Subdivided Module Catalogue
for the Subject

FOKUS Physics
as a Master’s with 1 major
with the degree "Master of Science"
(120 ECTS credits)

Examination regulations version: 2011
Responsible: Faculty of Physics and Astronomy
Course of Studies - Contents and Objectives

The FOKUS master study program is a special course, which provides on the one hand short time study (only 8 semesters in a consecutive Bachelor and Master program) and on the other hand puts significant emphasis on early integration of research activities. This Master study program is embedded an financed through the »Elitenetzwerk Bayern« (ENB). The master course is especially preparing the students for their later scientific work in the field of Physics. Qualified graduates may pursue doctoral work (degree Dr. rer. nat.) at doctorate-granting institutions. The goal of the studies is it to mediate special knowledge on the most important subsections of the experimental and theoretical physics and to make the students familiar with the methods of scientific and physical thinking and working. By training of analytic thinking abilities the students acquire the ability to deal later with the various fields of applications and to compile the special knowledge obtained within the Bachelor programme. During the Master thesis the student should independently work on a new thematic and temporally limited experimental or theoretical engineering-scientific task in the field of experimental or theoretical physics using well-known procedures and scientific criteria.
Abbreviations used

Course types: E = field trip, K = colloquium, O = conversatorium, P = placement/lab course, R = project, S = seminar, T = tutorial, Ü = exercise, V = lecture

Term: SS = summer semester, WS = winter semester

Methods of grading: NUM = numerical grade, B/NB = (not) successfully completed

Regulations: (L)ASPO = general academic and examination regulations (for teaching-degree programmes), FSB = subject-specific provisions, SFB = list of modules

Other: A = thesis, LV = course(s), PL = assessment(s), TN = participants, VL = prerequisite(s)

Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

In accordance with

the general regulations governing the degree subject described in this module catalogue:

ASPO2009

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

29-Jun-2011 (2011-40) except for mandatory electives added in Fast Track procedure at a later time

25-Mar-2013 (2012-185) except for mandatory electives added in Fast Track procedure at a later time

26-Sep-2012 (2012-33) except for mandatory electives added in Fast Track procedure at a later time

4-Nov-2014 (2014-71) except for mandatory electives added in Fast Track procedure at a later time

17-Dec-2014 (2014-85)
This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.
The subject is divided into

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### Current Topics in Experimental Physics

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### Theoretical Physics

Students must achieve a minimum of 5 ECTS credits.

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<td>11-FM-QUI-132-m01</td>
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<td>11-FM-DFT-142-m01</td>
<td>FOKUS Research Module Density Functional Theory and the Physics of Oxide Heterostructure</td>
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**Thesis (30 ECTS credits)**

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<td>FOKUS Project Practical Course Physics</td>
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<th>Module offered by</th>
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<tr>
<td>chairperson of examination committee</td>
<td>Faculty of Physics and Astronomy</td>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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**Contents**

Independent work on a current research topic of Experimental and Theoretical Physics and implementation of scientific experiments including analysis and documentation of the results.

**Intended learning outcomes**

The students are able to independently work on a current research area of Experimental or Theoretical Physics, to conduct and analyse scientific experiments and to document the results.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 20 pages) and talk (approx. 30 minutes) on respective topic researched

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th><strong>Module title</strong></th>
<th><strong>Abbreviation</strong></th>
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<tbody>
<tr>
<td>Professional Specialization FOKUS Physics</td>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

Introduction to current experimental or theoretical questions of a subdiscipline of Physics with special relevance to the planned topic of the Master's thesis. Summary of the required fundamental topics in a seminar presentation.

**Intended learning outcomes**

The students have advanced knowledge of a current experimental or theoretical subdiscipline of Physics with a special relevance to the intended topic of the Master's thesis. They know the current state of research in this area and are able to summarise their knowledge in an oral presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- talk with discussion (approx. 30 to 45 minutes)

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<thead>
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<th>Module title</th>
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<td>Scientific Methods and Project Management FOKUS Physics</td>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

**Contents**

Introduction to the methods of scientific work, taking into account methods of project planning. Application to theoretical and experimental questions of Physics, writing of a scientific project plan for the planned Master’s thesis.

**Intended learning outcomes**

The students have knowledge of scientific methods and methodological work, including project planning methods of a current experimental and theoretical subdiscipline of Physics with special relevance to the intended topic of the Master’s thesis. They are able to draft a project plan for the Master’s thesis and to plan the required experimental or theoretical work. They are able to describe their projects in oral presentations.

**Courses** (type, number of weekly contact hours, language — if other than German)

R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk with discussion (approx. 30 to 45 minutes)

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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<td>Advanced Seminar Experimental/Theoretical Physics</td>
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<td>Managing Directors of the Institute of Applied Physics and the Institute of Theoretical Physics and Astrophysics</td>
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<tbody>
<tr>
<td>1 semester</td>
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**Contents**

Seminar on current issues of Theoretical or Experimental Physics.

**Intended learning outcomes**

The students have advanced knowledge of a current specialist field of Experimental or Theoretical Physics. They are able to extract knowledge from professional publications and to summarise this knowledge and present it to a professional audience.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk with discussion (approx. 30 to 45 minutes)

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
## Module Catalogue for the Subject FOKUS Physics
### Master’s with 1 major, 120 ECTS credits

<table>
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<tr>
<td>1 semester</td>
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<td>Admission prerequisite to assessment: successful completion of approx. 50% of exercises. Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
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</table>

### Contents

- History of astronomy, coordinates and time measurement, the solar system, size scales in outer space, telescopes and detectors, stellar structure, stellar atmospheres, stellar evolution, final stages of stellar evolution, interstellar medium, structure of the Milky Way, local universe, expanding space-time, galaxies, active galactic nuclei, large-scale structure of the universe, Friedmann World Models, thermodynamics of the early universe, primordial nucleosynthesis, cosmic microwave background radiation, structure formation, inflation

### Intended learning outcomes

- The students are familiar with the modern world view of Astrophysics. They know methods and tools for astrophysical observations and evaluations. They are able to use these methods to plan and analyse own observations. They know the structure of the universe, e.g. of stars and galaxies and understand the process of their development.

### Courses

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### Method of assessment

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<tr>
<td>written examination (approx. 120 minutes)</td>
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### Allocation of places

- Only as part of pool of general key skills (ASQ): 15 places. Places will be allocated by lot.

### Additional information

-...

### Referred to in LPO I

-...
<table>
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<td>Organic Semiconductor</td>
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<td>Managing Director of the Institute</td>
<td>Faculty of Physics</td>
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### ModuleCatalogue for the Subject

**Module title**: Principles of Energy Technologies  
**Abbreviation**: 11-ENT-092-m01

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<td>Faculty of Physics and Astronomy</td>
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<td>Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
</tr>
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</table>

### Contents


### Intended learning outcomes

The students know the principles of different methods of energy technology, especially energy conversion, transport and storage. They understand the structures of corresponding installations and are able to compare them.

### Courses

<table>
<thead>
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### Method of assessment

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<tr>
<td>a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)</td>
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</table>

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.  
Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module Catalogue for the Subject

**FOKUS Physics**

**Master’s with 1 major, 120 ECTS credits**

<table>
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<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Introduction to Plasmaphysics</td>
<td>11-EPP-092-m01</td>
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**Module coordinator**  
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**  
Faculty of Physics and Astronomy

<table>
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<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
<th>Other prerequisites</th>
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**Contents**

Plasma Astrophysics: Dynamics of charged particles in electric and magnetic fields, Magnetohydrodynamics, Transport equations for energetic particles, Properties of magnetic turbulence, Propagation of solar particles within the solar wind, Particle acceleration via shock waves and via interaction with plasma turbulence, Particle acceleration and transport in galaxies and other astrophysical objects, Cosmic radiation.

**Intended learning outcomes**

The students know the principles of Plasma Physics, especially the description of transport phenomena in plasma. They are able to solve basic problems of Plasma Physics and to apply this knowledge to Astrophysics.

**Courses**  
(type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

--
## Module title
Semiconductor Lasers - Principles and Current Research

## Abbreviation
11-HLF-092-m01

### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents
This lecture discusses the principles of laser physics, based on the example of semiconductor lasers, and current developments regarding components. The principles of lasers are described on the basis of a general laser model, which will then be extended to special aspects of semiconductor lasers. Basic concepts such as threshold condition, characteristic curve and laser efficiency are derived from coupled rate equations for charge carriers and photons. Other topics of the lecture are optical processes in semiconductors, layer and ridge waveguides, laser resonators, mode selection, dynamic properties as well as technology for the generation of semiconductor lasers. The lecture closes with current topics of laser research such as quantum dot lasers, quantum cascade lasers, terahertz lasers or high-performance lasers.

### Intended learning outcomes
The students have advanced knowledge of the principles of semiconductor-laser physics. They can apply their knowledge to modern questions and know the applications in the current development of components.

### Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title: Thermodynamics and Economics
Abbreviation: 11-TDO-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: Only after succ. compl. of module(s)
Numerical grade: --

Duration: 1 semester
Module level: graduate
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents:
Energy and economic growth, entropy production, emission reduction. Part I describes the role of energy conversion in the development of the universe, the evolution of life and the unfolding of civilisation. In non-equilibrium thermodynamics, the entropy production density shows the relevance of the second law of thermodynamics for ecological damage and resource consumption. Energy conversion, entropy production and natural resources define the technological and ecological boundaries of industrial economic growth. Part 2 analyses how the factors capital, work, energy and creativity produce the goods and services of a national economy and determine economic growth. The productive power of cheap energy by far exceeds that of expensive labour. Within the current system of taxes and social security contributions, this discrepancy between power and costs of production factors leads to job cuts, waste of resources, impoverishment of nations and growing social tensions. The course discusses how factor income taxation can counteract this development. Part 3 includes seminar presentations, comprises the techniques of rational energy use and non-fossil energy use, and introduces the optimisation programme deeco (Dynamic Energy, Emission and Cost Optimization).

Intended learning outcomes:
The students understand that energy conversion and entropy production are going to play an important role in the world’s economic and social development. As an extension of economic theory, the students know the connections between thermodynamics and economy as well as the productive physical basis of modern economies. They are able to apply the acquired knowledge to particular problems.

NOTE: this is the module that was run by Prof. Dr. R. Kümmel, who has now retired. As the module was tailored to his own theory of economy, it has yet to be decided whether we will continue to offer this module.

Courses:
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
(a) written examination (approx. 90 minutes) or
(b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or
(c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or
(d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English
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</table>
Module title: Solid State Physics 2

Abbreviation: 11-FK2-092-m01

Module coordinator: Managing Director of the Institute of Applied Physics

Module offered by: Faculty of Physics and Astronomy

ECTS: 8

Method of grading: numerical grade

Duration: 1 semester

Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents:

Intended learning outcomes:
The students have specific and advanced knowledge in the field of Solid-State Physics. They are theoretically able to specialise in a sub-discipline of Solid-State Physics.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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## Module Catalogue for the Subject FOKUS Physics

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Solid State Spectroscopy</td>
<td>11-FKS-092-m01</td>
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### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

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</table>

### Duration
1 semester

### Module level
graduate

### Contents

### Intended learning outcomes
The students have specific and advanced knowledge in the field of solid-state spectroscopy. They know different types of spectroscopy and their fields of application. They understand the theoretical principles and the current developments in research.

### Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
---|---
Semiconductor Physics | 11-HLP-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
6 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have specific and advanced knowledge in the field of Semiconductor Physics. They know the physical principles of semiconductors and have gained an overview of the important characteristics of semiconductor materials.

Courses
(type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Semiconductor Nanostructures

### Abbreviation
11-HNS-092-m01

<table>
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### Contents
Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

### Intended learning outcomes
The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

### Courses
(type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German, English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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## Module Catalogue for the Subject
### FOKUS Physics
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
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<tr>
<td>Magnetism</td>
<td>11-MAG-092-m01</td>
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### Contents
Dia- and paramagnetism, exchange interaction, ferromagnetism, antiferromagnetism, anisotropy, domain structure, nanomagnetism, superparamagnetism, experimental methods to measure magnetic properties, Kondo effect.

### Intended learning outcomes
The students know basic terms, concepts and phenomena of magnetism and measuring methods for magnetic experiments; they are skilled in simple model building and in the formulation of mathematical-physical approaches and are able to apply them to tasks in the stated areas; they have competencies in independently working on problems of these areas; they are able to evaluate the accuracy of observations and analyses.

### Courses
(R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

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Language of assessment: German, English

### Allocation of places
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### Additional information
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Module Catalogue for the Subject
FOKUS Physics
Master's with 1 major, 120 ECTS credits

<table>
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<td>Nanoanalytics</td>
<td>11-NAN-092-m01</td>
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Contents

Intended learning outcomes
The students have basic knowledge of modern research methods for different nanostructures up to an atomic level. They know microscoping procedures that are used in practice in labs and the industry as well as spectroscopic methods for the determination of electronic properties. They are able to evaluate the efficiency of different research methods.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
--- | ---
Low-Dimensional Structures | 11-NDS-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
4 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Low-dimensional structures: Crystal lattice symmetry. Lattice dynamics and growth techniques of low-dimensional structures. Comparison between these structures and volume solids. X-ray diffractometry. Molecular beam epitaxy.

Intended learning outcomes
The students have knowledge of the theoretical principles of the growth of low dimensional structures. They know methods of producing and analysing such structures. They know the bandstructures of the most important semiconductors as well as the fabrication and characteristics of semiconductor heterostructures and MOS-diodes. They are familiar with the subband structure of semiconductor heterostructures and MOS-diodes and can evaluate the importance of many-particle effects. They are able to solve problems related to potentials in one dimension by applying Poisson's equation. They know the k*p perturbation theory and can deduce the 2D subband structure from the bulk band structure. They understand how an external magnetic field acts on the properties of a free electron gas in 2D. They have basic knowledge of the meaning of gauging, Landau-quantisation, filling factor and Landau degeneracy. They understand the dependence of various physical properties on the filling factor, and are able to solve implicit problems via numerical methods. They are familiar with elementary excitations in two-dimensional systems.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German, English

Allocation of places
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### Additional information

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</table>
**Module title**  
Nano-Optics

**Abbreviation**  
11-NOP-092-m01

**Module coordinator**  
Managing Director of the Institute of Applied Physics

**Module offered by**  
Faculty of Physics and Astronomy

**ECTS**  
4

**Method of grading**  
Only after succ. compl. of module(s)

**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**Contents**  

**Intended learning outcomes**  
The students have specific and advanced knowledge in the field of nano-optics. They are familiar with the theoretical principles and application areas of nano-optics and with current developments in this field.

**Courses**  
R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Quantum Mechanics II</td>
<td>11-QM2-092-m01</td>
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</table>

**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

<table>
<thead>
<tr>
<th>ECTS</th>
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<th>Only after succ. compl. of module(s)</th>
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<tbody>
<tr>
<td>8</td>
<td>numerical grade</td>
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</table>

**Duration**
1 semester

**Module level**
undergraduate

**Other prerequisites**
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**Contents**

"Quantum mechanics II" constitutes the central theoretical course of the international Master’s program in Physics. It builds upon basics which are acquired in the lecture "Quantum mechanics I" of the Bachelor’s degree. While the specific emphasis can be adjusted individually, the core topics that are supposed to be covered should include:

1. Second quantisation: Fermions and bosons
2. Band structures of particles in a crystal
3. Angular momentum, symmetry operators, Lie Algebras
4. Scattering theory: Potential scattering, partial wave expansion
5. Relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, Lorentz group, fine structure splitting of atomic spectra
6. Quantum entanglement
7. Canonical formalism

**Intended learning outcomes**
The students acquire in-depth knowledge of advanced quantum mechanics and have a thorough understanding of the mathematical and theoretical concepts of the listed topics. They are able to describe or model problems of modern theoretical Quantum Physics mathematically, to solve problems analytically, to use approximation methods and to interpret the results physically. The course is pivotal to subsequent theory courses in Astrophysics, High-Energy Physics and Condensed Matter/Solid-State Physics. The course is mandatory for all Master’s students.

**Courses** (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English
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<tr>
<td>Additional information</td>
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<td>Module title</td>
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<tr>
<td>Quantum Phenomena in electronic correlated Materials</td>
<td>11-QPM-092-m01</td>
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<td>Faculty of Physics and Astronomy</td>
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<th>Duration</th>
<th>Module level</th>
<th>Contents</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
<td>Quantum effects and phenomena in current solid-state research. Correlations. Free electron gas and Fermi liquid. Strongly correlated systems</td>
</tr>
</tbody>
</table>

### Intended learning outcomes

The students have specific, advanced knowledge of the current research on Solid-State Physics, especially on quantum effects in strongly correlated systems. They are able to understand the connections between the theoretical description of such systems and the current experimental results.

### Courses

- **R + V** (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)
Module title: Many Body Quantum Theory  
Abbreviation: 11-QVTP-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics  
Module offered by: Faculty of Physics and Astronomy

ECTS: 8  
Method of grading: Only after succ. compl. of module(s)  
Duration: 1 semester  
Module level: graduate  
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

This will usually be a course on quantum many particle physics approached by the perturbative methods using Green’s functions.  
An outline could be:  
1 Single-particle Green’s function  
2 Review of second quantization  
3 Diagrammatic method using many particle Green’s functions at temperature T=0  
4 Diagrammatic method for finite T  
5 Landau theory of Fermi liquids  
6 Superconductivity  
7 One-dimensional systems and bosonization

Intended learning outcomes

The students have mastered the principles of quantum field theory in many-particle systems. They are able to apply the acquired methods to current problems of Theoretical Solid-State Physics.

Courses (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.  
Language of assessment: German, English

Allocation of places

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Additional information

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Master’s with 1 major FOKUS Physics (2011)
Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Relativistic Effects in Mesoscopic Systems | 11-RMS-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---
5 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Relativistic effects in mesoscopic systems. - Spin-orbit coupling. - Dirac equation. - Quantum Hall effect. - Topological insulators. - Majorana fermions

Intended learning outcomes
The students have mastered the mathematical methods for the description of relativistic quantum systems, especially in the field of mesoscopic physics. They are able to apply their knowledge to simple systems.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Theoretical Solid State Physics

Module title | Abbreviation
--- | ---
Theoretical Solid State Physics | 11-TFK-092-m01

Module coordinator | Module offered by
--- | ---
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
8 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents


Intended learning outcomes

The students have basic knowledge of the theoretical description of solid-state phenomena. They know the corresponding mathematical or theoretical methods and are able to apply them to basic problems of solid-state theory and to understand the connections to experimental results. The individual students have elaborated on an advanced topic of solid-state theory and have discussed this topic in a seminar presentation.

Courses (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title: Theory of Superconductivity
Abbreviation: 11-TSL-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics
Module offered by: Faculty of Physics and Astronomy

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have basic knowledge of the theoretical models for the description of superconductivity. They know the properties and application areas of these models and are able to apply calculation methods to simple problems.

Courses
(type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
## Biophysical Measurement Technology in Medical Science

<table>
<thead>
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<tbody>
<tr>
<td>Biophysical Measurement Technology in Medical Science</td>
<td>11-BMT-092-m01</td>
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</table>

### Module Information

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<td>6</td>
<td>numerical grade</td>
<td>Only after succ. compl. of module(s)</td>
</tr>
</tbody>
</table>

#### Duration

1 semester

**Module level**: graduate

**ECTS**: 6

**Numerical grade**: No information available

**Method of grading**: Only after successful completion of module(s)

**Module offered by**: Faculty of Physics and Astronomy

**Module coordinator**: Managing Director of the Institute of Applied Physics

**Prerequisites**: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

The lecture covers the physical principles of imaging techniques and their application in Biomedicine. The main topics are conventional X-ray technique, computer tomography, imaging techniques of nuclear medicine, ultrasound and MR-tomography. The lecture additionally addresses systems theory of imaging systems and digital image processing.

### Intended learning outcomes

The students know the physical principles of imaging techniques and their application in Biomedicine. They understand the principles of image generation and are able to explain different techniques and interpret simple images.

### Courses

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

**Language of assessment**: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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## Laboratory and Measurement Technology in Biophysics

### Abbreviation
11-LMB-092-m01

<table>
<thead>
<tr>
<th>Module title</th>
<th>Module Coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>Laboratory and Measurement Technology in Biophysics</td>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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### Contents

The lecture covers relevant principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. The main topics are optical measuring techniques and sensors, methods of single-particle detection, special microscoping techniques and methods of structure elucidation of biomolecules.

### Intended learning outcomes

The students know the principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. They have knowledge of optical measuring techniques and their applications and are able to apply techniques of structure elucidation to simple biomolecules.

### Courses

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<td>R + V (no information on SWS (weekly contact hours) and course language available)</td>
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### Method of assessment

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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009. Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title: Physics of Complex Systems

Abbreviation: 11-PKS-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 6

Method of grading: Only after succ. compl. of module(s)

Duration: 1 semester

Module level: graduate

Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents:
1. Theory of critical phenomena in thermal equilibrium
2. Introduction into the physics out of equilibrium
3. Entropy production and fluctuation
4. Phase transitions away from equilibrium
5. Universalily
6. Spin glasses
7. Theory of neural networks

Intended learning outcomes:
The students have specific and advanced knowledge in the field of physics of complex systems. They know the methods of Statistical Physics, Computational Physics and non-linear dynamics, which are used to describe such systems. They are able to work on current research problems in this area.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Quantum Information and Quantum Computing

Module title: Quantum Information and Quantum Computing
Abbreviation: 11-QIC-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics
Module offered by: Faculty of Physics and Astronomy

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
The first part introduces the theoretical concepts of quantum information and quantum computers. It discusses the main quantum algorithms. The second part discusses experimental possibilities for the realisation of entangled states. One of the main topics is the production, controlling and manipulation of coherent two-electron spin states. The third part covers the description and explanation of decoherence of quantum mechanical states.

Intended learning outcomes
The students have an advanced understanding of quantum theory and basic knowledge of quantum calculation. They are able to solve simple problems of quantum information theory.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German, English

Allocation of places
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Additional information
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<tbody>
<tr>
<td>Statistics, Data Analysis and Computer Physics</td>
<td>11-SDC-092-m01</td>
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<tr>
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Contents

Statistics, data analysis and computer physics.

Intended learning outcomes

The students have specific and advanced knowledge in the field of statistics, data analysis and Computational Physics.

Courses (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module Catalogue for the Subject

**FOKUS Physics**  
Master's with 1 major, 120 ECTS credits

#### Module: Cosmology

<table>
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<tbody>
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<td>Cosmology</td>
<td>11-AKM-092-m01</td>
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#### Module Coordinator

Managing Director of the Institute of Theoretical Physics and Astrophysics

#### Module offered by

Faculty of Physics and Astronomy

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
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#### Duration

1 semester  

**Module level:** graduate

**Other prerequisites:** Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

#### Contents

Expanding space-time, Friedmannian cosmology, basics of general relativity, the early universe, inflation, dark matter, primordial nucleosynthesis, cosmic microwave background, structure formation, supercluster, galaxies and galaxy clusters, intergalactic medium, cosmological parameters

#### Intended learning outcomes

The students have basic knowledge of cosmology. They know the theoretical methods of cosmology and are able to relate them to observations. They have gained insights into current research topics and are able to work on scientific questions.

#### Courses

- **R + V** (no information on SWS (weekly contact hours) and course language available)

#### Method of assessment

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

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#### Additional information

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#### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title: Plasma-Astrophysics
Abbreviation: 11-APL-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have basic knowledge of Plasma Astrophysics. They have mastered the theoretical description of motion and acceleration of charged particles in space, they know corresponding measuring methods and can compare and evaluate theory and experiments.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
**Module Catalogue for the Subject**  
**FOKUS Physics**  
**Master's with 1 major, 120 ECTS credits**

### Module title

**Introduction to Space Physics**

**Abbreviation**

11-ASP-092-m01

### Module coordinator

Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

6

### Method of grading

numerical grade

### Only after succ. compl. of module(s)

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### Duration

1 semester

### Module level

graduate

### Other prerequisites

Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

1. Overview
2. Dynamics of charged particles in magnetic and electric fields
3. Elements of space physics
4. The sun and heliosphere
5. Acceleration and transport of energetic particles in the heliosphere
6. Instruments to measure energetic particles in extraterrestrial space

### Intended learning outcomes

The students have basic knowledge of Space Physics, in particular of the characterisation of the dynamics of charged particles in space and in the heliosphere. They know relevant parameters, theoretical concepts and measuring methods.

### Courses (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Atmosphere and Space Physics | 11-AWP-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
6 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have knowledge of the physics of planetary atmospheres, especially of the atmosphere of the Earth and near-Earth space. They are able to apply the acquired knowledge to the solution of problems of interplanetary space missions.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Group Theory

Abbreviation: 11-GRT-092-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 6

Method of grading: numerical grade

Duration: 1 semester

Module level: graduate

Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

- Group theory
- Finite groups
- Lie groups
- Lie algebra
- Depiction
- Tensors
- Classification theorem
- Applications

Intended learning outcomes

The students know the basics of group theory, especially of Lie groups. They are able to identify problems of group theory and to solve them by using the acquired methods. They are able to apply group theory to the formulation and processing of physical problems.

Courses

- R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment

- a) written examination (approx. 90 minutes) or
- b) oral examination of one candidate each or
- c) oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or
- d) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or
- d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>Quantum Field Theory II</td>
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**Contents**


**Intended learning outcomes**

The students have advanced knowledge of the methods and concepts of quantum field theory. They have mastered the principles, especially of renormalisation and gauge theories. They are able to formulate and solve simple problems of quantum field theory by using the acquired calculation methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Contents


### Intended learning outcomes

The students have gained an overview of renormalisation group methods for non-linear partial differential equations. They know important examples and corresponding solving methods and are able to apply them to specific tasks.

### Courses (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Relativistic Quantumfield Theory

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

ECTS
8

Method of grading
numerical grade

Duration
1 semester

Module level
graduate

Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have mastered the principles and underlying mathematics of relativistic quantum field theories. They know how to use perturbation theory and how to apply Feynman rules. They are able to calculate basics processes in the framework of quantum electrodynamics in leading order. Moreover, they have a basic understanding of radiative corrections and renormalisation.

Courses
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
**Theory of Relativity**

### Abbreviation
11-RTT-092-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
Only after succ. compl. of module(s)

### Numerical grade
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### Duration
1 semester

### Module level
graduate

### Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents
Mathematical foundations of the theory of relativity; differential forms; brief summary of special relativity; elements of differential geometry; electrodynamics as an example of a relativistic gauge theory; field equations of general relativity; stellar models; introduction to cosmology; Hamiltonian formulation

### Intended learning outcomes
The students are familiar with the basic physical and mathematical concepts of general relativity. They have a mathematical understanding of the formulation of general relativity on the basis of differential forms. They are able to apply the acquired knowledge to problems of Astrophysics and cosmology.

### Courses
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places
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### Additional information
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<table>
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<tr>
<td>Theoretical Elementary Particle Physics</td>
<td>11-TEP-092-m01</td>
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| Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy |

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**Contents**


**Intended learning outcomes**

The students are familiar with the mathematical methods of Elementary Particle Physics. They understand the structure of the standard model based on symmetry principles and experimental observations. They know calculation methods for the processing of simple problems and processes of Elementary Particle Physics. Furthermore, they know the tests and limits of the standard model and the basics of extended theories.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title: Experimental Particle Physics
Abbreviation: 11-TPE-092-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 4
Method of grading: Only after succ. compl. of module(s)

CONTENT

Physics with modern particle detectors at the LHC and at the Tevatron. Discovery of the Higgs boson. Search for supbersymmetry and other physics beyond the standard model. Determination of the top quark mass and W mass as well as other parameters of the standard model. Introduction to modern methods of analysis and assessment of systematic errors.

Intended learning outcomes

The students are familiar with the principles of modern particle detector physics, especially with currently open questions of Particle Physics, which are examined by using these detectors. They know modern methods of analysis and are able to put results into context and to assess their systematic uncertainties.

Courses

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocations of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>Particle Physics (Standard Model)</td>
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<td>Faculty of Physics and Astronomy</td>
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### Contents

Introduction to the theory of electroweak interaction and spontaneous symmetry breaking. Experiments on the standard model and determination of model parameters.

### Intended learning outcomes

The students know the theoretical fundamental laws of the standard model of Particle Physics and the key experiments that have established and confirmed the standard model. They are able to interpret experimental or theoretical results in the framework of the standard model and know its validity and limits.

### Courses

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module title

**FOKUS Research Module Experimental Particle Physics**

### Abbreviation

11-FM-TPE-092-m01

### Module coordinator

Chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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### Duration

1 semester

### Module level

Graduate

### Other prerequisites

11-KET; recommended: 11-DTS, 11-TPS

### Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the discipline of Experimental Particle Physics, reproduction of knowledge, acquisition of social and methodological competencies. Application of the acquired professional knowledge and methods to new scientific questions.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of Experimental Particle Physics, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

### Courses

- **Experimentelle Teilchenphysik (Experimental Particle Physics):** V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (details to be announced)
- **Kompaktseminar Experimentelle Teilchenphysik (Block Taught Seminar Experimental Particle Physics):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment

This module has the following assessment components:

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year (details to be announced); details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
FOKUS Research Module Semiconductor Lasers | 11-FM-HLF-092-m01

| Module coordinator | Module offered by |
---|---
chairperson of examination committee | Faculty of Physics and Astronomy |

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---
10 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
---|---|---
1 semester | graduate | -- |

**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the discipline of semiconductor lasers, reproduction of knowledge, acquisition of social and methodological competencies.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of semiconductor lasers, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

- Halbleiterlaser - Grundlagen und aktuelle Forschung (Semiconductor Lasers - Principles and Current Research): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- Kompaktseminar Halbleiterlaser (Block Taught Seminar Semiconductor Lasers): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>FOKUS Research Module Theory of Superconductivity</td>
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**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the discipline of Superconductivity, reproduction of knowledge, acquisition of social and methodological competencies.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of the theory of superconductivity, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

**Courses**

Theorie der Supraleitung (Theory of Superconduction): V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)

Kompaktseminar Theorie der Supraleitung (Block Taught Seminar Theory of Superconduction): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment**

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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FOKUS Research Module Theoretical Solid State Physics | 11-FM-TFK-092-m01

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Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | Recommended: 11-KM, 11-TQM

Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the discipline of Theoretical Solid-State Physics, reproduction of knowledge, acquisition of social and methodological competencies.

Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of Theoretical Solid-State Physics, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

Courses (type, number of weekly contact hours, language — if other than German)

Theoretische Festkörperphysik (Theoretical Solid State Physics): V (4 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (winter semester)
Kompaktseminar Theoretische Festkörperphysik (Block Taught Seminar Theoretical Solid State Physics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.
Students must register for assessment components 1 and 2 online (details to be announced).
Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.
To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Module title

**FOKUS Research Module Theoretical Astrophysics**

### Abbreviation

11-FM-AST-092-m01

### Module title

**FOKUS Research Module Theoretical Astrophysics**

### Abbreviation

11-FM-AST-092-m01

### Module coordinator

Chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

10

### Method of grading

Numerical grade

### Only after succ. compl. of module(s)

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### Duration

1 semester

### Module level

Graduate

### Other prerequisites

Mechanics, electrodynamics, programming in C++; recommended: atomic, nuclear and particle physics, thermodynamics.

### Contents

Specific and advanced knowledge of independent scientific work in Theoretical Astrophysics; modelling of complex observation results; numeric simulations. Reproduction of knowledge, acquisition of social and methodological competencies.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in Theoretical Astrophysics. They have basic knowledge of the methods of Theoretical Astrophysics. They are able to design complex observations and to test the models with the help of simulations. They are able to acquire advanced knowledge and to summarise their knowledge in an oral presentation.

### Courses

**Theoretische Astrophysik (Theoretical Astrophysics):** V (3 weekly contact hours) + Ü/P (1 weekly contact hour)

**Kompaktseminar Theoretische Astrophysik (Block Taught Seminar Theoretical Astrophysics):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)

2. Seminar: talk (approx. 30 to 45 minutes)

Assessment component 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title  
**FOKUS Research Spintronic and Physics**

**Abbreviation**  
11-FM-LHQ-092-m01

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Contents  
Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Spintronics and Nanophysics, reproduction of knowledge, acquisition of social and methodological competencies.

Intended learning outcomes  
The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of spintronics and Nanophysics, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

Courses  
(type, number of weekly contact hours, language — if other than German)

Lithographieverfahren in der Halbleitertechnik und Theorie des Quantentransports (Lithography in Semiconductor Technology and Theory of Quantum Transport): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (winter semester)  
Kompaktseminar Spintronik und Nanophysik (Block Taught Seminar Spintronics and Nanophysics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.  
Students must register for assessment components 1 and 2 online (details to be announced).  
Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.  
To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places

Additional information

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<tr>
<th>Module title</th>
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<td>FOKUS Research Module Relativistic Quantum Field Theory</td>
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<td>Lectures Theoretische Physik (Theoretical Physics); Quantenmechanik 2 (Quantum Mechanics 2) recommended.</td>
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</table>

**Contents**

Specific and advanced knowledge of independent scientific work in the specialist field of Relativistic Quantum Field Theory. Symmetries, Lagrange formalism for fields, field quantisation, gauge principle and interaction, perturbation theory, Feynman rules, quantum electrodynamic processes in Born approximation, radiative corrections, renormalisation.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in the field of relativistic quantum field theory. They know the principles and mathematical basics of relativistic quantum field theory and are able to apply perturbation theory and Feynman rules. They are able to summarise the acquired knowledge in an oral presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

- Relativistische Quantenfeldtheorie (Relativistic Quantum Field Theory): V (4 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (winter semester)
- Kompaktseminar Relativistische Quantenfeldtheorie (Block Taught Seminar Relativistic Quantum Field Theory): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (1 to 3 days) held towards the end of semester break or at the beginning of the subsequent semester)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.
Students must register for assessment components 1 and 2 online (details to be announced).
Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.
To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
FOKUS Research Module Relativistic Quantum Field Theory with Mini Research Project

Abbreviation
11-FM-RQFT-MF-092-m01

Module coordinator
chairperson of examination committee

Module offered by
Faculty of Physics and Astronomy

ECTS
16

Method of grading
numerical grade

Only after succ. compl. of module(s)
--

Duration
1 semester

Module level
graduate

Other prerequisites
Lectures Theoretische Physik (Theoretical Physics); Quantenmechanik 2 (Quantum Mechanics 2) recommended.

Contents
Specific and advanced knowledge of independent scientific work in the specialist field of Relativistic Quantum Field Theory. Symmetries, Lagrange formalism for fields, field quantisation, gauge principle and interaction, perturbation theory, Feynman rules, quantum electrodynamic processes in Born approximation, radiative corrections, renormalisation.

Intended learning outcomes
The students have special and advanced knowledge of independent scientific work in the field of relativistic quantum field theory. They know the principles and mathematical basics of relativistic quantum field theory and are able to apply perturbation theory and Feynman rules. They are able to summarise the acquired knowledge in an oral presentation. They are able to successfully implement the acquired methods in a mini research project and to write down the results in a report.

Courses (type, number of weekly contact hours, language — if other than German)
Relativistische Quantenfeldtheorie (Relativistic Quantum Field Theory): V (4 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (winter semester)
Kompaktseminar Relativistische Quantenfeldtheorie (Block Taught Seminar Relativistic Quantum Field Theory): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (1 to 3 days) held towards the end of semester break or at the beginning of the subsequent semester)
Miniforschungsprojekt Relativistische Quantenfeldtheorie (Mini Research Project Relativistic Quantum Field Theory): P (2 weekly contact hours), German or English, details on availability to be announced (either block taught during semester break or approx. 3 weeks part time)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English. Students must register for assessment components 1 through 3 online (details to be announced). Assessment component 1 will be offered once a year in the winter semester; details on when assessment components 2 and 3 will be offered to be announced. To pass this module, students must pass each of the assessment components 1 through 3.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module Catalogue for the Subject

**FOKUS Physics**

**Master's with 1 major, 120 ECTS credits**

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<thead>
<tr>
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<td>FOKUS Research Module Theoretical Elementary Particle Physics</td>
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<tr>
<td>1 semester</td>
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</table>

### Contents

Specific and advanced knowledge of independent scientific work in the specialist field of Theoretical Elementary Particle Physics. Principles of relativistic quantum field theory, perturbation theory and application of Feynman rules, standard model of strong and electroweak interaction of leptons and quarks.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of Theoretical Elementary Particle Physics. They know the mathematical methods for the description of phenomena of Elementary Particle Physics and understand the structure of the standard model based on symmetry principles and experimental observations. They are able to summarise the acquired knowledge in an oral presentation.

### Courses (type, number of weekly contact hours, language — if other than German)

- **Theoretische Elementarteilchenphysik** (Theoretical Elementary Particle Physics): V (4 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (summer semester)
- **Kompaktseminar Theoretische Elementarteilchenphysik** (Block Taught Seminar Theoretical Elementary Particle Physics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (1 to 3 days) held towards the end of semester break or at the beginning of the subsequent semester)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Contents

Specific and advanced knowledge of independent scientific work in the specialist field of Theoretical Elementary Particle Physics. Principles of relativistic quantum field theory, perturbation theory and application of Feynman rules, standard model of strong and electroweak interaction of leptons and quarks.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of Theoretical Elementary Particle Physics. They know the mathematical methods for the description of phenomena of Elementary Particle Physics and understand the structure of the standard model based on symmetry principles and experimental observations. They are able to summarise the acquired knowledge in an oral presentation. They are able to successfully implement the acquired methods in a mini research project and to write down the results in a report.

### Courses (type, number of weekly contact hours, language — if other than German)

- Theoretische Elementarteilchenphysik (Theoretical Elementary Particle Physics): V (4 weekly contact hours) + Ü/ P (2 weekly contact hours), German or English, once a year (summer semester)
- Kompaktseminar Theoretische Elementarteilchenphysik (Block Taught Seminar Theoretical Elementary Particle Physics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)
- Miniforschungsprojekt Theoretische Elementarteilchenphysik (Mini Research Project Theoretical Elementary Particle Physics): P (2 weekly contact hours), German or English, details on availability to be announced (either block taught during semester break or approx. 3 weeks part time)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English. Students must register for assessment components 1 through 3 online (details to be announced). Details on when assessment components 2 and 3 will be offered to be announced. To pass this module, students must pass each of the assessment components 1 through 3.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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**Module title**

FOKUS Research Module Biophysics - Laboratory and Measurement Technology

**Abbreviation**

11-FM-LMB-092-m01

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**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Biophysics - laboratory - metrology, reproduction of knowledge, acquisition of social and methodological competencies.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of Biophysics and laboratory and measuring techniques, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

**Courses (type, number of weekly contact hours, language — if other than German)**

Labor- und Messtechnik in der Biophysik (Laboratory and Measurement Technology in Biophysics): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)

Kompaktseminar Biophysik - Labor- und Messtechnik (Block Taught Seminar Biophysics - Laboratory and Measurement Technology): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced). Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>FOKUS Research Module Biophysics - Biophysical Measurement Technology in Medical Science</th>
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<tr>
<td>Abbreviation</td>
<td>11-FM-BMT-092-m01</td>
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<td>Other prerequisites</td>
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<tr>
<td>Contents</td>
<td>Specific and advanced knowledge of independent scientific work in a current research area, especially in the discipline of Biophysics - biophysical metrology in medicine, reproduction of knowledge, acquisition of social and methodological competencies.</td>
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<tr>
<td>Intended learning outcomes</td>
<td>The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of Biophysics and biophysical measuring techniques in medicine, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.</td>
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<td>Courses</td>
<td>Biophysikalische Messtechnik in der Medizin (Biophysical Measurement Technology in Medical Science): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (winter semester) Kompaktseminar Biophysik - Biophysikalische Messtechnik in der Medizin (Block Taught Seminar Biophysics - Biophysical Measurement Technology in Medical Science): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)</td>
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<td>Method of assessment</td>
<td>This module has the following assessment components 1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages) 2. Seminar: talk (approx. 30 to 45 minutes) Assessment components 1 and 2 will be offered in German or English. Students must register for assessment components 1 and 2 online (details to be announced). Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced. To pass this module, students must pass both assessment component 1 and assessment component 2.</td>
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Master's with 1 major FOKUS Physics (2011)
### Module title

**FOKUS Research Module Nano Optics**

### Abbreviation

11-FM-NOP-092-m01

### Module coordinator

chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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### Duration

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</table>

### Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Nano-Optics, reproduction of knowledge, acquisition of social and methodological competencies.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of nano-optics, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

### Courses

(type, number of weekly contact hours, language — if other than German)

- **Nanoelektronik (Nanoelectronics):** V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- **Kompaktseminar Nanoelektronik (Block Taught Seminar Nanoelectronics):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced). Students must meet certain prerequisites to qualify for admission to assessment component 1. The lecturer will inform them about the respective details at the beginning of the course.

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

--

### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title: FOKUS Research Module Low Dimensional Structures

Abbreviation: 11-FM-NDS-092-m01

Module coordinator: chairperson of examination committee

Module offered by: Faculty of Physics and Astronomy

ECTS: 8

Method of grading: numerical grade

Only after succ. compl. of module(s)

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:
Specific and advanced knowledge of independent scientific work in the field of low-dimensional structures. Crystal lattice symmetry, lattice dynamics, growth techniques

Intended learning outcomes:
The students have special and advanced knowledge of independent scientific work in the field of low-dimensional structures.

Courses:
Niederdimensionale Strukturen (Low Dimensional Structures): V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (details to be announced)

Kompaktseminar Niederdimensionale Strukturen (Block Taught Seminar Low Dimensional Structures): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment:
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year (details to be announced); details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<tr>
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<td>FOKUS Research Module Quantum Phenomena in electronic correlated Materials</td>
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<tr>
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</table>

**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of quantum phenomena in electronically correlated materials, reproduction of knowledge, acquisition of social and methodological competencies. Introduction to the exciting and current research area of "strongly correlated electron systems": Metal-insulator transitions, Kondo effect, heavy fermions, High-temperature superconductivity, and much more.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of quantum phenomena in electronically correlated materials, laboratory and measuring techniques, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

- Quantenphänomene in elektronisch korrelierten Materialien (Quantum Phenomena in Electronic Correlated Materials): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (details to be announced)
- Kompaktseminar Quantenphänomene in elektronisch korrelierten Materialien (Block Taught Seminar Quantum Phenomena in Electronic Correlated Materials): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year (details to be announced); details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title

FOKUS Research Module Quantum Phenomena in electronic correlated Materials with Mini Research Project

Abbreviation

11-FM-QPM-MF-092-m01

Module coordinator

chairperson of examination committee

Module offered by

Faculty of Physics and Astronomy

ECTS

14

Method of grading

Only after succ. compl. of module(s)

Duration

1 semester

Module level

graduate

Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of quantum phenomena in electronically correlated materials, reproduction of knowledge, acquisition of social and methodological competencies. Application of the acquired professional knowledge and methods to new scientific questions in a mini research project (e.g. experiments, case studies etc.). Introduction to the exciting and current research area of "strongly correlated electron systems": Metal-insulator transitions, Kondo effect, heavy fermions, high-temperature superconductivity, and much more.

Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of quantum phenomena in electronically correlated materials, and are able to reproduce the acquired knowledge, to apply the acquired methods, to summarise a sub-area of the current research area in an oral presentation and to successfully implement the acquired knowledge and methods in a mini research project.

Courses (type, number of weekly contact hours, language — if other than German)

Quantenphänomene in elektronisch korrelierten Materialien (Quantum Phenomena in Electronic Correlated Materials): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (details to be announced)
Kompaktseminar Quantenphänomene in elektronisch korrelierten Materialien (Block Taught Seminar Quantum Phenomena in Electronic Correlated Materials): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)
Miniforschungsprojekt Quantenphänomene in elektronisch korrelierten Materialien (Mini Research Project Quantum Phenomena in Electronic Correlated Materials): P (2 weekly contact hours), German or English, details on availability to be announced (either block taught during semester break or approx. 3 weeks part time)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English.

Students must register for assessment components 1 through 3 online (details to be announced).
Assessment component 1 will be offered once a year (details to be announced); details on when assessment components 2 and 3 will be offered to be announced.

To pass this module, students must pass each of the assessment components 1 through 3.

Allocation of places

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Additional information

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</table>
### Module Title

**FOKUS Research Module Dirac Fermions in Mesoscopic Systems**

### Abbreviation

11-FM-RMS-092-m01

### Module Coordinator

Chairperson of examination committee

### Module Offered by

Faculty of Physics and Astronomy

### ECTS

9

### Method of Grading

Only after successful completion of module(s)

### Duration

1 semester

### Module Level

Graduate

### Other Prerequisites

--

### Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Dirac fermions in mesoscopic systems, reproduction of knowledge, acquisition of social and methodological competencies.

### Intended Learning Outcomes

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of Dirac fermions in mesoscopic systems, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

### Courses

- **Relativistische Effekte in Mesoskopischen Systemen (Relativistic Effects in Mesoscopic Systems):** V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English
- **Kompaktseminar Dirac Fermionen in Mesoskopischen Systemen (Block Taught Seminar Dirac Fermions in Mesoscopic Systems):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of Assessment

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English. Students must register for assessment components 1 and 2 online (details to be announced). Details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of Places

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### Additional Information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
### Module title

**FOKUS Research Module Complex Systems with Mini Research Project**

### Abbreviation

11-FM-PKS-MF-092-m01

### Module coordinator

Chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

12

### Method of grading

Only after succ. compl. of module(s)

### Duration

1 semester

### Module level

Graduate

### Other prerequisites

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### Contents

Specific and advanced knowledge for independent scientific work in a current research area, especially in the specialist field of Complex Systems, reproduction of knowledge, acquisition of social and methodological competencies. Application of the acquired professional knowledge and methods to new scientific questions in a mini research project (e.g. experiments, case studies etc.). - Statistical mechanics and information theory. - Non-linear dynamics: Deterministic chaos, synchronisation, chaotic lasers. Encoding, chaotic networks. - Critical phenomena: Scaling law, phase transformations, Monte Carlo simulation. Random walk, stochastic processes beyond the thermal equilibrium.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of physics of complex systems. They know and are able to apply the methods of Statistical Physics and non-linear dynamics, which are used to describe physics of complex systems, to current questions. They have acquired advanced knowledge of a specialist field and prove their knowledge in a seminar presentation. They are able to successfully implement the acquired knowledge and methods in a mini research project.

### Courses (type, number of weekly contact hours, language — if other than German)

**Physik komplexer Systeme (Physics of Complex Systems):** V (2 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (winter semester)

**Kompaktseminar Komplexe Systeme (Block Taught Seminar Complex Systems):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Miniforschungsprojekt Komplexe Systeme (Mini Research Project Complex Systems):** P (2 weekly contact hours), German or English, details on availability to be announced (either block taught during semester break or approx. 3 weeks part time)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)

2. Seminar: talk (approx. 30 to 45 minutes)

3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English.

Students must register for assessment components 1 through 3 online (details to be announced).

Assessment component 1 will be offered once a year in the winter semester; details on when assessment components 2 and 3 will be offered to be announced.

To pass this module, students must pass each of the assessment components 1 through 3.

### Allocation of places

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### Additional information

--
Referred to in LPO I (examination regulations for teaching-degree programmes)
## Module title

**FOKUS Research Module Complex Systems**

**Abbreviation**

11-FM-PKS-092-m01

### Module coordinator

chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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### Duration

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### Contents

Specific and advanced knowledge for independent scientific work in the field of physics of complex systems.
- Statistical mechanics and information theory.  
- Critical phenomena: Scaling law, phase transformations, Monte Carlo simulation. Random walk, stochastic processes beyond the thermal equilibrium.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of physics of complex systems. They know and are able to apply the methods of Statistical Physics and non-linear dynamics, which are used to describe physics of complex systems, to current questions. They have acquired advanced knowledge of a specialist field and prove their knowledge in a seminar presentation.

### Courses

( type, number of weekly contact hours, language — if other than German)

- **Physik komplexer Systeme** (Physics of Complex Systems): V (2 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, once a year (winter semester)
- **Kompaktseminar Komplexe Systeme** (Block Taught Seminar Complex Systems): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered in the winter semester (details to be announced); details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
<td>Managing Director of the Institute of Theoretical Physics and Astrophysics</td>
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<td>Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
</tr>
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</table>

**Contents**


**Intended learning outcomes**

The students have knowledge of the mathematical and physical principles of supersymmetry and supersymmetric models. They understand the theory’s formalism and recognise its connections to other models as well as its importance for phenomenology of elementary particles.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
## Module Catalogue for the Subject

### Master’s with 1 major, FOKUS Physics

#### Module title
- **Electronics**

#### Abbreviation
- 11-A2-092-m01

#### Module coordinator
- Managing Director of the Institute of Applied Physics

#### Module offered by
- Faculty of Physics and Astronomy

#### ECTS
- 6

#### Method of grading
- Numerical grade

#### Only after succ. compl. of module(s)
- --

#### Duration
- 1 semester

#### Module level
- Undergraduate

#### Other prerequisites
- Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents
- Principles of electronic components and circuits. Analogous circuit technology: Passive (resistors, capacitors, coils and diodes) and active components (bipolar and field-effect transistors, operational amplifiers). Digital circuits: different types of gates and CMOS circuits. Microcontroller

### Intended learning outcomes
- The students have knowledge of the practical setup of electronic circuits from the field of analogous and digital circuit technology.

### Courses
- **V + Ü** (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
- **written examination** (approx. 90 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

### Allocation of places
- Only as part of pool of general key skills (ASQ): 15 places. Places will be allocated by lot.

### Additional information
- --

### Referred to in LPO I
- (examination regulations for teaching-degree programmes)
- --
### Module title
Semiconductor Physics and Devices

### Abbreviation
11-SPD-102-m01

### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

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### Duration
1 semester

### Module level
graduate

#### Contents
Principles of Semiconductor Physics. Introduction to key theories on semiconductors. Components from the areas of electronics and photonics.

#### Intended learning outcomes
The students are familiar with the properties of semiconductors, they have gained an overview of the electronic and phononic band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport and are able to apply Poisson, Boltzmann and continuity equations to the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the methods of planar technology and current developments in this sector, they have a basic understanding of component production. They understand the structure and function of the main components of electronics (diodes, transistor, FET, thyristor, diac, triac), microwave applications (tunnel, impatt, baritt and Gunn diode) and optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser). They know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological importance. They are familiar with current developments in the field of components.

#### Courses
(V + R (no information on SWS (weekly contact hours) and course language available)

#### Method of assessment
written examination (approx. 90 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places
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#### Additional information
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<table>
<thead>
<tr>
<th>Referred to in LPO I  (examination regulations for teaching-degree programmes)</th>
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<tbody>
<tr>
<td>Module title</td>
<td>Abbreviation</td>
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<tr>
<td>Quantum Transport in Semiconductor Nanostructures</td>
<td>11-QTH-102-m01</td>
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<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<tr>
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<td>Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
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</tbody>
</table>

**Contents**

The lecture addresses the fundamental transport phenomena of electrons in nanostructures. This includes the topics of: ballistic and diffuse transport, electron interference effects, quantisation of conductivity, interaction phenomena between electrons, Coulomb blockade, thermoelectric properties, description of spin-dependent transport phenomena, topological insulators, solid-state quantum computers.

**Intended learning outcomes**

The students have mastered the basics of electronics of nanostructures in theory and practice. They know functions and applications of respective components.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Renormalization Group Methods in Field Theory

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

ECTS
6

Method of grading
Numerical grade

Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Renormalisation group methods for non-linear partial differential equations, field theoretical contexts and non-analysed behaviour of cryogenic temperatures.

Intended learning outcomes
The students gain an overview of non-linearities in partial differential equations and their solution on the basis of the renormalisation group method.

Courses (type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title: Spintronics
Abbreviation: 11-SPI-102-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
This lecture covers the basic principles of spin transport, with a particular emphasis on the phenomena of giant magnetoresistance and tunnel magnetoresistance. As a last point, we discuss new phenomena from the field of spin dynamics and current-induced spin phenomena.

Intended learning outcomes
The students know the basic principles of spin transport models and the applications of spin transport in information technology. They have gained an overview of current findings in this field (giant magnetoresistance, tunnel magnetoresistance).

Courses
(type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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<td>Theoretical Astrophysics</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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**Contents**
Theoretical Astrophysics, models for the description of complex observation results, numeric simulations.

**Intended learning outcomes**
The students have basic knowledge of the methods of Theoretical Astrophysics. They are able to design complex observations and to test the models with the help of simulations.

**Courses** (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 120 minutes)

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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**Module title**  
Strong Interaction in Accelerator Experiments  

**Abbreviation**  
11-WWB-102-m01

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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses**  
(type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

**Language of assessment:** German, English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

--
Module title: Advanced Practical Course Master
Abbreviation: 11-PFM-111-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 10
Method of grading: Only after succ. compl. of module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Principles of Nuclear, Atomic and Molecular Physics, experiments on cryogenic temperatures and correlated systems, properties of solids, surfaces and interfaces. Experiments on the following topics: X-rays - nuclear magnetic resonance (NMR) - quantum Hall effect - optical pumping and spectroscopy in the field of optics - Hall effect - superconductivity - laser - solid-state optics

Intended learning outcomes:
Knowledge of conducting experiments, analysing and documenting experimental results, basic knowledge of issuing scientific publications, application of modern evaluation systems. The students are familiar with modern experimental methods. They are able to work on a task on the basis of publications, to conduct and evaluate an experiment and to present and discuss their results in a scientific publication.

Courses:
Prep seminar for Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master): S (1 weekly contact hour)
Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master) Part 1: P (3 weekly contact hours), German or English
Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master) Part 2: P (3 weekly contact hours), German or English
Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master) Part 3: P (3 weekly contact hours), German or English

Method of assessment:
This module has the following assessment components
1. Prep seminar for Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master): oral examination (approx. 5 to 10 minutes)
2. Lab course in part 1 (Fortgeschrittenen-Praktikum Master/Advanced Practical Course Master Part 1): a) Preparing the experiment will be considered successfully completed if an oral test (approx. 30 minutes) is passed prior to the experiment. b) Performing and evaluating the experiment will be considered successfully completed if a test is passed. Students must prepare an experiment log (approx. 8 pages).
3. Lab course in part 2 (Fortgeschrittenen-Praktikum Master/Advanced Practical Course Master Part 2): a) Preparing the experiment will be considered successfully completed if an oral test (approx. 30 minutes) is passed prior to the experiment. b) Performing and evaluating the experiment will be considered successfully completed if a test is passed. Students must prepare an experiment log (approx. 8 pages).
4. Lab course in part 3 (Fortgeschrittenen-Praktikum Master/Advanced Practical Course Master Part 3): a) Preparing the experiment will be considered successfully completed if an oral test (approx. 30 minutes) is passed prior to the experiment. b) Performing and evaluating the experiment will be considered successfully completed if a test is passed. Students must prepare an experiment log (approx. 8 pages).

Language of assessment: German or English
Students must register for assessment components 1 through 4 online (details to be announced).
Only those students who have attended the prep seminar for Fortgeschrittenen-Praktikum Master (Advanced Practical Course Master) will be allowed to perform experiments as part of the courses Fortgeschrittenen-Praktikum Master Parts 1 through 3.
Students will be offered one opportunity to retake element a) and/or element b) in the respective semester. To pass an assessment component, they must pass both elements (a and b) in the same semester.
To pass this module, students must pass each of the assessment components 1 through 4.

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<th>Allocation of places</th>
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# Module Catalogue for the Subject

## FOKUS Physics

### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Methods in Surface Spectroscopy</td>
<td>11-MSS-102-m01</td>
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#### Module coordinator
Managing Director of the Institute of Applied Physics

#### Module offered by
Faculty of Physics and Astronomy

### ECTS

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#### Duration
1 semester

#### Module level
graduate

#### Other prerequisites

Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

Boundary conditions of experiments: Ultra-high vacuum, surface sensibility, light-matter-interaction, principles of photoelectron spectroscopy (PES), one-particle image of PES, three step model, many-particle effects, line shape, satellites, Fermi liquid, quasiparticles, exemplary systems and spectra, measurements with synchrotron radiation, related experimental methods.

### Intended learning outcomes

The students know the physical principles and experimental methods of surface spectroscopy. They are able to conduct, evaluate and interpret simple measurements.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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### Module title

**Practical Course Astrophysics**

**Abbreviation**

11-APP-111-m01

### Module coordinator

Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

6

### Method of grading

Only after succ. compl. of module(s)

### Duration

1 semester

### Module level

graduate

### Other prerequisites

Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

Astrophysical experiments in the fields of detectors, telescopes, methodology, analysis and astronomic observations.

### Intended learning outcomes

The students have mastered experimental methods of Astrophysics and are able to analyse and interpret the measuring data and present the results. They are familiar with the working methods of observational Astronomy and with basic techniques of detecting electromagnetic radiation. They are able to plan and evaluate observations and measurements and to present the results.

### Courses

- **Type**: P
- **Weekly contact hours**: (no information available)
- **Language**: German

### Method of assessment

- **Type**: Preparing, performing and evaluating the experiments will be considered successfully completed if a Testat (exam) is passed. Experiments that were not successfully completed can be repeated once. Or **b)** discussion to test the candidate’s understanding of the physics-related contents and results of the experiment (approx. 20 minutes).

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

### Allocation of places

- **Type**: --

### Additional information

- **Type**: --

### Referred to in LPO I

(examination regulations for teaching-degree programmes)
## Module title

**Particle Radiation Detectors**

### Abbreviation

11-DTS-111-m01

## Module coordinator

Managing Director of the Institute of Applied Physics

## Module offered by

Faculty of Physics and Astronomy

## ECTS

4

## Method of grading

Numerical grade

## Only after succ. compl. of module(s)

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## Duration

1 semester

## Module level

Graduate

## Other prerequisites

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## Contents

Principles of interaction between particles and matter. Particle detectors for space and time measurement, determination of momentum, energy and particle identification. Conception of particle detectors in examples.

## Intended learning outcomes

The students know the physical principles and the basic structure of particle detectors. They know the functions and applications of different types of detectors, they can explain the measurement of physical values and have basic knowledge of the conception of detector systems.

## Courses

(V + Ü (no information on SWS (weekly contact hours) and course language available)

## Method of assessment

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

## Allocation of places

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## Additional information

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## Referred to in LPO 1 (examination regulations for teaching-degree programmes)

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### Modern Astrophysics

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#### Managing Director of the Institute of Theoretical Physics and Astrophysics
Faculty of Physics and Astronomy

#### ECTS

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#### Duration, Module level, Other prerequisites

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#### Contents

Introduction to a field of modern Astrophysics, e.g. extra-galactic jets.

#### Intended learning outcomes

The students know the current state of research on the modern topic of Astrophysics. They know the physical values and are to plan and conduct observations in this area. This includes the ability to conceptualise a specific observational project and e.g. to apply for observation time at large telescopes.

#### Courses (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

#### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or
- b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

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<td>Current Topics in Experimental Physics</td>
<td>11-EXE5-111-m01</td>
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<tr>
<td>chairperson of examination committee</td>
<td>Faculty of Physics and Astronomy</td>
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</table>

**Contents**

Current topics of Experimental Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master's programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses**

(V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(a) written examination (approx. 120 minutes, for modules with less than 4 ECTS credits approx. 90 minutes; unless otherwise specified) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Current topics of Experimental Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

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**Courses**

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Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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Current Topics in Experimental Physics | 11-EXE7-111-m01

Module coordinator
chairperson of examination committee

Module offered by
Faculty of Physics and Astronomy

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Duration | Module level | Other prerequisites
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1 semester | graduate | Approval by examination committee required.

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Language of assessment: German, English

Allocation of places
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Additional information
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Current topics of Experimental Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

### Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master’s programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

### Courses (type, number of weekly contact hours, language — if other than German)

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Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module Catalogue for the Subject
FOKUS Physics
Master’s with 1 major, 120 ECTS credits

<table>
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<th>Module title</th>
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<td>Electron Electron Interaction</td>
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### Contents


### Intended learning outcomes

The students know the principles of the theoretical description of electron-electron interactions in one dimension.

### Courses

(type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Contents

- a) metal-insulators and topological insulators
- b) transport phenomena
- c) magnetic impurities in metals. Kondo effect and heavy fermions
- d) electron-phonon interaction
- e) one-dimensional conductors

Intended learning outcomes

The students have advanced knowledge of the theoretical description of solid-state phenomena. They know the mathematical or theoretical methods and are able to apply them to problems of solid-state theory and understand the connections to experimental results. The individual students have elaborated on an advanced topic of solid-state theory and have discussed this topic in a seminar presentation.

Courses (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
## Computational Astrophysics

### Module title
Computational Astrophysics

### Abbreviation
11-NMA-111-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
Graduate

### Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

### Intended learning outcomes
The students are able to solve typical problems and equations of Astrophysics and other subdisciplines of Physics with the help of numerical simulations. They are especially capable of choosing adequate strategies to approach such problems and of validating the results.

### Courses
(V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(a) written examination (approx. 120 minutes) or (b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or (c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or (d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places
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### Additional information
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<tr>
<td>Introduction to Elementary Particle Theory</td>
<td>11-ETT-111-m01</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**Contents**

**Intended learning outcomes**
The students have in-depth knowledge of Theoretical Elementary Particle Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German, English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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Module title | Abbreviation
---|---
Quantum Loop Gravity | 11-QSG-102-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
4 | numerical grade | --

Duration | Module level | Other prerequisites
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1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Aside from string theory, quantum loop gravity (QLG) is one of the most important approaches to a quantum mechanical description of gravity. General relativity is formulated in Hamiltonian formalism and the elemental variables are identified with the corresponding Poisson brackets. These variables are quantised in the typical manner on discretised graphs, so-called spin networks. In doing so, e.g. a quantisation of elemental volumes appears. Therefore, QLG belongs to the speculative theories which paint a picture of the constitution of space and time.

Intended learning outcomes
The students know the principles of quantum loop gravity. They have acquired advanced knowledge of a selected topic and have proved their knowledge in a seminar presentation.

Courses (type, number of weekly contact hours, language — if other than German)
V + S (no information on SWS (weekly contact hours) and course language available)

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Language of assessment: German, English

Allocation of places
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**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master’s programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

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Language of assessment: German, English

**Allocation of places**

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**Intended learning outcomes**

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**Courses**

(type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Module coordinator**

Chairperson of examination committee

**Module offered by**

Faculty of Physics and Astronomy

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**Duration**

1 semester

**Module level**

Graduate

**Other prerequisites**

Approval by examination committee required.

### Contents

Current topics of Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

### Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master’s programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

### Courses

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### Method of assessment

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Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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# Current Topics in Theoretical Physics

**Module title**: Current Topics in Theoretical Physics  
**Abbreviation**: 11-EXT8-111-m01

**Module coordinator**: chairperson of examination committee  
**Module offered by**: Faculty of Physics and Astronomy

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<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
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<tbody>
<tr>
<td>8</td>
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</table>

**Duration**: 1 semester  
**Module level**: graduate  
**Other prerequisites**: Approval by examination committee required.

## Contents

Current topics of Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

## Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master’s programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

## Courses

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<thead>
<tr>
<th>Type</th>
<th>Number of weekly contact hours</th>
<th>Language</th>
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</thead>
<tbody>
<tr>
<td>V + R</td>
<td>no information on SWS (weekly contact hours) and course language available</td>
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## Method of assessment

(a) written examination (approx. 120 minutes, for modules with less than 4 ECTS credits approx. 90 minutes; unless otherwise specified) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Language of assessment: German, English

## Allocation of places

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## Additional information

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## Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Ultrafast Spectroscopy and Quantum Control</td>
<td>08-PCM4-PHY-111-m01</td>
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<table>
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<tr>
<th>Module coordinator</th>
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<tbody>
<tr>
<td>lecturer of the seminar &quot;Ultrakurzzeitspektroskopie and Quantenkontrolle&quot;</td>
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</thead>
<tbody>
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</table>

**Contents**

German contents available but not translated yet.

Das Modul behandelt spezielle Themen der Ultrakurzzeitspektroskopie und Quantenkontrolle. Schwerpunkte sind ultrakurze Laserimpulse, zeitaufgelöste Laserspektroskopie sowie kohärente Kontrolle.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses**

S + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (90 minutes) or oral examination of one candidate each (20 minutes) or talk (30 minutes) Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)
Module title
FOKUS Research Module Applied Semiconductor Physics and Devices

Abbreviation
11-FM-SPD-102-m01

Module coordinator
chairperson of examination committee

Module offered by
Faculty of Physics and Astronomy

ECTS
10

Method of grading
numerical grade

Only after succ. compl. of module(s)
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Duration
1 semester

Module level
graduate

Other prerequisites
11-KM-2

Contents
Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Semiconductor Physics and Components, reproduction of knowledge, acquisition of social and methodological competencies. Principles of Semiconductor Physics. Introduction to key theories on semiconductors. Components from the areas of electronics and photonics.

Intended learning outcomes
The students have special and advanced knowledge of independent scientific work in Applied Semiconductor Physics. They are familiar with the properties of semiconductors, they have gained an overview of the electronic and phononic band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological importance. They have acquired advanced knowledge of a special topic and are able to summarise their knowledge in an oral presentation.

Courses (type, number of weekly contact hours, language — if other than German)

Halbleiterphysik und Bauelemente (Applied Semiconductor Physics and Devices): V (3 weekly contact hours) + U/P (1 weekly contact hour), German or English, once a year (winter semester)

Kompaktseminar Halbleiterphysik und Bauelemente (Block Taught Seminar Applied Semiconductor Physics and Devices): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<tr>
<td>FOKUS Research Module Quantum Transport in Semiconductor Nanostructures</td>
<td>11-FM-QTH-102-m01</td>
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<td>Faculty of Physics and Astronomy</td>
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<tbody>
<tr>
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<td>graduate</td>
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</table>

### Contents

Specific and advanced knowledge of independent scientific work in the field of quantum transport. Transport phenomena that cannot be observed in classical electronic switches appear in highly miniaturised electronic components. The research module provides insights into production techniques, characteristics and application fields of modern nanoelectronic components, which function on the basis of ballistic and coherent transport.

### Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the current research area of quantum transport. They have mastered the basics of electronics of nanostructures in theory and practice. They know functions and applications of respective components and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a field of the current research area in an oral presentation.

### Courses (type, number of weekly contact hours, language — if other than German)

- Quantentransport in Halbleiter-Nanostrukturen (Quantum Transport in Semiconductor Nanostructures): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- Kompaktseminar Quantentransport in Halbleiternanostrukturen (Block Taught Seminar Quantum Transport in Semiconductor Nanostructures): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English. Students must register for assessment components 1 and 2 online (details to be announced). Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced. To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title: FOKUS Research Module Methods in Surface Spectroscopy
Abbreviation: 11-FM-MSS-102-m01

Module coordinator: chairperson of examination committee
Module offered by: Faculty of Physics and Astronomy

ECTS: 8
Method of grading: numerical grade
Only after succ. compl. of module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: 11-TQM, 11-KM2, 11-FK2 (or 11-T3, 11-E5, 11-E7)

Contents:
Experimental determination of the electronic structure of solids and surfaces: Band dispersion and band gaps, quasiparticles, electronic correlations, etc.

Intended learning outcomes:
The students know the physical principles and experimental methods of surface spectroscopy. They are able to conduct, evaluate and interpret simple measurements. They have acquired advanced knowledge of a subdiscipline and are able to summarise their knowledge in an oral presentation.

Courses:
Methods in Surface Spectroscopy: V (3 weekly contact hours), usually English, once a year (winter semester)
Kompaktseminar (Block Taught Seminar) Applications of Surface Spectroscopy: S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment:
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.
Students must register for assessment components 1 and 2 online (details to be announced).
Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.
To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title | Abbreviation
---|---
FOKUS Research Module Methods in Surface Spectroscopy with Mini Research Project | 11-FM-MSS-MF-102-m01

Module coordinator | Module offered by
chairperson of examination committee | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
12 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | 11-TQM, 11-KM2, 11-FK2 (or 11-T3, 11-E5, 11-E7)

Contents
Experimental determination of the electronic structure of solids and surfaces: Band dispersion and band gaps, quasiparticles, electronic correlations

Intended learning outcomes
The students have gained insights into a modern research area neighbouring on different areas of "Condensed Matter", they have acquired basic knowledge for the application of modern methods of surface spectroscopy (photo emission, Auger spectroscopy, spectroscopy with synchrotron radiation etc.) and are able to interpret and present the results obtained with these methods in a presentation or a poster.

Courses (type, number of weekly contact hours, language — if other than German)
Methods in Surface Spectroscopy: V (3 weekly contact hours), usually English, once a year (winter semester)
Kosmologie (Cosmology): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English
Kompaktseminar (Block Taught Seminar) Applications of Surface Spectroscopy: S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)
Miniforschungsprojekt zu Surface Spectroscopy (Mini Research Project Surface Spectroscopy): P (2 weekly contact hours)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English.
Students must register for assessment components 1 through 3 online (details to be announced).
Assessment component 1 will be offered once a year in the winter semester; details on when assessment components 2 and 3 will be offered to be announced.
To pass this module, students must pass each of the assessment components 1 through 3.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<tr>
<th><strong>Module title</strong></th>
<th><strong>Abbreviation</strong></th>
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<td>FOKUS Research Module High Energy Astrophysics</td>
<td>11-FM-HAS-111-m01</td>
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<th><strong>Module offered by</strong></th>
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<tr>
<td>chairperson of examination committee</td>
<td>Faculty of Physics and Astronomy</td>
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<th><strong>Other prerequisites</strong></th>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
<td>11-A4, 11-KET</td>
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</tbody>
</table>

**Contents**

Specific and advanced knowledge for independent scientific work in the research area of High-Energy Astrophysics.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in the field of High-Energy Astrophysics. They have knowledge of cosmology and/or Plasma Astrophysics (cf. modules 11-AKM, 11-APL). They are able to reproduce and summarise the acquired knowledge in a seminar presentation.

**Courses**

(type, number of weekly contact hours, language — if other than German)

- Plasma-Astrophysik (Plasma-Astrophysics): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- Kosmologie (Cosmology): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English
- Kompaktseminar Hochenergie-Astrophysik (Block Taught Seminar High Energy Astrophysics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Details on when assessment component 2 will be offered to be announced.

Lectures and exercises will cover either plasma-astrophysics or cosmology (as announced by or agreed upon with the lecturer).

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title

FOKUS Research Module High Energy Astrophysics with Mini Research Project

Abbreviation

11-FM-HAS-MF-111-m01

Module coordinator

chairperson of examination committee

Module offered by

Faculty of Physics and Astronomy

ECTS

Method of grading

Only after succ. compl. of module(s)

16

numerical grade

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Duration

Module level

Other prerequisites

1 semester

graduate

11-A4, 11-KET

Contents

Specific and advanced knowledge for independent scientific work in the research area of High-Energy Astrophysics.

Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of High-Energy Astrophysics. They are able to reproduce and summarise the acquired knowledge in an oral presentation. They are able to apply the acquired methods, to conduct and evaluate astrophysical experiments and to present the obtained results.

Courses (type, number of weekly contact hours, language — if other than German)

Plasma-Astrophysik (Plasma-Astrophysics): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)

Kosmologie (Cosmology): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English

Kompaktseminar Hochenergie-Astrophysik (Block Taught Seminar High Energy Astrophysics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Astrophysikalisches Praktikum (Practical Course Astrophysics): P (4 weekly contact hours)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)

2. Seminar: talk (approx. 30 to 45 minutes)

3. Lab course (research project): a) Preparing, performing and evaluating the experiments will be considered successfully completed if a Testat (exam) is passed. Students will be given one opportunity to repeat experiments they did not pass. Or b) discussion to test the students' understanding of the physics-related contents and results of the experiment (approx. 20 minutes).

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 through 3 online (details to be announced).

Details on when assessment component 2 will be offered to be announced.

Lectures and exercises will cover either plasma-astrophysics or cosmology (as announced by or agreed upon with the lecturer).

To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places

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Additional information

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Referred to in LPO 1 (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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FOKUS Research Module Spectroscopy and Nano-Optics | 11-FM-NOS-F-111-m01

Module coordinator | Module offered by
--- | ---
chairperson of examination committee | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
10 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | 11-KM, 11-TQM

Contents
Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Nano-Optics, reproduction of knowledge, acquisition of social and methodological competencies.

Intended learning outcomes
The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of nano-optics, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

Courses
<table>
<thead>
<tr>
<th>type, number of weekly contact hours, language — if other than German</th>
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</thead>
<tbody>
<tr>
<td>Festkörper-Spektroskopie (Solid State Spectroscopy): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)</td>
</tr>
<tr>
<td>Kompaktseminar Nano-Optik und Spektroskopie (Block Taught Seminar Nano-Optics and Spectroscopy): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)</td>
</tr>
</tbody>
</table>

Method of assessment
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.
Students must register for assessment components 1 and 2 online (details to be announced). Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.
To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title | Abbreviation
--- | ---
**FOKUS Research Module Nano-Optics and Spectroscopy** | **11-FM-NOS-N-111-m01**

<table>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of Nano-Optics and Spectroscopy, reproduction of knowledge, acquisition of social and methodological competencies.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area, especially in the field of nano-optics and spectroscopy, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

- **Nano-Optik (Nano-Optics):** V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- **Kompaktseminar Nano-Optik (Block Taught Seminar Nano-Optics):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components:

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced). Students must meet certain prerequisites to qualify for admission to assessment component 1. The lecturer will inform them about the respective details at the beginning of the course.

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject
### FOKUS Physics
### Master's with 1 major, 120 ECTS credits

<table>
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<th>Module title</th>
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<td>11-MA-PF-111-m01</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

### Contents
Mostly independent processing of an experimental or theoretical task in a current research area of Experimental or Theoretical Physics, especially according to known procedures and scientific aspects; writing of the thesis.

### Intended learning outcomes
The students are able to independently work on an experimental or theoretical task from a current research area of Theoretical Physics, especially in accordance with known methods and scientific aspects and to summarise their results in a final paper.

### Courses
(type, number of weekly contact hours, language — if other than German)
no courses assigned

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written thesis
Language of assessment: German, English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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<table>
<thead>
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<td>Current Topics in Physics</td>
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<tr>
<td>chairperson of examination committee</td>
<td>Faculty of Physics and Astronomy</td>
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<tbody>
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<td>graduate</td>
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**Contents**

Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 120 minutes, for modules with less than 4 ECTS credits approx. 90 minutes; unless otherwise specified) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
Principles of two- and threedimensional Röntgen imaging | 11-ZDR-111-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
6 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Physics of X-ray generation (X-ray tubes, synchrotron). Physics of the interaction between X-rays and matter (photon absorption, scattering), physics of X-ray detection. Mathematics of reconstruction algorithms (filtered back projection, Fourier reconstruction, iterative methods). Image processing (image data pre-processing, feature extraction, visualisation, ...). Applications of X-ray imaging in the industrial sector (component testing, material characterisation, metrology, biology, ...). Radiation protection and biological radiation effect (dose, ...).

Intended learning outcomes

The students know the principles of generating X-rays and of their interactions with matter. They know imaging techniques using X-rays and methods of image processing as well as application areas of these methods.

Courses (type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title | Abbreviation
---|---
Introduction to Electron Microscopy | 11-IEM-111-m01

**Module coordinator**
Managing Director of the Institute of Applied Physics

**Module offered by**
Faculty of Physics and Astronomy

**ECTS**
4

**Method of grading**
numerical grade

**Only after succ. compl. of module(s)**
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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**Contents**


**Intended learning outcomes**
The students have basic knowledge of modern research methods of electron microscopy up to an atomic level. They know microscoping procedures that are used in practice in labs and the industry as well as electron-microscopic methods for chemical analysis. They are able to evaluate the efficiency of different research methods.

**Courses**
(type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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**Contents**

Current topics of Experimental Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master’s programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
Field Theory in Solid State Physics | 11-FTFK-112-m01

| Module coordinator | Module offered by |
---|---|
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---|
8 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
---|---|---|
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew. |

Contents

This will usually be a course on quantum many particle physics using the method of functional integration. An outline could be:

1. Coherent states and review of second quantization
2. The functional integral formalism at finite temperatures T
3. Perturbation theory at T=0
4. Order parameters and broken symmetry
5. Green’s functions
6. The Landau theory of Fermi liquids
7. Further developments

Intended learning outcomes

The students have mastered the principles of quantum field theory in many-particle systems. They are able to apply the acquired methods to current problems of Theoretical Solid-State Physics.

Courses (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Concepts of Theoretical Astroparticle physics

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### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
4

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents
Concepts of Theoretical Astro-Particle Physics, e.g. Dark matter, cosmic radiation, neutrinos, baryogenesis, cosmic accelerators, dark energy, inflation.

### Intended learning outcomes
The students have basic knowledge of the concepts of Theoretical Astroparticle Physics. They are able to describe phenomena of Astroparticle Physics on the basis of methods of Theoretical Physics and to find solution approaches for problems.

### Courses
V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
**Module title**

General Theory of Relativity

**Abbreviation**

11-ART-112-m01

**Module coordinator**

Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**

Faculty of Physics and Astronomy

**ECTS** 4

**Method of grading** numerical grade

**Duration** 1 semester

**Module level** graduate

**Other prerequisites** Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**Contents**

Mathematical foundations of the theory of relativity; differential forms; brief summary of special relativity; elements of differential geometry; electrodynamics as an example of a relativistic gauge theory; field equations of general relativity; stellar models; introduction to cosmology; Hamiltonian formulation

**Intended learning outcomes**

The students are familiar with the basic physical and mathematical concepts of general relativity. They have a mathematical understanding of the formulation of general relativity on the basis of differential forms. They are able to apply the acquired knowledge to problems of Astrophysics and cosmology.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module Title: Special Theory of Relativity

**Abbreviation:** 11-SRT-112-m01

**Module Coordinator:**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module Offered by:**
Faculty of Physics and Astronomy

**ECTS:** 4

**Method of Grading:**
Only after succ. compl. of module(s)

**Duration:** 1 semester

**Module Level:** Graduate

**Other Prerequisites:**
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents
Mathematical principles; differential forms; special relativity; Minkowski space; Lorentz transformation, Hamiltonian equation of motion; relativistic free particle

### Intended Learning Outcomes
The students are familiar with the physical concepts and mathematical principles of special relativity. They are familiar with modern mathematical formulation of special relativity. They are able to apply the acquired knowledge to problems of special relativity.

### Courses

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<td>c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks)</td>
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

### Allocation of Places

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### Additional Information

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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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**Contents**

Current topics of Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master's programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 120 minutes) or
- b) oral examination of one candidate each or
- c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or
- d) presentation/seminar presentation (approx. 30 minutes)

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module title**  
FOKUS Research Module

**Abbreviation**  
11-FM4-112-m01

**Module coordinator**  
chairperson of examination committee

**Module offered by**  
Faculty of Physics and Astronomy

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**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
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**Contents**

Specific and advanced knowledge of independent scientific work in a current research area.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area. They have mastered the basics in theory and practice. They are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a topic of the selected research area in an oral presentation.

**Courses**

- **FOKUS Vorlesung zu aktuellen Forschungsthemen** (FOKUS Lecture on Topics in Current Research): V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, details on availability to be announced.
- **FOKUS Kompaktseminar** (FOKUS Block Taught Seminar): S (2 weekly contact hours), German or English, details on availability to be announced.

**Method of assessment**

This module has the following assessment components:

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages).
2. Seminar: talk (approx. 30 to 45 minutes).

Assessment components 1 and 2 will be offered in German or English. Students must register for assessment components 1 and 2 online (details to be announced). Details on when assessment components will be offered to be announced. To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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**Contents**

Specific and advanced knowledge of independent scientific work in a current research area.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area. They have mastered the basics in theory and practice. They are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a topic of the selected research area in an oral presentation.

**Courses**

- FOKUS Vorlesung zu aktuellen Forschungsthemen (FOKUS Lecture on Topics in Current Research): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, details on availability to be announced
- FOKUS Kompaktseminar (FOKUS Block Taught Seminar): S (2 weekly contact hours), German or English, details on availability to be announced

**Method of assessment**

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced). Details on when assessment components will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

**Allocation of places**

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**Additional information**

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Contents

Specific and advanced knowledge of independent scientific work in a current research area.

Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area. They have mastered the basics in theory and practice. They are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a topic of the selected research area in an oral presentation.

Courses (type, number of weekly contact hours, language — if other than German)

FOKUS Vorlesung zu aktuellen Forschungsthemen (FOKUS Lecture on Topics in Current Research): V (4 weekly contact hours) + Ü/P (2 weekly contact hours), German or English, details on availability to be announced.

FOKUS Kompaktseminar (FOKUS Block Taught Seminar): S (2 weekly contact hours), German or English, details on availability to be announced.

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages).
2. Seminar: talk (approx. 30 to 45 minutes).

Assessment components 1 and 2 will be offered in German or English. Students must register for assessment components 1 and 2 online (details to be announced). Details on when assessment components will be offered to be announced. To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places

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Additional information

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**Contents**

Specific and advanced knowledge of independent scientific work in a current research area.

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The students have special and advanced knowledge of independent scientific work in a current research area. They have mastered the basics in theory and practice. They are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a topic of the selected research area in an oral presentation. They are able to successfully implement the acquired methods in a mini research project and to write down the results in a report.

**Courses** (type, number of weekly contact hours, language — if other than German)

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- **FOKUS Kompaktseminar (FOKUS Block Taught Seminar):** S (2 weekly contact hours), German or English, details on availability to be announced
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**Allocation of places**

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**Additional information**

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# Module Catalogue for the Subject FOKUS Physics

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**Module coordinator**

Chairperson of examination committee

**Module offered by**

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**Duration**

1 semester

**Module level**

Graduate

**Other prerequisites**

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Students must register for assessment components 1 and 3 online (details to be announced).

Details on when assessment components will be offered to be announced.

To pass this module, students must pass each of the assessment components 1 through 3.

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
# Module Catalogue for the Subject

## FOKUS Physics

### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Analysis and Geometry of Classical Systems</td>
<td>10-M=MP1-122-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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</thead>
<tbody>
<tr>
<td>Dean of Studies Mathematik (Mathematics)</td>
<td>Institute of Mathematics</td>
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<tbody>
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</table>

### Contents

Modern analytic methods (such as partial differential equations) and geometric methods (such as differential geometry) for the description of classical physics. Examples include movements of deformable bodies as reaction to outer load (deformation of elastic bodies, flow of a fluid, stream of a gas). Additional examples include geometric mechanics and symplectic geometry, classical field theory and classical gauge theory, general relativity theory.

### Intended learning outcomes

The student gains insight into modern methods in mathematics, which are applied in classical physics. He/She masters advanced techniques in this field and is able to apply them to complex problems.

### Courses

(V + Ü) (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
Module title | Algebra and Dynamics of Quantum Systems
---|---
Abbreviation | 10-M=MP2-122-m01

Module coordinator | Dean of Studies Mathematik (Mathematics)
Module offered by | Institute of Mathematics

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</table>

Duration | 1 semester
Module level | graduate
Other prerequisites | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Modern algebraic methods for dynamics of quantum systems, e.g. operator algebras with applications in algebraic quantum field theory, spectral theory, symmetries and representation theory.

Intended learning outcomes
The student gains insight into modern methods in mathematics, which are applied in quantum physics. He/She masters advanced techniques in this field and is able to apply them to complex problems.

Courses (type, number of weekly contact hours, language — if other than German)
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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## Module Catalogue for the Subject FOKUS Physics

Master's with 1 major, 120 ECTS credits

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<td>Image and Signal Processing in Physics</td>
<td>11-BSV-122-m01</td>
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<td>Faculty of Physics and Astronomy</td>
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</table>

## Contents

Periodic and aperiodic signals; principles of discreet and exact Fourier transformation; principles of digital signal and image processing; discretisation of signals/sampling theorem (Shannon); homogeneous and linear filters, convolution product; tapering functions and interpolation of images; the Parsival theorem, correlation and energetic observation; statistical signals, image noise, moments, stationary signals; tomography: Hankel and Radon transformation.

## Intended learning outcomes

The students have advanced knowledge of digital image and signal processing. They know the physical principles of image processing and are familiar with different methods of signal processing. They are able to explain different methods and to implement them, especially in the field of tomography.

## Courses (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

## Allocation of places

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## Additional information

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## Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module title
Astronomical Methods

### Abbreviation
11-ASM-131-m01

### Managing Director of the Institute of Theoretical Physics and Astrophysics
Faculty of Physics and Astronomy

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<th>Module level</th>
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</table>

### Contents
Methods of observational astronomy across the electromagnetic spectrum. Extraction and reduction of observational data from radio, optical, X-ray and gamma-ray telescopes.

### Intended learning outcomes
Overview of the methods used in observational astronomy in various parts of the electromagnetic spectrum (radio, optical, X-ray and gamma-ray energies). Knowledge of principles and applications of these methods and ability to conduct astronomical observations.

### Courses (type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Critical Phenomena

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**Module coordinator**

Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**

Faculty of Physics and Astronomy

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

In Statistical Physics, critical phenomena refer to the universal behaviour in the proximity of continuous phase transitions. The theory, which can be explained through critical phenomena, is called renormalisation group and plays an important role in many areas of Physics. The lecture serves as an introduction to critical phenomena and to renormalisation group theory and discusses selected applications. Basic phenomenology: Universality, scaling relationships, critical exponents. Mean field theory. Renormalisation group theory. Duality and high-/low-temperature development. Finite size scaling theory. Exact solutions.

### Intended learning outcomes

The students know the principles of the theory of critical phenomena and are able to apply the calculation methods to simple problems.

### Courses

V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

(a) written examination project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks), presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
FOKUS Research Module Topological Insulators | 11-FM-TI-131-m01

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<td>1 semester</td>
<td>graduate</td>
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</table>

Contents

Topological insulators are a new class of materials with special electrical properties. In this research module, we present and discuss the principles necessary to understand these materials on the basis of current research results.

Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in the field of topological insulators, and are able to reproduce the acquired knowledge, to apply the acquired methods and to summarise a sub-area of the current research area in an oral presentation.

Courses (type, number of weekly contact hours, language — if other than German)

Quantentransport in Halbleiter-Nanostrukturen (Quantum Transport in Semiconductor Nanostructures): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)

Kompaktseminar Topologische Isolatoren (Block Taught Seminar Topological Insulators): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (1 to 3 days) held towards the end of semester break or at the beginning of the subsequent semester)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module: Disordered Systems

Abbreviation: 11-UGS-131-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 4

Method of grading: Only after succ. compl. of module(s)

Duration: 1 semester

Module level: graduate

Other prerequisites:
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semesters.

Contents
Part 1: Part 1 discusses systems of interacting electrons with random potentials or random interactions with the help of quantum statistical methods which are introduced in a separate lesson. The students learn to calculate transport properties, magnetic instabilities and phase transitions as well as competing orders. Part II: Part II covers non-linear partial differential equations, which also describe systems far beyond equilibrium and systems with random inhomogeneity. Where applicable, exact solubility in a space dimension will be covered; otherwise and in more than one space dimension, diagram methods and renormalisation groups are applied, which will be introduced separately. As a methodological development of the methods of the course Mathematics 3, the path integral method is derived for classical and quantum mechanical models and differential equations (e.g. Feynman-Kac method).

Intended learning outcomes
The students acquire insights into the calculability of the behaviour of physical and non-physical models with random parameters. They learn to construct diagram developments for specific models, both for Hamiltonian systems and non-equilibrium differential equations. They understand why physical laws describing the behaviour of non-ordered systems are often times simpler and how a new order arises from disorder. They learn to differentiate between quantum mechanical uncertainty and random uncertainty as well as between disorder and chaos.

Courses (type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<th>Module title</th>
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<tr>
<td>Solid State Spectroscopy 2</td>
<td>11-FKS2-132-m01</td>
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<tr>
<td>1 semester</td>
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</table>

**Contents**

Modern scattering methods; neutron scattering as a method to investigate the atomic and magnetic structure and excitations such as phonons and magnetic waves; resonant elastic X-ray scattering and absorption; investigation of magnetic, orbital and charge order; X-ray and neutron reflectometry; investigation of the structural, magnetic and electronic properties of thin films and superlattices; resonant inelastic X-ray scattering; investigation of excitations in solids and thin films; STEM ("scanning transmission electron microscopy"); further topics upon agreement.

**Intended learning outcomes**

The students know different modern scattering methods such as neutron scattering, resonant elastic X-ray scattering, modern scattering theory, X-ray and neutron reflectometry and resonant inelastic X-ray scattering. They are familiar with the theoretical principles and applications of these methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

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**Additional information**

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<td>Physics of Advanced Materials</td>
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</table>

### Contents

General properties of various material groups such as liquids, liquid crystals and polymers; magnetic materials and superconductors; thin films, heterostructures and superlattices. Methods of characterising these material groups; two-dimensional layer materials.

### Intended learning outcomes

The students know the properties and characterising methods of some modern materials.

### Courses

V + R (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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## Module title
Topological Order

<table>
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<th>11-TOPO-132-m01</th>
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## Contents
In modern Solid-State Physics, the concept of topologically ordered phases plays an increasingly important role. These phases possess no order in the conventional sense of a broken symmetry, but are characterised by topological quantum numbers. Examples of topological quantum numbers or phases include:

1. The fractional charge and statistics of quasiparticle excitation in quantum Hall fluids.
2. The fractional quantisation of spins in spin liquids and the accompanying split-up of spin and charge in antiferromagnets.
3. The topological anomalies of fractionally quantised systems on the torus (or generally on surfaces with genus \( g \geq 0 \)).
4. Majorana fermion states at the interfaces between topological superconductors and topologically trivial regions. The lecture explains the fundamental concepts with the help of basic examples.

## Intended learning outcomes
The students acquire in-depth knowledge of topological order in quantum condensates.

## Courses
(V + R (no information on SWS (weekly contact hours) and course language available)

## Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

## Allocation of places
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## Additional information
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**Contents**

The students are familiar with the theory of topological effects in Solid-State Physics. They know the mathematical methods necessary for their description and are able to apply these methods to simple problems.

**Intended learning outcomes**

The students are familiar with the theory of topological effects in Solid-State Physics. They know the mathematical methods necessary for their description and are able to apply these methods to simple problems.

**Courses**

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(a) written examination (approx. 90 minutes) or (b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or (c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or (d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject

**FOKUS Physics**

### Master's with 1 major, 120 ECTS credits

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<th>Abbreviation</th>
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<tr>
<td>Quantum Information Technology</td>
<td>11-QUI-132-m01</td>
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<th>Module offered by</th>
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<tbody>
<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

### Contents

Basic concepts of quantum mechanics, quantum bits and algorithms, quantal measurements, experimental approaches towards quantum computing (on the basis of photons, ions and nuclear spins), quantum operations and quantum noise, quantum information and communication.

### Intended learning outcomes

The students are familiar with the basic quantum mechanical terms of quantum information technology. They know experimental approaches for the realisation of quantum computers and for the transfer of quantum information.

### Courses

<table>
<thead>
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<th>(type, number of weekly contact hours, language — if other than German)</th>
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### Method of assessment

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<th>(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)</th>
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<tbody>
<tr>
<td>a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)</td>
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
FOKUS Quantum Information Technology | 11-FM-QUI-132-m01

| Module coordinator | Module offered by |
---|---|
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---|
10 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
---|---|---|
1 semester | graduate | -- |

Contents
Basic concepts of quantum mechanics, quantum bits and algorithms, quantal measurements, experimental approaches towards quantum computing (on the basis of photons, ions and nuclear spins), quantum operations and quantum noise, quantum information and communication.

Intended learning outcomes
The students have special and advanced knowledge of independent scientific work in the field of quantum information, they are able to reproduce the acquired knowledge, to apply the acquired methods, to summarise a sub-area of the current research area in an oral presentation and to successfully implement the acquired knowledge and methods in a mini research project.

Courses (type, number of weekly contact hours, language — if other than German)
Quanteninformationstechnologie (Quantum Information Technology): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (winter semester)
Kompaktseminar Quanteninformationstechnologie (Block Taught Seminar Quantum Information Technology): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
This module has the following assessment components
1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
Assessment components 1 and 2 will be offered in German or English.
Students must register for assessment components 1 and 2 online (details to be announced).
Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.
To pass this module, students must pass both assessment component 1 and assessment component 2.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title | Thermodynamics and Economics | Abbreviation | 11-TDOE-141-m01

Module coordinator | Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by | Faculty of Physics and Astronomy

ECTS | 3 | Method of grading | Only after succ. compl. of module(s)

Duration | 1 semester | Module level | graduate | Other prerequisites

Contents

Energy and economic growth, entropy production, emission reduction.

Part I describes the role of energy conversion in the development of the universe, the evolution of life and the unfolding of civilisation. The entropy production density of non-equilibrium thermodynamics shows the relevance of the second law of thermodynamics for ecological damage and resource consumption. Energy conversion, entropy production and natural resources define the technological and ecological boundaries of industrial economic growth.

Part 2 analyses how the factors capital, work, energy and creativity produce the goods and services of a national economy and determine economic growth. The productive power of cheap energy by far exceeds that of expensive labour. Within the current system of taxes and social security contributions, this discrepancy between power and costs of production factors leads to job cuts, waste of resources, impoverishment of nations and growing social tensions. The course discusses how factor income taxation can counteract this development.

Part 3 includes seminar presentations, comprises the techniques of rational energy use and non-fossil energy use, and introduces the optimisation programme deeco (Dynamic Energy, Emission and Cost Optimization).

Intended learning outcomes

The students understand that energy conversion and entropy production are going to play an important role in the world’s economic and social development. As an extension of economic theory, the students know the connections between thermodynamics and economy as well as the productive physical basis of modern economies. They are able to apply the acquired knowledge to particular problems.

NOTE: this is the module that was run by Prof. Dr. R. Kümmel, who has now retired. As the module was tailored to his own theory of economy, it has yet to be decided whether we will continue to offer this module.

Courses (type, number of weekly contact hours, language — if other than German)

V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
# Module Catalogue for the Subject
## FOKUS Physics
### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>FOKUS Research Module Topology in Solid State Physics</td>
<td>11-FM-TFP-141-m01</td>
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<table>
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<th>Module coordinator</th>
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<tr>
<td>chairperson of examination committee</td>
<td>Faculty of Physics and Astronomy</td>
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<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

## Contents

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field.

## Intended learning outcomes

The students have special and advanced knowledge of independent scientific work in a current research area.

## Courses (type, number of weekly contact hours, language — if other than German)

- Topologie in der Festkörperphysik (Topology in Solid State Physics): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- Kompaktseminar Topologie in der Festkörperphysik (Block Taught Seminar Topology in Solid State Physics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the summer semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

## Allocation of places

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## Additional information

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## Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module Catalogue for the Subject
FOKUS Physics
Master's with 1 major, 120 ECTS credits

<table>
<thead>
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<th>Module title</th>
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<tbody>
<tr>
<td>FOKUS Research Module Topology in Solid State Physics with Mini Research Project</td>
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<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**

Specific and advanced knowledge of independent scientific work in a current research area, especially in the specialist field of topology in Solid-State Physics.

**Intended learning outcomes**

The students have special and advanced knowledge of independent scientific work in a current research area of topology in Solid-State Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

- Topologie in der Festkörperphysik (Topology in Solid State Physics): V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (summer semester)
- Kompaktseminar Topologie in der Festkörperphysik (Block Taught Seminar Topology in Solid State Physics): S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)
- Miniforschungsprojekt Topologie in der Festkörperphysik (Mini Research Project Topology in Solid State Physics): P (2 weekly contact hours), German or English, details on availability to be announced (either block taught during semester break or approx. 3 weeks part time)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)
2. Seminar: talk (approx. 30 to 45 minutes)
3. Research project: project report (approx. 8 pages)

Assessment components 1 through 3 will be offered in German or English.
Students must register for assessment components 1 through 3 online (details to be announced).
Assessment component 1 will be offered once a year in the summer semester; details on when assessment components 2 and 3 will be offered to be announced.
To pass this module, students must pass each of the assessment components 1 through 3.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module Title

**Module title**

FOKUS Research Module Quantum Information Technology

**Abbreviation**

11-FM-QUI-141-m01

### Module Coordinator

Managing Director of the Institute of Applied Physics

### Module Offered by

Faculty of Physics and Astronomy

### ECTS

10

### Method of Grading

Numerical grade

### Module Duration

1 semester

### Module Level

Graduate

### Other Prerequisites

--

### Contents

Basic concepts of quantum mechanics, quantum bits and algorithms, quantal measurements, experimental approaches towards quantum computing (on the basis of photons, ions and nuclear spins), quantum operations and quantum noise, quantum information and communication.

### Intended Learning Outcomes

The students have special and advanced knowledge of independent scientific work in the field of quantum information, they are able to reproduce the acquired knowledge, to apply the acquired methods, to summarise a sub-area of the current research area in an oral presentation and to successfully implement the acquired knowledge and methods in a mini research project.

### Courses

**Quanteninformationstechnologie (Quantum Information Technology):** V (3 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (winter semester)

**Kompaktseminar Quanteninformationstechnologie (Block Taught Seminar Quantum Information Technology):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of Assessment

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)

2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced). Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of Places

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### Additional Information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Master's with 1 major FOKUS Physics (2011)

JMU Würzburg • generated 17-Sep-2019 • exam. reg. data record 88[e07]-|[-|H][2011] page 151 / 153
Module title
Densitiy Functional Theory and the Physics of Oxide Heterostructure
Abbreviation
11-DFT-142-m01
Module coordinator
chairperson of examination committee
Module offered by
Faculty of Physics and Astronomy
ECTS
4
Method of grading
numerical grade
Only after succ. compl. of module(s)
Duration
1 semester
Module level
graduate
Other prerequisites

Contents
The students are familiar with the physical values of oxide heterostructures and with the principles and methods of density functional theory. They are able to model problems of Theoretical Physics with the help of important programmes such as Wien2k or VASP. They can make simple calculations with the help of density functional theory.

Intended learning outcomes
The students are familiar with the physical values of oxide heterostructures and with the principles and methods of density functional theory. They are able to model problems of Theoretical Physics with the help of important programmes such as Wien2k or VASP. They can make simple calculations with the help of density functional theory.

Courses
(type, number of weekly contact hours, language — if other than German)
V + D (no information on SWS (weekly contact hours) and course language available)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: approx. 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module Catalogue for the Subject FOKUS Physics

**Master's with 1 major, 120 ECTS credits**

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<tbody>
<tr>
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<td>graduate</td>
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</table>

### Contents

Concepts and principles of density functional theory.

### Intended learning outcomes

The students know the concepts and principles of density functional theory.

### Courses

**Dichtefunktionaltheorie und Physik der oxidischen Heterostrukturen (Density Functional Theory and Physics of Oxide Heterostructures):** V (2 weekly contact hours) + Ü/P (1 weekly contact hour), German or English, once a year (winter semester)

**Kompaktseminar Dichtefunktionaltheorie und Physik der oxidischen Heterostrukturen (Block Taught Seminar Density Functional Theory and Physics of Oxide Heterostructures):** S (2 weekly contact hours), German or English, details on availability to be announced (block taught seminar (3 days), usually held during semester break)

### Method of assessment

This module has the following assessment components

1. Topics covered in lectures and exercises: written examination (approx. 90 minutes) or talk (approx. 30 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes) or project report (approx. 8 pages)

2. Seminar: talk (approx. 30 to 45 minutes)

Assessment components 1 and 2 will be offered in German or English.

Students must register for assessment components 1 and 2 online (details to be announced).

Assessment component 1 will be offered once a year in the winter semester; details on when assessment component 2 will be offered to be announced.

To pass this module, students must pass both assessment component 1 and assessment component 2.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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