena	2 SWS	Practice / 🗣	Schultz, Schmalian

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.231 Course: Supersymmetry and Exotics at Colliders, with Exercises [T-PHYS-113734]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: M-PHYS-106848 - Supersymmetry and Exotics at Colliders, with Exercises

Type	Credits	Grading scale	Version
Oral examination	12	Grade to a third	1

Events					
WT 24/25	4026061	Supersymmetry and Exotics at Colliders	4 SWS	Lecture / 🗣	Mühlleitner
WT 24/25	4026062	Exercises to Supersymmetry and Exotics at Colliders	2 SWS	Practice / 🗣	Mühlleitner, NN

Legend: 🖥 Online, ❃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.232 Course: Supersymmetry and Exotics at Colliders, with Exercises (Minor) [T-PHYS-113735]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: M-PHYS-106849 - Supersymmetry and Exotics at Colliders, with Exercises (Minor)

Type	Credits	Grading scale	Version
Completed coursework (oral)	12	pass/fail	1

Events					
WT 24/25	4026061	Supersymmetry and Exotics at Colliders	4 SWS	Lecture / 🗣	Mühlleitner
WT 24/25	4026062	Exercises to Supersymmetry and Exotics at Colliders	2 SWS	Practice / 🗣	Mühlleitner, NN

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.233 Course: Supersymmetry and Exotics at Colliders, without Exercises [T-PHYS-113736]

Responsible: Prof. Dr. Milada Margarete Mühlleitner
Organisation: KIT Department of Physics
Part of: M-PHYS-106850 - Supersymmetry and Exotics at Colliders, without Exercises

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 24/25	4026061	Supersymmetry and Exotics at Colliders	4 SWS	Lecture / 🗣	Mühlleitner

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.234 Course: Surface Science, with Exercises [T-PHYS-113098]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: M-PHYS-106482 - Surface Science, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	10	Grade to a third	Irregular	1

Events					
ST 2023	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori
ST 2023	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Willke, Zakeri-Lori
ST 2024	4021121	Surface Science	4 SWS	Lecture / 🗣	Wulfhekel, Gerhard
ST 2024	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Wulfhekel, Gerhard, Gerber
ST 2025	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori
ST 2025	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Willke, Zakeri-Lori, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.235 Course: Surface Science, with Exercises (Minor) [T-PHYS-113100]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: M-PHYS-106484 - Surface Science, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	10	pass/fail	Irregular	1

Events					
ST 2023	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori
ST 2023	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Willke, Zakeri-Lori
ST 2024	4021121	Surface Science	4 SWS	Lecture / 🗣	Wulfhekel, Gerhard
ST 2024	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Wulfhekel, Gerhard, Gerber
ST 2025	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori
ST 2025	4021122	Exercises to Surface Science	1 SWS	Practice / 🗣	Willke, Zakeri-Lori, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

5.236 Course: Surface Science, without Exercises [T-PHYS-113099]

Responsible: TT-Prof. Dr. Philip Willke
Prof. Dr. Wulf Wulfhekel
PD Dr. Khalil Zakeri-Lori

Organisation: KIT Department of Physics

Part of: M-PHYS-106483 - Surface Science, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2023	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori
ST 2024	4021121	Surface Science	4 SWS	Lecture / 🗣	Wulfhekel, Gerhard
ST 2025	4021121	Surface Science	4 SWS	Lecture / 🗣	Willke, Zakeri-Lori

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.237 Course: Symmetries and Groups [T-PHYS-104596]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102317 - Symmetries and Groups

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
WT 22/23	4025031	Symmetries, Groups and Extended Gauge Theories	4 SWS	Lecture / 🗣	Nierste
WT 22/23	4025032	Exercises to Symmetries, Groups and Extended Gauge Theories	2 SWS	Practice / 🗣	Nierste, Lang

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.238 Course: Symmetries and Groups (Minor) [T-PHYS-104597]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102318 - Symmetries and Groups (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
WT 22/23	4025031	Symmetries, Groups and Extended Gauge Theories	4 SWS	Lecture / 🗣	Nierste
WT 22/23	4025032	Exercises to Symmetries, Groups and Extended Gauge Theories	2 SWS	Practice / 🗣	Nierste, Lang

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.239 Course: Symmetries, Groups and Extended Gauge Theories [T-PHYS-102393]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102315 - Symmetries, Groups and Extended Gauge Theories

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Irregular	1

Events					
WT 22/23	4025031	Symmetries, Groups and Extended Gauge Theories	4 SWS	Lecture / 🗣	Nierste
WT 22/23	4025032	Exercises to Symmetries, Groups and Extended Gauge Theories	2 SWS	Practice / 🗣	Nierste, Lang

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.240 Course: Symmetries, Groups and Extended Gauge Theories (Minor) [T-PHYS-102444]

Responsible: Prof. Dr. Ulrich Nierste
Organisation: KIT Department of Physics
Part of: M-PHYS-102316 - Symmetries, Groups and Extended Gauge Theories (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Irregular	1

Events					
WT 22/23	4025031	Symmetries, Groups and Extended Gauge Theories	4 SWS	Lecture / 🗣	Nierste
WT 22/23	4025032	Exercises to Symmetries, Groups and Extended Gauge Theories	2 SWS	Practice / 🗣	Nierste, Lang

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.241 Course: The ABC of DFT [T-PHYS-105960]

Responsible: Prof. Dr. Carsten Rockstuhl
Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102984 - The ABC of DFT

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2023	4023151	The ABC of DFT	2 SWS	Lecture / 🗣	Krstic, Wenzel
ST 2023	4023152	Exercises to The ABC of DFT	1 SWS	Practice / 🗣	Wenzel, Holzer
ST 2024	4023151	The ABC of DFT	2 SWS	Lecture / 🗣	Krstic, Wenzel
ST 2024	4023152	Exercises to The ABC of DFT	1 SWS	Practice / 🗣	Wenzel, Holzer
ST 2025	4023151	The ABC of DFT	2 SWS	Lecture / 🗣	Krstic, Wenzel, Holzer
ST 2025	4023152	Exercises to The ABC of DFT	1 SWS	Practice / 🗣	Wenzel, Holzer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.242 Course: Theoretical Cosmology, with Exercises [T-PHYS-113731]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold
Organisation: KIT Department of Physics
Part of: M-PHYS-106845 - Theoretical Cosmology, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Each summer term	1

Events					
ST 2025	4022201	Theoretical Cosmology	4 SWS	Lecture / 🗣	Kahlhöfer
ST 2025	4022202	Exercises to Theoretical Cosmology	2 SWS	Practice / 🗣	Kahlhöfer, Mansour, Rink

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.243 Course: Theoretical Cosmology, with Exercises (Minor) [T-PHYS-113732]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: M-PHYS-106846 - Theoretical Cosmology, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Each summer term	1

Events					
ST 2025	4022201	Theoretical Cosmology	4 SWS	Lecture / 🗣	Kahlhöfer
ST 2025	4022202	Exercises to Theoretical Cosmology	2 SWS	Practice / 🗣	Kahlhöfer, Mansour, Rink

Legend: 📱 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.244 Course: Theoretical Cosmology, without Exercises [T-PHYS-113733]

Responsible: Prof. Dr. Felix Kahlhöfer
Prof. Dr. Thomas Schwetz-Mangold

Organisation: KIT Department of Physics

Part of: M-PHYS-106847 - Theoretical Cosmology, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2025	4022201	Theoretical Cosmology	4 SWS	Lecture / 🗣	Kahlhöfer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.245 Course: Theoretical Molecular Biophysics, with Seminar [T-PHYS-102365]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102169 - Theoretical Molecular Biophysics, with Seminar

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
WT 22/23	4023031	Theoretische molekulare Biophysik	2 SWS	Lecture / 🗣	Wenzel
WT 22/23	4023032	Übungen zu Theoretische molekulare Biophysik	1 SWS	Practice / 🗣	Wenzel
WT 23/24	4023031	Theoretical Molecular Biophysics	2 SWS	Lecture / 🖥	Wenzel
WT 23/24	4023032	Exercises to Theoretical Molecular Biophysics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.246 Course: Theoretical Molecular Biophysics, with Seminar (Minor) [T-PHYS-102420]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102170 - Theoretical Molecular Biophysics, with Seminar (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
WT 22/23	4023031	Theoretische molekulare Biophysik	2 SWS	Lecture / 🗣	Wenzel
WT 22/23	4023032	Übungen zu Theoretische molekulare Biophysik	1 SWS	Practice / 🗣	Wenzel
WT 23/24	4023031	Theoretical Molecular Biophysics	2 SWS	Lecture / 🖥	Wenzel
WT 23/24	4023032	Exercises to Theoretical Molecular Biophysics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.247 Course: Theoretical Molecular Biophysics, without Seminar [T-PHYS-104473]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102171 - Theoretical Molecular Biophysics, without Seminar

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 22/23	4023031	Theoretische molekulare Biophysik	2 SWS	Lecture / 🗣	Wenzel
WT 22/23	4023032	Übungen zu Theoretische molekulare Biophysik	1 SWS	Practice / 🗣	Wenzel
WT 23/24	4023031	Theoretical Molecular Biophysics	2 SWS	Lecture / 🖥	Wenzel
WT 23/24	4023032	Exercises to Theoretical Molecular Biophysics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.248 Course: Theoretical Molecular Biophysics, without Seminar (Minor) [T-PHYS-104474]

Responsible: Prof. Dr. Wolfgang Wenzel
Organisation: KIT Department of Physics
Part of: M-PHYS-102172 - Theoretical Molecular Biophysics, without Seminar (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 22/23	4023031	Theoretische molekulare Biophysik	2 SWS	Lecture / 🗣	Wenzel
WT 22/23	4023032	Übungen zu Theoretische molekulare Biophysik	1 SWS	Practice / 🗣	Wenzel
WT 23/24	4023031	Theoretical Molecular Biophysics	2 SWS	Lecture / 🖥	Wenzel
WT 23/24	4023032	Exercises to Theoretical Molecular Biophysics	1 SWS	Practice / 🗣	Wenzel

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.249 Course: Theoretical Nanooptics [T-PHYS-104587]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: M-PHYS-102295 - Theoretical Nanooptics

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 22/23	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Fernandez Corbaton, Rockstuhl
WT 22/23	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Fernandez Corbaton, Rockstuhl
WT 23/24	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Garst, Fernandez Corbaton
WT 23/24	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Garst, Fernandez Corbaton
WT 24/25	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Rockstuhl, Fernandez Corbaton
WT 24/25	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Fernandez Corbaton, Rockstuhl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.250 Course: Theoretical Nanooptics (Minor) [T-PHYS-106311]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-103177 - Theoretical Nanooptics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 22/23	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Fernandez Corbaton, Rockstuhl
WT 22/23	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Fernandez Corbaton, Rockstuhl
WT 23/24	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Garst, Fernandez Corbaton
WT 23/24	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Garst, Fernandez Corbaton
WT 24/25	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Rockstuhl, Fernandez Corbaton
WT 24/25	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Fernandez Corbaton, Rockstuhl

Legend: Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.251 Course: Theoretical Optics [T-PHYS-104578]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-102277 - Theoretical Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2023	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Narozhnyy
ST 2023	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Narozhnyy, Perdana
ST 2024	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2024	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN
ST 2025	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2025	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.252 Course: Theoretical Optics - Unit [T-PHYS-102305]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: M-PHYS-102279 - Theoretical Optics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each summer term	1

Events					
ST 2023	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Narozhnyy
ST 2023	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Narozhnyy, Perdana
ST 2024	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2024	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN
ST 2025	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2025	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.253 Course: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises [T-PHYS-102544]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
ST 2023	4025112	Übungen zur Theoretischen Teilchenphysik I	2 SWS	Practice / 🗣	Melnikov, Haindl, Pikelner
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026112	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Mühlleitner, Borschensky
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser
WT 24/25	4026121	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.254 Course: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor) [T-PHYS-102540]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102037 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
ST 2023	4025112	Übungen zur Theoretischen Teilchenphysik I	2 SWS	Practice / 🗣	Melnikov, Haindl, Pikelner
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026112	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Mühlleitner, Borschensky
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser
WT 24/25	4026121	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.255 Course: Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises [T-PHYS-102546]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.256 Course: Theoretical Particle Physics I, Fundamentals, with Exercises [T-PHYS-102545]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102034 - Theoretical Particle Physics I, Fundamentals, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
ST 2023	4025112	Übungen zur Theoretischen Teilchenphysik I	2 SWS	Practice / 🗣	Melnikov, Haindl, Pikelner
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026112	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Mühlleitner, Borschensky
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser
WT 24/25	4026121	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.257 Course: Theoretical Particle Physics I, Fundamentals, with Exercises (Minor) [T-PHYS-102541]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102038 - Theoretical Particle Physics I, Fundamentals, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
ST 2023	4025112	Übungen zur Theoretischen Teilchenphysik I	2 SWS	Practice / 🗣	Melnikov, Haindl, Pikelner
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026112	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Mühlleitner, Borschensky
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser
WT 24/25	4026121	Exercises to Theoretical Particle Physics I	2 SWS	Practice / 🗣	Steinhauser, Stremmer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.258 Course: Theoretical Particle Physics I, Fundamentals, without Exercises [T-PHYS-102547]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102036 - Theoretical Particle Physics I, Fundamentals, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
ST 2023	4025111	Theoretische Teilchenphysik I	4 SWS	Lecture / 🗣	Melnikov
WT 23/24	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Mühlleitner
WT 24/25	4026111	Theoretical Particle Physics I	4 SWS	Lecture / 🗣	Steinhauser

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.259 Course: Theoretical Particle Physics II, with Exercises [T-PHYS-102552]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102046 - Theoretical Particle Physics II, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Each summer term	1

Events					
WT 22/23	4026011	Theoretische Teilchenphysik II	4 SWS	Lecture / 🗣	Mühlleitner
WT 22/23	4026012	Übungen zu Theoretische Teilchenphysik II	2 SWS	Practice / 🗣	Mühlleitner, NN
WT 23/24	4026011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Melnikov
WT 23/24	4026012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Melnikov, Pikelner
ST 2024	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Nierste
ST 2024	4025012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Nierste, Kretz
ST 2025	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Mühlleitner
ST 2025	4025012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Mühlleitner, Bonetti, Fontes

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.260 Course: Theoretical Particle Physics II, with Exercises (Minor) [T-PHYS-102548]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102044 - Theoretical Particle Physics II, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Each summer term	1

Events					
WT 22/23	4026011	Theoretische Teilchenphysik II	4 SWS	Lecture / 🗣	Mühlleitner
WT 22/23	4026012	Übungen zu Theoretische Teilchenphysik II	2 SWS	Practice / 🗣	Mühlleitner, NN
WT 23/24	4026011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Melnikov
WT 23/24	4026012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Melnikov, Pikelner
ST 2024	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Nierste
ST 2024	4025012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Nierste, Kretz
ST 2025	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Mühlleitner
ST 2025	4025012	Exercises to Theoretical Particle Physics II	2 SWS	Practice / 🗣	Mühlleitner, Bonetti, Fontes

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.261 Course: Theoretical Particle Physics II, without Exercises [T-PHYS-102554]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste

Organisation: KIT Department of Physics

Part of: M-PHYS-102048 - Theoretical Particle Physics II, without Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
WT 22/23	4026011	Theoretische Teilchenphysik II	4 SWS	Lecture / 🗣	Mühlleitner
WT 23/24	4026011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Melnikov
ST 2024	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Nierste
ST 2025	4025011	Theoretical Particle Physics II	4 SWS	Lecture / 🗣	Mühlleitner

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 5.262 Course: Theoretical Quantum Optics [T-PHYS-110303]

Responsible: Prof. Dr. Anja Metelmann
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-105094 - Theoretical Quantum Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 22/23	4023011	Theoretical Quantum Optics	2 SWS	Lecture / 🗣	Metelmann
WT 22/23	4023012	Exercises to Theoretical Quantum Optics	1 SWS	Practice / 🗣	Metelmann, Böhling
WT 23/24	4023011	Theoretical Quantum Optics	2 SWS	Lecture / 🗣	Metelmann
WT 23/24	4023012	Exercises to Theoretical Quantum Optics	1 SWS	Practice / 🗣	Orr, Metelmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.263 Course: Theoretical Quantum Optics (Minor) [T-PHYS-110884]

Responsible: Prof. Dr. Anja Metelmann
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-105395 - Theoretical Quantum Optics (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Irregular	1

Events					
WT 22/23	4023011	Theoretical Quantum Optics	2 SWS	Lecture / 🗣	Metelmann
WT 22/23	4023012	Exercises to Theoretical Quantum Optics	1 SWS	Practice / 🗣	Metelmann, Böhling
WT 23/24	4023011	Theoretical Quantum Optics	2 SWS	Lecture / 🗣	Metelmann
WT 23/24	4023012	Exercises to Theoretical Quantum Optics	1 SWS	Practice / 🗣	Orr, Metelmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.264 Course: Theory and Applications of Quantum Machines [T-PHYS-112018]

Responsible: Prof. Dr. Anja Metelmann
Organisation: KIT Department of Physics
Part of: M-PHYS-105942 - Theory and Applications of Quantum Machines

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	4024181	Theory and Applications of Quantum Machines	2 SWS	Lecture / 🗣	Metelmann
ST 2024	4024182	Exercises to Theory and Applications of Quantum Machines	2 SWS	Practice / 🗣	Orr, Metelmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.265 Course: Theory and Applications of Quantum Machines (Minor) [T-PHYS-112019]

Responsible: Prof. Dr. Anja Metelmann
Organisation: KIT Department of Physics
Part of: M-PHYS-105943 - Theory and Applications of Quantum Machines (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
ST 2024	4024181	Theory and Applications of Quantum Machines	2 SWS	Lecture / 🗣	Metelmann
ST 2024	4024182	Exercises to Theory and Applications of Quantum Machines	2 SWS	Practice / 🗣	Orr, Metelmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.266 Course: Theory of Magnetism, with Exercises [T-PHYS-110869]

Responsible: Prof. Dr. Markus Garst
Organisation: KIT Department of Physics
Part of: M-PHYS-105381 - Theory of Magnetism, with Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2025	4023171	Theory of Magnetism	2 SWS	Lecture / 🗣	Garst, Masell
ST 2025	4023172	Exercises to Theory of Magnetism	2 SWS	Practice / 🗣	Garst, Masell

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.267 Course: Theory of Magnetism, with Exercises (Minor) [T-PHYS-110873]

Responsible: Prof. Dr. Markus Garst
Organisation: KIT Department of Physics
Part of: M-PHYS-105385 - Theory of Magnetism, with Exercises (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Irregular	1

Events					
ST 2025	4023171	Theory of Magnetism	2 SWS	Lecture / 🗣	Garst, Masell
ST 2025	4023172	Exercises to Theory of Magnetism	2 SWS	Practice / 🗣	Garst, Masell

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.268 Course: Theory of Seismic Waves [T-PHYS-104736]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-102367 - Theory of Seismic Waves

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2023	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2023	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen
ST 2024	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2024	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen
ST 2025	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2025	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.269 Course: Theory of Seismic Waves (Minor) [T-PHYS-105571]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-102657 - Theory of Seismic Waves (Minor)

Type	Credits	Grading scale	Version
Completed coursework	6	pass/fail	1

Events					
ST 2023	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2023	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen
ST 2024	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2024	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen
ST 2025	4060221	Theory of Seismic Waves	2 SWS	Lecture / 🗣	Bohlen, Hertweck
ST 2025	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice / 🗣	Hertweck, Bohlen

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.270 Course: Theory of Strongly Correlated Electron Systems [T-PHYS-112245]

Responsible: PD Dr. Robert Eder
Organisation: KIT Department of Physics
Part of: M-PHYS-106056 - Theory of Strongly Correlated Electron Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	12	Grade to a third	Irregular	1

Events					
WT 22/23	4024071	Theory of Strongly Correlated Electron Systems	4 SWS	Lecture / 🗣	Eder
WT 22/23	4024072	Exercises to Theory of Strongly Correlated Electron Systems	2 SWS	Practice / 🗣	Eder

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.271 Course: Topology in Condensed Matter Physics: Fundamentals and Advanced Topics [T-PHYS-113258]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: M-PHYS-106586 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4024081	Topology in Condensed Matter Physics	3 SWS	Lecture / 🗣	Gornyi, Mirlin
WT 23/24	4024082	Exercises to Topology in Condensed Matter Physics	1 SWS	Practice / 🗣	Poboiko, Gornyi, Mirlin

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

5.272 Course: Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor) [T-PHYS-113259]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: M-PHYS-106587 - Topology in Condensed Matter Physics: Fundamentals and Advanced Topics (Minor)

Type	Credits	Grading scale	Version
Completed coursework	8	pass/fail	1

Events					
WT 23/24	4024081	Topology in Condensed Matter Physics	3 SWS	Lecture / 🗣	Gornyi, Mirlin
WT 23/24	4024082	Exercises to Topology in Condensed Matter Physics	1 SWS	Practice / 🗣	Poboiko, Gornyi, Mirlin

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.273 Course: Topology in Condensed Matter Physics: Fundamentals and Selected Topics [T-PHYS-113260]

Responsible: apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin

Organisation: KIT Department of Physics

Part of: M-PHYS-106588 - Topology in Condensed Matter Physics: Fundamentals and Selected Topics

Type	Credits	Grading scale	Version
Oral examination	2	Grade to a third	1

Events					
WT 23/24	4024081	Topology in Condensed Matter Physics	3 SWS	Lecture / 🗣	Gornyi, Mirlin
WT 23/24	4024082	Exercises to Topology in Condensed Matter Physics	1 SWS	Practice / 🗣	Poboiko, Gornyi, Mirlin

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.274 Course: Tropical Meteorology [T-PHYS-111411]

Responsible: Prof. Dr. Peter Knippertz
Organisation: KIT Department of Physics
Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	3

Events					
WT 22/23	4052111	Tropical Meteorology	2 SWS	Lecture / Blended	Knippertz
WT 22/23	4052112	Exercises to Tropical Meteorology	1 SWS	Practice / Blended	Knippertz, Lemburg
WT 23/24	4052111	Tropical Meteorology	2 SWS	Lecture / Blended	Knippertz
WT 23/24	4052112	Exercises to Tropical Meteorology	1 SWS	Practice / Blended	Knippertz, Woodhams
WT 24/25	4052111	Tropical Meteorology	2 SWS	Lecture / Blended	Knippertz
WT 24/25	4052112	Exercises to Tropical Meteorology	1 SWS	Practice / Blended	Knippertz, Lemburg, Ssemujju

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Students must achieve 50% of the points on the exercise sheets.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.275 Course: Turbulent Diffusion [T-PHYS-111427]

Responsible: Prof. Dr. Corinna Hoose
Dr. Gholamali Hoshyaripour

Organisation: KIT Department of Physics

Part of: M-PHYS-104577 - Selected Topics in Meteorology (Second Major, graded)
M-PHYS-104578 - Selected Topics in Meteorology (Minor, ungraded)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each summer term	3

Events					
ST 2023	4052081	Turbulent Diffusion	2 SWS	Lecture / 🗣	Hoshyaripour, Hoose
ST 2023	4052082	Exercises to Turbulent Diffusion	1 SWS	Practice / 🗣	Hoshyaripour, Hoose, Chopra
ST 2024	4052081	Turbulent Diffusion	2 SWS	Lecture / 🗣	Hoshyaripour, Hoose
ST 2024	4052082	Exercises to Turbulent Diffusion	1 SWS	Practice / 🗣	Hoshyaripour, Hoose, Chopra
ST 2025	4052081	Turbulent Diffusion	2 SWS	Lecture / 🗣	Hoshyaripour, Hoose
ST 2025	4052082	Exercises to Turbulent Diffusion	1 SWS	Practice / 🗣	Hoshyaripour, Hoose, Chopra

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
There are 7 exercises with 100 points in total.

To pass the prerequisite students must:

- Obtain at least 50 points from exercises.
- Present and explain at least one of the ICON-ART exercises in the class.

Prerequisites
None

Recommendation
None

Annotation
None

Workload
90 hours

T 5.276 Course: Wildcard Non-Physics Elective, Module with 1 Brick, 8 CP graded [T-PHYS-104384]

Organisation: KIT Department of Physics

Part of: M-PHYS-102091 - Wildcard Non-Physics Elective, Module with 1 Brick

Type	Credits	Grading scale	Version
Examination of another type	8	Grade to a third	1

Prerequisites

none

T 5.277 Course: Wildcard Non-Physics Elective, Module with 2 Bricks, 4 CP graded [T-PHYS-106221]

Organisation: KIT Department of Physics

Part of: M-PHYS-103129 - Wildcard Non-Physics Elective, Module with 2 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Irregular	1

Prerequisites

none

5.278 Course: Wildcard Non-Physics Elective, Module with 2 Bricks, 4 CP graded [T-PHYS-106222]

Organisation: KIT Department of Physics

Part of: M-PHYS-103129 - Wildcard Non-Physics Elective, Module with 2 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Irregular	1

Prerequisites

none

T 5.279 Course: Wildcard Non-Physics Elective, Module with 3 Bricks, 2 CP graded [T-PHYS-106225]

Organisation: KIT Department of Physics
Part of: M-PHYS-103130 - Wildcard Non-Physics Elective, Module with 3 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Irregular	1

Prerequisites
none

T 5.280 Course: Wildcard Non-Physics Elective, Module with 3 Bricks, 3 CP graded [T-PHYS-106224]

Organisation: KIT Department of Physics

Part of: M-PHYS-103130 - Wildcard Non-Physics Elective, Module with 3 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Irregular	1

Prerequisites

none

T 5.281 Course: Wildcard Non-Physics Elective, Module with 3 Bricks, 3 CP graded [T-PHYS-106223]

Organisation: KIT Department of Physics

Part of: M-PHYS-103130 - Wildcard Non-Physics Elective, Module with 3 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Irregular	1

Prerequisites

none

T 5.282 Course: Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded [T-PHYS-106229]

Organisation: KIT Department of Physics

Part of: M-PHYS-103131 - Wildcard Non-Physics Elective, Module with 4 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Irregular	1

Prerequisites

none

T 5.283 Course: Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded [T-PHYS-106226]

Organisation: KIT Department of Physics

Part of: M-PHYS-103131 - Wildcard Non-Physics Elective, Module with 4 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Irregular	1

Prerequisites

none

T 5.284 Course: Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded [T-PHYS-106228]

Organisation: KIT Department of Physics
Part of: M-PHYS-103131 - Wildcard Non-Physics Elective, Module with 4 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Irregular	1

Prerequisites
none

T 5.285 Course: Wildcard Non-Physics Elective, Module with 4 Bricks, 2 CP graded [T-PHYS-106227]

Organisation: KIT Department of Physics

Part of: M-PHYS-103131 - Wildcard Non-Physics Elective, Module with 4 Bricks

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Irregular	1

Prerequisites

none

T 5.286 Course: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab [T-PHYS-111156]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105555 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 22/23	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Baumbach, Al Hassan, Kalt
WT 22/23	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Baumbach, Al Hassan, Kalt
WT 23/24	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 23/24	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Kaminski, Baumbach
WT 23/24	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Kaminski, Baumbach
WT 24/25	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 24/25	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Kaminski, Baumbach
WT 24/25	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Kaminski, Baumbach

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.287 Course: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor) [T-PHYS-111158]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105557 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, with Exercises and Lab (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each winter term	1

Events					
WT 22/23	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 22/23	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Baumbach, Al Hassan, Kalt
WT 22/23	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Baumbach, Al Hassan, Kalt
WT 23/24	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 23/24	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Kaminski, Baumbach
WT 23/24	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Kaminski, Baumbach
WT 24/25	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 24/25	4028062	Exercises to X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	1 SWS	Practice / 🗣	Kaminski, Baumbach
WT 24/25	4028063	Lab course to X-ray Physics I	1 SWS	Practical course / 🗣	Kaminski, Baumbach

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.288 Course: X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab [T-PHYS-111157]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105556 - X-ray Physics I: Scattering, Diffraction & Spectroscopy on Crystals, thin Films and Nanostructures, without Exercises and without Lab

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 23/24	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov
WT 24/25	4028061	X-ray Physics I: Scattering, Diffraction and Spectroscopy on Crystals, Thin Films and Nanostructures	2 SWS	Lecture / 🗣	Baumbach, Stankov

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.289 Course: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab [T-PHYS-111159]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105558 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2023	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2023	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Spiecker, Baumbach, Stankov
ST 2023	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Spiecker, Baumbach, Stankov
ST 2024	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2024	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Spiecker, Baumbach, Stankov
ST 2024	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Spiecker, Baumbach, Stankov
ST 2025	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2025	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Baumbach, Stankov, Hurst, Zuber
ST 2025	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Baumbach, Stankov, Hurst, Zuber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

T 5.290 Course: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor) [T-PHYS-111161]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105560 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, with Exercises and Lab (Minor)

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	8	pass/fail	Each summer term	1

Events					
ST 2023	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2023	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Spiecker, Baumbach, Stankov
ST 2023	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Spiecker, Baumbach, Stankov
ST 2024	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2024	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Spiecker, Baumbach, Stankov
ST 2024	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Spiecker, Baumbach, Stankov
ST 2025	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2025	4028132	Übungen zu X-ray Physics II	1 SWS	Practice / 🗣	Baumbach, Stankov, Hurst, Zuber
ST 2025	4028133	Praktikum zu X-ray Physics II	1 SWS	Practical course / 🗣	Baumbach, Stankov, Hurst, Zuber

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.291 Course: X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab [T-PHYS-111160]

Responsible: Prof. Dr. Gerd Tilo Baumbach
Dr. Svetoslav Stankov

Organisation: KIT Department of Physics

Part of: M-PHYS-105559 - X-ray Physics II: Optical Coherence, Imaging and Computed Tomography, without Exercises and without Lab

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Events					
ST 2023	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2024	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov
ST 2025	4028131	X-ray Physics II: Optical Coherence, Imaging and Computed Tomography	2 SWS	Lecture / 🗣	Baumbach, Stankov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled