LUDWIG-
MAXIMILIANS-
UNIVERSITÄT
MÜNCHEN

Module Catalogue

Master's Programme: Physics

(Master of Science, M.Sc.)

(120 ECTS-Punkte, start of studies in the winter semester)

Based on the *Prüfungs- und Studienordnung*

adopted by the Senate of LMU Munich on June 22, 2023

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Inhaltsverzeichnis

Abbreviations and annotations

CP	Credit Points, ECTS credits
ECTS	European Credit Transfer and Accumulation System
h	hours
SoSe	summer semester
SWS	contact hours
WiSe	winter semester
WP	compulsory elective course/module
P	mandatory course/module

1. The ECTS credits assigned in the Module Catalogue are designated as follows: Credit Points not listed in parentheses are awarded when the pertinent examination of the module or module parts have/has been completed successfully. Credit Points in parentheses are listed for calculatory purposes only.

2. The semester for taking a module can either be binding or may be considered as a recommendation, depending on the applicable data in Anlage 2 of the Prüfungs- und Studienordnung for your Programme. In this Module catalogue, the options are indicated as „scheduled semester“ and „recommended semester“.

3. Please note: The Module Catalogue is merely intended to serve as an orientation whereas the provisions of the applicable version of the Prüfungs- und Studienordnung (in German only) of your Programme are legally binding. See: www.lmu.de/studienangebot and select your Programme.

Module: WP 1 Key Qualifications I

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 1.1 Key Qualifications for Master's Students 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex I.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module teaches content that goes beyond the subject of study and is particularly relevant to the profession of physicist, e.g. programming, science communication, patents, founding a business.
Learning outcomes	Students gain insights into the topics mentioned; depending on the chosen topic, skills for application are practised.
Type of examination	Written exam or oral examination or presentation
Type of assessment	The successful completion of the module will not be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 2 Key Qualifications II

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 2.1 Key Qualifications for Master's Students 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex I.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module teaches content that goes beyond the subject of study and is particularly relevant to the profession of physicist, e.g. programming, science communication, patents, founding a business.
Learning outcomes	Students gain insights into the topics mentioned; depending on the chosen topic, skills for application are practised.
Type of examination	Written exam or oral examination or presentation
Type of assessment	The successful completion of the module will not be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English

Additional information	None

Module: WP 3 Modern Foreign Languages

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Exercise course	WP 3.1 Modern Foreign Language Course	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex I.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module teaches knowledge of a modern foreign language. Students can choose from a variety of language courses at different levels.
Learning outcomes	Students acquire foreign language skills in a modern foreign language.
Type of examination	Written exam or oral examination or presentation
Type of assessment	The successful completion of the module will not be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 4 Advanced Solid State Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 4.1 Advanced Solid State Physics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 4.2 Advanced Solid State Physics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module broadens and deepens the knowledge of students in the field of solid-state physics and introduces advanced concepts. The module provides an understanding of physical properties and phenomena observed in solid state materials including mechanical, electrical, optical and magnetic properties, and superconductivity.
Learning outcomes	Students will acquire in-depth knowledge of fundamental and advanced concepts in solid state physics and are able to describe related physical phenomena. They will get an overview of important developments and up-to-date topics of current research in solid state physics and learn about applications of solid-state materials.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and

	potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dimitri Efetov
Language(s)	English
Additional information	None

Module: WP 5 Advanced Quantum Mechanics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 5.1 Advanced Quantum Mechanics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 5.2 Advanced Quantum Mechanics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module provides a second course on quantum mechanics, which is a recommended prerequisite for any future courses such as many-body physics and field theory in all areas of physics. The contents of this module vary somewhat from year to year, depending on the preferences of the lecturer; interested students are advised to contact the lecturer in advance for details. A typical lecture course on Quantum Mechanics II starts with a chapter recapitulating the material of Quantum Mechanics I, namely the basic postulates, the density matrix formalism, path integrals, angular momentum, perturbation theory. The next chapter provides a brief introduction to concepts of quantum information theory, such as entanglement and the role it plays in the Bell inequalities. A brief chapter on topological concepts, such as the Aharonov-Bohm phase, Berry phase, and Landau levels could follow. The course proceeds with a chapter on the quantization of the electromagnetic field, a discussion of light-matter interactions, and the derivation of selection rules based on symmetry arguments. This is followed by chapters on time-dependent perturbation theory and on scattering theory, including concepts as

	the Born approximation, Lippmann-Schwinger equation, T-matrix etc. The course includes a chapter on relativistic quantum mechanics, discussing the Klein-Gordon and Dirac equations and its consequences, such as spin-orbit coupling and fine structure with possible excursions to the graphene dispersion and Klein tunneling. The final chapter covers the formalism of second quantization and simple applications such as solving tight-binding models and the role of statistics.
Learning outcomes	After successful completion of the module students - have a solid basis to undertake studies in many-body physics, field theory, particle physics, solid-state physics, cold atomic physics, quantum optics etc.; - are familiar with coupling quantum particles to gauge potentials; - are able to solve single particle scattering problems; - understand relativistic quantum mechanics, the difference between positive and negative energy states, and can recognize the Dirac equation as an effective Hamiltonians; have a working knowledge of second quantization.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Lode Pollet
Language(s)	English
Additional information	None

Module: WP 6 Introduction to Advanced Astrophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 6.1 Introduction to Advanced Astrophysics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 6.2 Introduction to Advanced Astrophysics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module comprises a first basic lecture on fundamental and advanced astrophysics and an overview of corresponding concepts, experimental and theoretical methods, with an associated exercise course. ***Lecture: Introduction to Advanced Astrophysics (WP 6.1):*** The lecture introduces the most important concepts and methods of fundamental and advanced astrophysics, and an understanding of the interplay of the various astrophysical processes controlling the evolution of our Universe. Major topics of the lecture are: Basic concepts related to radiation, radiative transfer, observational methods and devices, solar and exo-planets, stellar atmospheres, structure and evolution, stellar remnants, the interstellar medium and star formation. Basic concepts of chemical evolution, stellar and galaxy dynamics, dark matter, active galactic nuclei and massive black holes, large-scale structures, the spatial distribution of

	galaxies and galaxy clusters, cosmology, the early universe, and the formation and evolution of galaxies. The basic astrophysical processes are motivated and underpinned with scientific concepts. ***Exercise course: Introduction to Advanced Astrophysics (WP 6.2):*** The content discussed in the lecture will be practised using typical applications.
Learning outcomes	The aim of this module is to provide students with a deep understanding of the fundamental knowledge, concepts and methods of astrophysics and concrete applications to typical situations. Students are enabled to solve astrophysical problems on the basis of understanding the complex interrelation between the different astrophysical branches. ***Lecture: Introduction to Advanced Astrophysics (WP 6.1):*** By providing the students with the fundamental knowledge and insights into astrophysical processes and procedures as well as their concrete applications, students should gain a detailed overview of the different areas of astrophysics. In particular, students should learn to recognise interrelationships across topics. ***Exercise course: Introduction to Advanced Astrophysics (WP 6.2):*** Simple problem solutions are to be developed, specified and implemented independently. Students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Preibisch
Language(s)	English
Additional information	None

Module: WP 7 Basic Research Methods and Tools of Advanced Astrophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 7.1 Basic Research Methods and Tools of Advanced Astrophysics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 7.2 Basic Research Methods and Tools of Advanced Astrophysics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an overview of concepts and experimental and/or theoretical basic research methods and tools of advanced astrophysics, by means of a lecture from the fields of statistics, hydrodynamics, plasma physics, radiative transfer, observational methods, or applied quantum mechanics (with focus on atomic and molecular physics), as well as a corresponding exercise course. ***Lecture from the field of statistics, hydrodynamics, plasma physics, radiative transfer, observational methods , or applied quantum mechanics (WP7.1)*** The lecture provides an overview of the concepts of statistical methods and their application to (observational) data analysis, or of concepts and methods of hydrodynamics (including numerical aspects), or of plasma physics, or of concepts and methods of radiative transfer in different astrophysical environments and wavelength domains, or of concepts and methods of observational methods and the design and operation of instruments and telescopes, or of concepts

	and methods of applied quantum mechanics, with focus on atomic and molecular physics. ***Corresponding exercise course, supplementing the lecture from the field of statistics, hydrodynamics, plasma physics, radiative transfer, observationsl methods, or applied quantum mechanics (WP 7.2)*** The contents discussed in the lecture are practised using corresponding applications, including numerical methods.
Learning outcomes	The aim of this module is to provide students with a deep understanding of the fundamental knowledge and procedures of specific fields that are essential for astrophysical work. Students are enabled to solve corresponding problems on the basis of understanding the inherent, complex interrelations. ***Lecture from the field of statistics, hydrodynamics, plasma physics, radiative transfer, observational methods, or applied quantum mechanics (WP 7.1)*** By providing basic knowledge and insights into the procedures of statistical methods, or hydrodynamics, or plasma physics, or radiative transfer, or observational methods, or applied quantum mechanics, as well as their specific applications, students should develop a thorough understanding of these topics that are essential tools for current astrophysical research. Moreover, they are also enabled to transfer the lecture content to current problems. ***Corresponding exercise course, supplementing the lecture from the field of statistics, hydrodynamics, plasma physics, radiative transfer, observationsl methods, or applied quantum mechanics (WP 7.2)*** Simple problem solutions shall be independently developed, specified and implemented. Students should learn to apply the content discussed in the lecture to practical tasks, also (if applicable), by means of numerical methods.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Klaus Dolag
Language(s)	English
Additional information	None

Module: WP 8 Current Research Approaches in Advanced Astrophysics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 8.1 Current Research Approaches in Advanced Astrophysics 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 8.2 Current Research Approaches in Advanced Astrophysics 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 8.3 Current Research Approaches in Advanced Astrophysics 1 (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module comprises a lecture covering current research in one of the major astrophysical branches, and a corresponding seminar and exercise course. During the lecture, fundamental concepts and methods of the field will be discussed, whilst during the seminar, specific aspects of current research will be detailed by participating students. ***Lecture: Current Research Approaches in Advanced Astrophysics 1 (WP 8.1)*** In this lecture, the most important concepts and methods of one of the major branches of astrophysics are outlined, leading also to an understanding of the interplay of the corresponding astrophysical processes. ***Exercise course: Current Research Approaches in Advanced Astrophysics 1 (WP 8.2)***

	The contents discussed in the lecture and seminar will be practised using typical applications. ***Seminar: Current Research Approaches in Advanced Astrophysics 1 (WP 8.3)*** In this seminar, specific aspects of current research in the field covered by the lecture will be presented by participating students, both with respect to concepts and methods, as well as with respect to examples for typical applications. The seminar is particularly intended to cover those details which are not discussed in the lecture.
Learning outcomes	The aim of this module is to provide students with a deep understanding of the fundamental knowledge, concepts and methods of current research in one of the major branches of astrophysics, as well as to become familiar with concrete applications to typical situations. In the seminar, participating students will present additional material and/or important details not covered in the lecture, and in the exercise course they will be enabled to solve corresponding problems (referring to the contents of both lecture and seminar), on the basis of understanding the complex interrelation between the involved astrophysical processes. This module, if chosen, will substantially facilitate an understanding of the scientific background of the upcoming Master’s thesis, when conducted on a similar topic as covered here. ***Lecture: Current Research Approaches in Advanced Astrophysics 1 (WP 8.1)*** Students should gain an overview on the current research status of a specific, important branch of astrophysics, by providing them with the fundamental knowledge and insights into corresponding astrophysical processes and procedures as well as their concrete applications. In particular, students should learn to recognise interrelationships across topics. ***Exercise course: Current Research Approaches in Advanced Astrophysics 1 (WP 8.2)*** Students should learn to apply the contents discussed in the lecture and seminar to practical tasks. Simple problem solutions are to be developed, specified and implemented independently. ***Seminar: Current Research Approaches in Advanced Astrophysics 1 (WP 8.3)*** Participating students will present additional material and/or important details about the current research status of the specific field that are not covered in the lecture. They should learn how specific concepts and methods can be used to investigate corresponding current astrophysical questions. The presentations will be prepared by the students under the guidance of experienced supervisors, and they will learn (besides the actual topic of the talk) how to

	give a scientific presentation, and how to use modern visual media.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Kevin Heng
Language(s)	English
Additional information	None

Module: WP 9 Basic Research Concepts of Advanced Astrophysics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 9.1 Basic Research Concepts of Advanced Astrophysics 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 9.2 Basic Research Concepts of Advanced Astrophysics 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module comprises a lecture concentrating on one of the major astrophysical branches, and a corresponding exercise course. During the lecture, fundamental concepts and methods of the field will be discussed in detail. ***Lecture: Basic Research Concepts of Advanced Astrophysics 1 (WP 9.1)*** In this 4-SWS lecture, the most important concepts and methods of one of the major branches of astrophyiscs are discussed in detail, leading to an understanding of the interplay of the corresponding astrophysical processes. ***Exercise course: Basic Research Concepts of Advanced Astrophysics 1 (WP 9.2)*** The contents discussed in the lecture will be practised using typical applications.
Learning outcomes	The aim of this elective module is to provide students with a detailed understanding of the concepts and research methods in one of the major branches of astrophysics, as well as

	to become familiar with concrete applications to typical situations. Both objectives will be reached on the basis of understanding the complex interrelation between the involved astrophysical processes. This module, if chosen, will substantially facilitate an understanding of the scientific background of the upcoming Master's thesis, when conducted on a similar topic as covered here. ***Lecture: Basic Research Concepts of Advanced Astrophysics 1 (WP 9.1)*** Students should gain a detailed overview on the current research status of a specific, important branch of astrophysics, by providing them with the fundamental knowledge and insights into field-related astrophysical processes and procedures as well as their concrete applications. In particular, students should learn how specific research concepts and methods can be used to investigate corresponding astrophysical questions, and to recognise interrelationships across topics. ***Exercise course: Basic Research Concepts of Advanced Astrophysics 1 (WP 9.2)*** Students should learn to apply the contents discussed in the lecture to practical tasks. Simple problem solutions are to be developed, specified and implemented independently.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Preibisch
Language(s)	English
Additional information	None

Module: WP 10 Current Research Approaches in Advanced Astrophysics II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 10.1 Current Research Approaches in Advanced Astrophysics 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 10.2 Current Research Approaches in Advanced Astrophysics 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 10.3 Current Research Approaches in Advanced Astrophysics 2 (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module comprises a lecture covering current research in one of the major astrophysical branches, and a corresponding seminar and exercise course. During the lecture, fundamental concepts and methods of the field will be discussed, whilst during the seminar, specific aspects of current research will be detailed by participating students. ***Lecture: Current Research Approaches in Advanced Astrophysics 2 (WP 10.1)*** In this lecture, the most important concepts and methods of one of the major branches of astrophysics are outlined, leading also to an understanding of the interplay of the corresponding astrophysical processes. ***Exercise course: Current Research Approaches in Advanced Astrophysics 2 (WP 10.2)***

	The contents discussed in the lecture and seminar will be practised using typical applications. ***Seminar: Current Research Approaches in Advanced Astrophysics 2 (WP 10.3)*** In this seminar, specific aspects of current research in the field covered by the lecture will be presented by participating students, both with respect to concepts and methods, as well as with respect to examples for typical applications. The seminar is particularly intended to cover those details which are not discussed in the lecture.
Learning outcomes	The aim of this elective module is to provide students with a deep understanding of the fundamental knowledge, concepts and methods of current research in one of the major branches of astrophysics, as well as to become familiar with concrete applications to typical situations. In the seminar, participating students will present additional material and/or important details not covered in the lecture, and in the exercise course they will be enabled to solve corresponding problems (referring to the contents of both lecture and seminar), on the basis of understanding the complex interrelation between the involved astrophysical processes. This module, if chosen, will substantially facilitate an understanding of the scientific background of the upcoming Master's thesis, when conducted on a similar topic as covered here. ***Lecture: Current Research Approaches in Advanced Astrophysics 2 (WP 10.1)*** Students should gain an overview on the current research status of a specific, important branch of astrophysics, by providing them with the fundamental knowledge and insights into corresponding astrophysical processes and procedures as well as their concrete applications. In particular, students should learn to recognise interrelationships across topics. ***Exercise course: Current Research Approaches in Advanced Astrophysics 2 (WP 10.2)*** Students should learn to apply the contents discussed in the lecture and seminar to practical tasks. Simple problem solutions are to be developed, specified and implemented independently. ***Seminar: Current Research Approaches in Advanced Astrophysics 2 (WP 10.3)*** Participating students will present additional material and/or important details about the current research status of the specific field that are not covered in the lecture. They should learn how specific concepts and methods can be used to investigate corresponding current astrophysical questions. The presentations will be prepared by the students under the guidance of experienced supervisors, and they will learn (besides the actual topic of the talk) how to

	give a scientific presentation, and how to use modern visual media.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Kevin Heng
Language(s)	English
Additional information	None

Module: WP 11 Basic Research Concepts of Advanced Astrophysics II

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 11.1 Basic Research Concepts of Advanced Astrophysics 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 11.2 Basic Research Concepts of Advanced Astrophysics 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module comprises a lecture concentrating on one of the major astrophysical branches, and a corresponding exercise course. During the lecture, fundamental concepts and methods of the field will be discussed in detail. ***Lecture: Basic Research Concepts of Advanced Astrophysics 2 (WP 11.1)*** In this 4-SWS lecture, the most important concepts and methods of one of the major branches of astrophyiscs are discussed in detail, leading to an understanding of the interplay of the corresponding astrophysical processes. ***Exercise course: Basic Research Concepts of Advanced Astrophysics 2 (WP 11.2)*** The contents discussed in the lecture will be practised using typical applications.
Learning outcomes	The aim of this elective module is to provide students with a detailed understanding of the concepts and research methods in one of the major branches of astrophysics, as well as

	to become familiar with concrete applications to typical situations. Both objectives will be reached on the basis of understanding the complex interrelation between the involved astrophysical processes. This module, if chosen, will substantially facilitate an understanding of the scientific background of the upcoming Master's thesis, when conducted on a similar topic as covered here. ***Lecture: Basic Research Concepts of Advanced Astrophysics 2 (WP 11.1)*** Students should gain a detailed overview on the current research status of a specific, important branch of astrophysics, by providing them with the fundamental knowledge and insights into field-related astrophysical processes and procedures as well as their concrete applications. In particular, students should learn how specific research concepts and methods can be used to investigate corresponding astrophysical questions, and to recognise interrelationships across topics. ***Exercise course: Basic Research Concepts of Advanced Astrophysics 2 (WP 11.2)*** Students should learn to apply the contents discussed in the lecture to practical tasks. Simple problem solutions are to be developed, specified and implemented independently.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Preibisch
Language(s)	English
Additional information	None

Module: WP 12 Stars, Planets, Star Formation I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 12.1 Stars, Planets, Star Formation 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 12.2 Stars, Planets, Star Formation 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of stellar and/or planetary structure and evolution and/or of star formation. The contents discussed in the lecture are practised by means of typical applications.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the properties of stars and/or planets, and/or into the various processes controlling and affecting the formation of stars. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Preibisch
Language(s)	English
Additional information	None

Module: WP 13 Circumstellar Disks and Planet Formation I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 13.1 Circumstellar Disks and Planet Formation 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 13.2 Circumstellar Disks and Planet Formation 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of circumstellar disks and the formation of planets. The contents discussed in the lecture are practised by means of typical applications.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the properties and evolution of circumstellar disks, and the formation of planets. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Til Birnstiel
Language(s)	English
Additional information	None

Module: WP 14 Radiative Processes in the Atmospheres of Planets, Stars, and the Interstellar Medium I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 14.1 Radiative Processes in the Atmospheres of Planets, Stars, and the Interstellar Medium 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 14.2 Radiative Processes in the Atmospheres of Planets, Stars, and the Interstellar Medium 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of radiative processes in astrophysics, particularly in the atmospheres of planets, stars, and in the Interstellar Medium. The contents discussed in the lecture are practised by means of typical applications.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the the approaches and methods of radiative transfer in astrophysics. Important radiative processes and their effects within the atmospheres of planets, stars, and in the Interstellar Medium should be understood. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both

	using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Kevin Heng
Language(s)	English
Additional information	None

Module: WP 15 Structure and Evolution of Galaxies I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 15.1 Structure and Evolution of Galaxies 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 15.2 Structure and Evolution of Galaxies 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research on the structure and evolution of galaxies. The contents discussed in the lecture are practised by means of typical applications.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the structure and evolution of galaxies. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Klaus Dolag
Language(s)	English
Additional information	None

Module: WP 16 Cosmology and Large Scale Structures I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 16.1 Cosmology and Large Scale Structures 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 16.2 Cosmology and Large Scale Structures 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research on Cosmology, as well as studies of the design and properties of large-scale structures. The contents discussed in the lecture are practised by means of typical applications.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into Cosmology and Large Scale Structures. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jochen Weller
Language(s)	English
Additional information	None

Module: WP 17 Specific Research Approaches in the Application of Experimental and Observational Methods I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 17.1 Specific Research Approaches in the Application of Experimental and Observational Methods 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 17.2 Specific Research Approaches in the Application of Experimental and Observational Methods 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and applications of selected experimental and observational methods in astrophysics. The contents discussed in the lecture are practised by means of typical examples.
Learning outcomes	By providing basic knowledge and insights into experimental and observational methods in astrophysics as well as their concrete applications, students should develop the ability to transfer the content presented in the lecture to current problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joseph Mohr
Language(s)	English
Additional information	None

Module: WP 18 Specific Research Approaches in the Application of Theoretical and Numerical Methods I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 18.1 Specific Research Approaches in the Application of Theoretical and Numerical Methods 1 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 18.2 Specific Research Approaches in the Application of Theoretical and Numerical Methods 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and applications of selected theoretical and numerical methods in astrophysics. The contents discussed in the lecture are practised by means of typical examples. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	By providing basic knowledge and insights into theoretical and numerical methods in astrophysics as well as their concrete applications, students should develop the ability to transfer the content presented in the lecture to current problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should

	learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Klaus Dolag
Language(s)	English
Additional information	None

Module: WP 19 Fundamentals of Advanced Biophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 19.1 Fundamentals of Advanced Biophysics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 19.2 Fundamentals of Advanced Biophysics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of fundamental topics in advanced biophysics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of fundamental research topics in advanced biophysics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English

Additional information	None

Module: WP 20 Biophysics of Molecules

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 20.1 Biophysics of Molecules (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 20.2 Biophysics of Molecules (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The program covers the physics of biological macromolecules: Protein Structure, Function and Folding, DNA & RNA, Polymer Physics & Single Molecule Mechanics, Filaments & Motors, Complex Macromolecular Solutions.
Learning outcomes	The module provides an understanding of physics in biological macromolecules, such as proteins and nucleic acids.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English
Additional information	None

Module: WP 21 Biophysics of Systems

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 21.1 Biophysics of Systems (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 21.2 Biophysics of Systems (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The lecture covers the physics of biological systems, including their origin, evolution, pattern formation, embryogenesis, biochemical networks, chemotaxis, gene regulation, high throughput methods, neural networks and game theory.
Learning outcomes	The module expands upon specialized knowledge in the areas of cellular biophysics, molecular biophysics, and theoretical biophysics, with a focus on the physics underlying biological systems.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Braun

Language(s)	English
Additional information	None

Module: WP 22 Optoelectronics I: Inorganic Materials

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 22.1 Optoelectronics 1: Inorganic Materials (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 22.2 Optoelectronics 1: Inorganic Materials (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module provides an understanding of inorganic (nano)materials, heterostructures, physical phenomena, concepts, systems and technologies. Topics include: Electronic and optical properties of inorganic semiconductors; Growth and nanofabrication (nanostructured crystals and colloidal nanocrystals); Heterostructures and interfaces; Transport; Coulomb and spin effects; Optoelectronic and electrooptic effects; Nonlinear optical effects; Nanophotonics: dielectric effects; LEDs, lighting, laser diodes; Photodetectors and solar cells; Optical modulators, switches and amplifiers; Optical communication systems and more.
Learning outcomes	The students acquire knowledge of the electronic and optical properties of inorganic semiconductors and are able to describe related physical phenomena. A solid foundation is created for the course participants to understand the working principles of optoelectronic devices based on inorganic semiconductors.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jochen Feldmann
Language(s)	English
Additional information	None

Module: WP 23 Electronics I: Analog Electronics in the Lab

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota- tion	Contact hours	Self-study hours	ECTS
Lecture	WP 23.1 Electronics 1: Analog Electronics in the Lab (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 23.2 Electronics 1: Analog Electronics in the Lab (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module teaches the basic concepts of analog electronics, which are required for understanding experimental techniques used in scientific laboratories. Topics include: • Fundamentals of semiconductor device physics • Linear devices, diodes, and transistors • Analysis of circuit networks • Precision and power amplifiers • Applications of operational amplifiers • Sensors, actuators, and feedback algorithms • Electronic laboratory instrumentation The module focuses in particular on the quantitative understanding of electronic circuits. Live experiments will highlight the most important properties of the presented circuits.
Learning outcomes	After successful completion of the course, the students will have acquired basic knowledge of analog electronics and of the most common devices and techniques. They will be able to analyze electronic circuits, to understand their fundamental properties and limitations and to adjust them to specific requirements. The students will be in the position to design

	basic measurement and control electronics for application in a research laboratory.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Roland Kersting
Language(s)	English
Additional information	Literature: • The students will receive lecture notes, which cover the fundamental concepts of analog electronics and laboratory applications. More than 100 circuit layouts will provide the students with an extensive library for their own design of analog circuits. • T. L. Floyd, Electronic Devices, Pearson, 2015 P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press

Module: WP 24 Nanophotonics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 24.1 Nanophotonics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 24.2 Nanophotonics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of different approaches for controlling light on the nanoscale and its interaction with matter. Topics covered include: • Macroscopic electromagnetism • Propagation and focusing of light, limits of resolution and localization • Photonic crystals and optical microcavities • Quantum emitters and single photon sources • Weak and strong coupling, photonic density of states • Mie theory • Non-radiative nanophotonics • Propagating and localized surface plasmons • Metamaterials and metasurfaces Manophotonics-enhanced molecular sensing
Learning outcomes	The aim of the module is to provide students with a fundamental understanding of different nanophotonics platforms for controlling light-matter coupling and their practical applications for innovative optical devices. After successful completion of the module, the students will have acquired knowledge

	of the main concepts underlying modern nanophotics, and will be equipped to follow the recent literature in this area.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Andreas Tittl
Language(s)	English
Additional information	None

Module: WP 25 Materials Science I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 25.1 Fundamentals in Materials Science (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 25.2 Fundamentals in Materials Science (Exercise)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Materials Science I is an interdisciplinary series of lecture units and exercises given or supervised by lecturers from different faculties of LMU, TUM, and local industry. The attending students likewise come from different fields (mainly geomaterials and geochemistry, chemistry, physics). The exercises are lab experiments and information research including patent information. Material Science I (winter semester) gives an overview into ancient and modern materials classes, covers fundamentals of structural, mechanical, magnetic, dielectric, transport, and thermal properties, and highlights important analytical techniques. Materials Science II (summer semester) discusses specific topics in a similar interdisciplinary way.
Learning outcomes	Getting an overview and fundamental skills and knowledge in materials science: material properties and their optimization by selection of appropriate chemical systems and processing techniques.
Type of examination	Exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	None

Module: WP 26 Current Research Topics in Advanced Elementary Particle Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 26.1 Current Research Topics in Advanced Elementary Particle Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 26.2 Current Research Topics in Advanced Elementary Particle Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced elementary particle physics. Special attention is paid to recent developments in research
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced elementary particle physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr

Language(s)	English
Additional information	None

Module: WP 27 Experimental Methods of Advanced Elementary Particle Physics

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 27.1 Experimental Methods of Advanced Elementary Particle Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced experimental methods of elementary particle physics. Special attention is paid to recent developments in experimental methods.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected topics in advanced experimental methods of elementary particle physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr
Language(s)	English

Additional information	None

Module: WP 28 Selected Research Topics in Advanced Elementary Particle Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 28.1 Selected Research Topics in Advanced Elementary Particle Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced elementary particle physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced elementary particle physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr
Language(s)	English
Additional information	None

Module: WP 29 Artificial Intelligence: Applications in Theoretical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 29.1 Artificial Intelligence: Applications in Theoretical Physics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 29.2 Artificial Intelligence: Applications in Theoretical Physics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The students develop a theoretical and practical understanding on how to use learning algorithms to address topics in theoretical physics. This includes a discussion of relevant AI methods, an overview of existing approaches and in particular models with many learnable parameters. The relevant physics background is introduced.
Learning outcomes	The students gain an understanding on how to use AI methods relevant for contemporary questions in theoretical physics. They know how to use models with many learnable parameters. - Use AI methods relevant for contemporary questions in theoretical physics. - Understanding of relevant AI methods - Understanding of theoretical physics problem Use models with many learnable parameters in practice

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Lode Pollet
Language(s)	English
Additional information	None

Module: WP 30 Advanced Artificial Intelligence in Mathematics, Statistics and Computer Science

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 30.1 Advanced Artificial Intelligence in Mathematics, Statistics and Computer Science (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 30.2 Advanced Artificial Intelligence in Mathematics, Statistics and Computer Science (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	It is strongly recommended to have attended the course "Einführung in die Künstliche Intelligenz" or "Grundlagen der Küntlichen Intelligenz"as well as the prerequisits for these courses.
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The course builds directly on the introductory course in Artificial Intelligence and covers advanced topics in AI that go beyond the level and scope of that course. This includes topics in knowledge representation, e.g. of important concepts such as uncertainty and preferences, as well as related methods for reasoning, learning and decision making. The course will also cover current developments and emerging topics in AI, such as generative modelling.
Learning outcomes	On completion of this module, students will have an in-depth understanding of advanced concepts and selected topics in Artificial Intelligence. In particular, this includes a deeper understanding of models and tools for knowledge representation, reasoning, learning and decision making.

	Students will also have an overview of recent developments, current trends and emerging issues in AI.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Eyke Hüllermeier
Language(s)	English
Additional information	None

Module: WP 31 Fundamentals of Advanced Laser Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 31.1 Fundamentals of Advanced Laser Physics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 31.2 Fundamentals of Advanced Laser Physics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module teaches the theoretical and technical foundations of femtosecond laser technology, as well as the implementations of this technology in real-world advanced laser facilities. The module also provides an overview of the applications of femtosecond laser pulses with extreme electric fields in medical physics, nuclear physics, quantum electrodynamics, chemistry, biology, and material sciences.
Learning outcomes	Upon completion of this module, students will gain a comprehensive overview of the principles and characteristics of femtosecond laser pulses. They will be adept at analyzing the implications and effects of femtosecond pulses on atoms, molecules and charged particles individually and in plasmas. Students will demonstrate a nuanced understanding of the theoretical and technical aspects of femtosecond laser technology, applying this knowledge to explore and appreciate the practical implication of the term 'laser-based'.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jörg Schreiber
Language(s)	English
Additional information	None

Module: WP 32 Photonics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 32.1 Photonics 1 (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 32.2 Photonics 1 (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module provides an introduction to the fundamental concepts and principles of photonics. It covers a wide range of topics, from the basics of ray optics and geometric optics to more advanced topics such as optical resonators, nonlinear optics, Fourier optics, and lasers. It also introduces the exciting realm of attosecond physics.
Learning outcomes	Upon successful completion of this lecture course, students will develop a strong conceptual understanding of the fundamental principles of photonics, which will allow them to analyze the behavior of light in optical systems, understand the principles of nonlinear optics and its applications, and explain the principles of laser operation.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Ferenc Krausz
Language(s)	English
Additional information	None

Module: WP 33 Applied Laser Physics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 33.1 Applied Laser Physics 1 (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 33.2 Applied Laser Physics 1 (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module teaches basic concepts and practical aspects of designing ultrashort, high energy laser systems, with particular focus on achieving the highest beam quality and intensity in focus. It lays out the mathematical description of laser pulses in temporal and spectral space, introduces the chirped-pulse amplification principle (CPA) to avoid nonlinear propagation effects, and discusses the design of stretcher-compressor systems to realize an ultra-intense CPA laser. After introducing the Kerr-lens mode-locking technique for producing ultrabroadband pulses, it discusses their amplification to high energies and introduces amplifier design principles, before wrapping up with a chapter on ultrashort pulse characterization.
Learning outcomes	The students will obtain a comprehensive practical tool box to understand and design ultrafast, high peak power laser systems, as well as a good knowledge background to design, commission and operate ultrafast laser systems in science and industry.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Stefan Karsch
Language(s)	English
Additional information	None

Module: WP 34 Fundamentals of Advanced Medical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 34.1 Fundamentals of Advanced Medical Physics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 34.2 Fundamentals of Advanced Medical Physics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Lasers and laser-based particle acceleration are enabler for exploring physical and chemical processes that are fundamental to radiation biology and related medical physics applications. The module bridges between conventional accelerator technology and new methodologies that arise with combining lasers and accelerators. Integrated into this exploration is an in-depth understanding of the technical foundations of modern technology as it evolves into new fundamentals.
Learning outcomes	Upon completion of this module, students will gain a comprehensive overview of the principles of accelerator and laser technology. They will be adept at analyzing complex problems that cover the interaction of lasers and (charged) particles with atoms, molecules and charged particles individually as well as in gases, liquids, solids and in plasmas. Students will demonstrate a nuanced understanding of the theoretical and technical aspects of accelerator technology, applying this knowledge to explore and appreciate the practical

	implications. Additionally, they will develop numerical problem-solving skills, critical thinking abilities, and effective communication of scientific concepts, paving the way for active participation in discussions related to advancing medical physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jörg Schreiber
Language(s)	English
Additional information	None

Module: WP 35 Medical Physics in Radiation Therapy

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 35.1 Medical Physics in Radiation Therapy (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 35.2 Medical Physics in Radiation Therapy (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This lecture addresses the basics of medical physics in radiation therapy (RT) with focus on external beams, starting from the historical developments and the physical and radiobiological rationale. After a review of relevant radiation physics concepts, it delves into the fundamental theory and instrumentation of dosimetry. Next, it introduces relevant dosimetric measurements and computational methods for treatment planning and quality assurance (QA) procedures, including advanced developments. It concludes with a hands-on training on modern tools in RT.
Learning outcomes	The attendees will acquire in-depth knowledge in the field of RT, from the different used technologies in external beam RT along with their historical and technical development, through the physics and biological rationale of RT, up to the fundamentals of dosimetry for beam characterization, treatment planning and QA. Moreover, they will receive hands-on training in modern RT techniques.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 36 Advanced Radio Therapy

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 36.1 Advanced Radio Therapy (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This lecture gives in-depth insights in modern photon therapy, with emphasis on the major techniques of intensity modulated radiotherapy and rotational therapy already established in clinical routine, along with an overview of emerging technologies. After introducing modern X-ray therapy techniques, it provides details of advanced quality assurance, image guidance and adaptive therapy, with practical examples and a concluding reflection on future new developments.
Learning outcomes	Students learn the technologies of modern RT, with emphasis on the medical physics aspects of advanced quality assurance, patient specific plan verification and different workflows of image guidance. Completion of the module equips the students with the understanding of the complexity of modern RT and the hardware/software tools used to ensure precise and effective RT treatments.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 37 Computational Methods in Medical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 37.1 Computational Methods in Medical Physics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module teaches established computational algorithms covering a wide spectrum of radiation therapy and medical imaging applications. It covers algorithmic aspects of Monte Carlo for radiation transport, Fourier transform, Ray tracing, Dose calculation and basic Artificial Intelligence.
Learning outcomes	Students learn the mathematical background of methods and techniques commonly employed in Medical Physics. After the completion of the module the students are not only familiar with these methods but are also capable of deriving their own software implementations.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	PD Dr. Georgios Dedes
Language(s)	English
Additional information	None

Module: WP 38 Data Analysis and Statistics in Medical Physics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 38.1 Data Analysis and Statistics in Medical Physics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module teaches fundamental techniques for the analysis of data in medical physics applications. The module covers basic approaches for data description, interpretation and analysis, with a focus on quantitative and graphical methods. Topics include the use of probabilistic models and statistical tests, data regression, data classification, resampling and clustering.
Learning outcomes	Students learn the theoretical and methodological basics to analyse data for statistical analysis. After successful completion of the module, the students have acquired the key theoretical foundations that are necessary for the understanding and critical interpretation of data analysis techniques. Although the focus is on medical physics applications, the general concepts can be extended to data analysis in other fields.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Marco Riboldi
Language(s)	English
Additional information	None

Module: WP 39 Data Analysis and Statistics in Medical Physics II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 39.1 Data Analysis and Statistics in Medical Physics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 39.2 Data Analysis and Statistics in Medical Physics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module teaches fundamental techniques for the analysis of data in medical physics applications. The module covers basic approaches for data description, interpretation and analysis, with a focus on quantitative and graphical methods. Topics include the use of probabilistic models and statistical tests, data regression, data classification, resampling and clustering. Practical exercises on the implementation of the aforementioned methods on real and simulated data are assigned, as a way to reinforce the understanding of the basic principles and to provide interpretation of the corresponding results.
Learning outcomes	Students learn the basics to analyse data for statistical analysis, including both theoretical/methological aspects and the corresponding implementation details. After successful completion of the module, the students have acquired the necessary skills for the implementation of data analysis techniques, along with the ability to give an interpretation based on the theoretical approaches. Although the focus is

	on medical physics applications, the general concepts can be extended to data analysis in other fields.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Marco Riboldi
Language(s)	English
Additional information	None

Module: WP 40 Advanced Atmospheric Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 40.1 Advanced Atmospheric Physics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 40.2 Advanced Atmospheric Physics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In order to gain an understanding of the physical basis of climate and climate change, the students will develop a climate model. The course aims for (1) an understanding of the basic elements of climate; (2) an introduction to radiative/convective equilibrium models; (3) a thorough understanding of solar and thermal radiative transfer including trace gases, molecules, and clouds, multiple scattering, and interaction with the Earth's surface; (4) the radiation budget of the Earth; (5) forcing and feedback mechanisms; (6) temperature change by a doubling/quadrupling of the CO_2 concentration as well as modifications of other trace gas concentrations or surface properties.
Learning outcomes	To gain an understanding of the greenhouse effect and of climate change by developing a simple but quantitative climate model using only elementary physics; at the end of the lecture the students will be able to predict the temperature change caused by a changing CO_2 or CH_4 concentration, including water vapor, surface albedo, and cloud feedbacks.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English
Additional information	None

Module: WP 41 Advanced Atmospheric Dynamics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 41.1 Advanced Atmospheric Dynamics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 41.2 Advanced Atmospheric Dynamics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module aims to provide a rigorous and intuitive treatment of mid-latitude weather systems, yielding fundamental theoretical insights into their formation and development. The approach is modern, beginning with simple linear models, but going on to emphasize the role of fundamental conservation laws and similarity relationships that give insight even into complicated nonlinear systems. The module covers aspects as balanced flow, PV-thinking, invertibility, quasi-geostrophic theory of atmospheric disturbances, baroclinic and barotropic instability, wave-mean flow interactions as well as turbulence and predictability.
Learning outcomes	Students can explain well-founded dynamical principles and apply relationships in the atmosphere on the basis of physical laws and solve meteorological problems mathematically.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. George Craig
Language(s)	English
Additional information	None

Module: WP 42 Atmospheric Observation Methods

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 42.1 Atmospheric Observation Methods (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 42.2 Atmospheric Observation Methods (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Measurement methods and evaluation procedures for determination of various parameters that describe the state of the atmosphere. These can be basic parameters such as temperature, air pressure or radiation, but also other specific parameters such as pollutant concentrations, emissions, clouds, aerosols or land use classifications.
Learning outcomes	Students should acquire knowledge of the scientific basis of the observations to interpret and classify results, the ability to develop and apply atmospheric measurement methods and to use scientific evaluations to determine the state of the atmosphere.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Mark Wenig
Language(s)	English
Additional information	None

Module: WP 43 Earth System Modeling

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 43.1 Earth System Modeling (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module is concerned with the physical basis of both idealized and comprehensive numerical climate models. Underlying physical conservation laws, their representation in models, and necessary parametrizations as well as fundamental concepts of climate change such as radiative forcing, climate feedbacks, scenarios for future climate projections for the different Earth system components, general circulation aspects of climate change or chemistry-climate interactions can be aspects included in this module.
Learning outcomes	Familiarity and ability to interpret and critically assess outcomes from the IPCC reports and the climate change literature in general.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Thomas Birner
Language(s)	English
Additional information	None

Module: WP 44 Components of the Climate System

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 44.1 Components of the Climate System (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The morphology of climate system components (e.g. land-surface, cryosphere, oceans, troposphere, stratosphere) and suited observation techniques are covered in this module. This can include the underlying physical principles of drivers of mean state, natural variability, and long-term changes of each component, as well as fundamentals of climate dynamics within, as well as across climate system components.
Learning outcomes	Ability to describe and explain core characteristics of climate system components and how they are coupled, and the dynamics that give rise to climate variability and long-term change.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Birner

Language(s)	English
Additional information	None

Module: WP 45 Atmospheric Processes

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 45.1 Atmospheric Processes (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In this module individual atmospheric processes will be discussed in more detail in contrast to modules evaluating their role in relation to other parts of or the complete Earth-Atmosphere system. This includes a focus on the interfaces to Earth surface or space, specific cloud processes or aerosol gas-chemistry aspects, and specific aspects of upper atmosphere height layers (e.g., mesosphere, stratosphere).
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer

Language(s)	English
Additional information	None

Module: WP 46 Current Research Topics in Experimental Meteorology

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 46.1 Current Research Topics in Experimental Meteorology (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current research topics in Experimental Meteorology. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in Experimental Meteorology.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English
Additional information	None

Module: WP 47 Advanced Quantum Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 47.1 Advanced Quantum Physics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 47.2 Advanced Quantum Physics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Introduction and application of advanced concepts and techniques from quantum mechanics, using modern scientific methods applied to topics from modern quantum physics applications. These are both introduced and applied to concrete systems of interest in modern physics.
Learning outcomes	Students learn to apply methods from quantum physics to new physical systems. New methods and concepts important in the physics of quantum systems are introduced. Their applications in modern quantum physics research are explored and an introduction to research areas from this field is provided.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English
Additional information	None

Module: WP 48 Quantum Hardware

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 48.1 Quantum Hardware (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 48.2 Quantum Hardware (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module provides an introduction to various different physical implementations of quantum systems, for applications of quantum technologies including quantum computation, simulation, metrology and sensing. It gives an overview of the most relevant experimental realizations such as superconducting qubits, semiconductors, atoms, ions or NV centers.
Learning outcomes	Students will learn how quantum systems can be implemented, and what typical and specific properties and issues with different implementations are. A specific focus will be on causes and consequences of dephasing and quantum errors, as well as the challenges and limitations for high-fidelity state preparation and read-out.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Monika Aidelsburger
Language(s)	English
Additional information	None

Module: WP 49 Fundamentals of Quantum Simulation

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 49.1 Fundamentals of Quantum Simulation (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 49.2 Fundamentals of Quantum Simulation (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Modern experimental and theoretical methods to implement and describe quantum systems are introduced and applied to fundamental quantum mechanical systems and questions. A particular focus is on the preparation, control and analysis of quantum states in physical systems such as neutral atoms or ions.
Learning outcomes	Students will learn the fundamental methods how quantum systems an be created, as well as how they can be described. In addition, students will learn how to work directly with published research results in the field. In this process, they get an introductory overview into one or more of the subfields of quantum simulation or computation as well as other systems with quantum mechanical descriptions.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English
Additional information	None

Module: WP 50 Fundamentals of Quantum Optics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 50.1 Fundamentals of Quantum Optics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 50.2 Fundamentals of Quantum Optics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The Module gives an overview over the field of Quantum optics, and covers the basic techniques and the most relevant phyiscal systems which are important to the field. This includes the quantum representation of light fields, the quantum description of light coupling to matter as well as the basic building blocks of quantum optics setups such as cavities, detectors and implementations of two-level systems with atoms, ions, and other techniques.
Learning outcomes	Students will learn how to describe optical sytems with a quantum mechanical formulation using modern physics notation, and understand key systems and experiments in quantum optics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English
Additional information	None

Module: WP 51 Plasma Physics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 51.1 Plasma Physics 1 (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 51.2 Plasma Physics 1 (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The course covers basic knowledge and principles of plasma physics. It teaches the basics of • Plasma characterization in density vs. temperature range from space plasmas to free electrons in metalls • Quasineutrality of plasmas, Debye length and Plasma Frequency, Plasma-Wall contact • Coulomb collisions and basic parameter dependences of collision times, electrical and thermal conductance • Thermodynamic equilibria in vastly different plasmas depending on mean free path of photons and electrons • Plasma particle trajectories when magnetic fields are present, guiding-center Ansatz, particle drifts, magnetic mirrors, adiabatic invariants • Phase space probability distribution and kinetic equation, landau damping, , derivation of fundamental magnetic hydrodynamic (MHD) equations and their application in particular for plasma equilibria. • Plasma waves and their properties in plasmas without and with magnetic fields

Learning outcomes	The students are able to describe the physical fundamentals of plasma physics and are able to connect these to fundamentals of mechanics, electrodynamics and thermodynamics. The application of these contents is exercised in the tutorials. Moreover, students are in the position to understand and explain on a basic level the relationship between the contents of this module and related modules from fluid dynamics, astrophysics or atmospheric physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Thomas Pütterich, PD Dr. Jörg Stober
Language(s)	English
Additional information	None

Module: WP 52 Magnetohydrodynamics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 52.1 Magnetohydrodynamics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 52.2 Magnetohydrodynamics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In magnetically confinemed fusion plasmas, there exists a variety of macroscopic instability processes that limit or reduce the magnetic confinement capabilities. Specifically, tokamak operational space is limited in current, current density, plasma density, edge and global pressure by MHD instabilites. It is the aim of the course to give an introdution to the basic concepts of MHD stability theory and to show how these different limits can be explained by different MHD instabilities. We will also point out where MHD cannot explain the whole picture (yet). In most cases, the topics discussed will be linked to present day plasma physics research, mostly in terms of tokamak stability. Specifically, the following topics will be treated: • The MHD Model • Consequences of MHD equations, MHD Equilibria • Linear ideal MHD stability analysis • Current driven modes: internal / external kinks • Localised pressure driven modes: interchange / ballooning • Edge Localised Modes (ELMs) • Global pressure driven modes: Troyon limit, resistive wall modes

	• Introduction to resistive MHD, linear and nonlinear tearing • Classical tearing modes • Disruptions • m=1 modes, sawtooth instability • Neoclassical tearing modes • Active control of MHD stability limits
Learning outcomes	After participating in the course, participants will understand the general concepts of fluid theory, linear stability analysis and nonlinear saturation. More specifically, the course offers a good understanding of the various types of instabilities occurring in magnetically confined plasmas, from both the theoretical as well as the experimental point of view.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Hartmut Zohm
Language(s)	English
Additional information	None

Module: WP 53 Fundamentals of Prospective Topics in Advanced Modern Experimental Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 53.1 Fundamentals of Prospective Topics in Advanced Modern Experimental Physics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 53.2 Fundamentals of Prospective Topics in Advanced Modern Experimental Physics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module introduces prospective topics in advanced modern experimental physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 54 Theoretical Solid State Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 54.1 Theoretical Solid State Physics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 54.2 Theoretical Solid State Physics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The aim of this module is to learn established and modern concepts in theoretical condensed matter physics. The contents of this module vary somewhat from year to year, depending on the preferences of the lecturer; interested students are advised to contact the lecturer in advance for details. A typical module could be structured as follows: It starts with a brief recapitulation of crystal structures and classification, then addresses X-ray elastic scattering and neutron inelastic scattering and discusses static and dynamic structure factors. Next come phonons, followed by tight-binding models (e.g. the dispersion of graphene and polyacetylene), also highlighting the consequences of inversion symmetry, time reversal symmetry, and spin-obit coupling. Next is a phenomenological discussion on semiconductors. The second half of the module is devoted to the integer quantum Hall effect, the Berry phase and the role of topology, topological insulators and the fractional quantum Hall effect. Further optional topics include Anderson localization, magnetism or BCS superconductivity. The module does not use techniques from field theory.
Learning outcomes	The main goal of this module is to give an overview over the many phenomena in modern condensed matter theory from

	a material-specific point of view. After successful completion of the module students are able to: - understand X-ray and neutron scattering; - understand the role of symmetry and topology in band structures; - compute phonon and tight-binding spectra; - explain the working of semiconductors; - compute the Berry phase; - understand the bulk-edge correspondence in topological materials; - work with Laughlin wavefunctions and composite fermi-ons; work through advanced condensed matter physics topics on their own.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 55 Quantum Electrodynamics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 55.1 Quantum Electrodynamics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 55.2 Quantum Electrodynamics (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Canonical quantization, Klein-Gordon and Dirac fields, gauge principle and QED Lagrangian, S-matrix, Feynman rules, basic QED processes, radiative corrections.
Learning outcomes	The module aims to convey a detailed understanding of QED and the ability to perform concrete perturbative calculations of elementary processes.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Georgi Dvali
Language(s)	English

Additional information	None

Module: WP 56 General Relativity

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 56.1 General Relativity (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 56.2 General Relativity (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Introduction to the differential geometry: manifolds, vectors and tensors, connection, metric, geodesics and curvature. Furthermore, the equivalence principle, special relativity, propagation of light and redshift, Einstein's equations, Newtonian limit of General Relativity, coordinates conditions Cauchy problem, spherically symmetric gravitational field and Schwarzschild solution, perihelion shift and deviation of light, weak gravitational field and post-newtonian approximation, gravitational waves, black holes are discussed.
Learning outcomes	The aim of the module is an acquaintance with the basic concepts of General Relativity and familiarity with the most important concepts of differential geometry.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Viatcheslav Mukhanov
Language(s)	English
Additional information	None

Module: WP 57 String Theory I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 57.1 String Theory 1 (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 57.2 String Theory 1 (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module gives an introduction into the theory of closed strings (Nambu-Goto action, Polyakov action) in terms of a two-dimensional conformal field theory. It describes the various approaches to quantization and introduces compactifications on tori. Later, the discussion is extended to open strings and D-branes and the relation between string theory and its low energy description in terms of an effective field theory is developed. It gives an outlook to modern topics in target space like dualities, M-Theory, AdS/CFT correspondence.
Learning outcomes	The main goals of this module are an understanding of the fundamental aspects of perturbative bosonic strings in the framework of a two-dimensional conformal world-sheet theory and its relation to quantum field theories.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst
Language(s)	English
Additional information	None

Module: WP 58 Selected Topics in Theoretical and Mathematical Physics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 58.1 Lecture on Selected Topics in Theoretical and Mathematical Physics 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In this course, selected special topics in theoretical and mathematical physics are presented. Special attention is paid to recent developments in research.
Learning outcomes	This course provides an in-depth discussion of a specific topic aiming to make contact with ongoing research.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 59 Selected Topics in Theoretical and Mathematical Physics II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 59.1 Lecture on Selected Topics in Theoretical and Mathematical Physics 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In this course, selected topics in theoretical and mathematical physics are presented. Special attention is paid to recent developments in research.
Learning outcomes	This course provides an in-depth discussion of a specific topic aiming to make contact with ongoing research.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 60 Condensed Matter Field Theories

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 60.1 Condensed Matter Field Theories (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 60.2 Condensed Matter Field Theories (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module develops advanced methods to study interacting quantum many-particle systems in and out of equilibrium. The contents of this module vary somewhat from year to year, depending on the preferences of the lecturer; interested students are advised to contact the lecturer in advance for details. A typical module could be structured as follows: It starts with a short recapitulation of field theoretical fundamentals, in particular functional integral techniques. The next part of the module introduces the renormalization group as a central tool for understanding effective low-energy properties of interacting quantum many-particle systems. Topics include scaling, perturbative renormalization, RG flows and fixed points, as well as the Kondo effect and the superfluid-Mott insulator transition as examples. The module then covers fundamentals of low-dimensional systems (Luttinger liquids, bosonization) and the Keldysh technique to study many-particle systems out of equilibrium. Final topics include instantons and non-perturbative techniques as well as optional topics, such as the quantum Hall effect (integer and fractional), Chern-Simons theory, disorder in many-particle systems, high-Tc superconductivity and quantum phase transitions.

Learning outcomes	After completing the Module the student is able to: - Explain the basic ideas of a renormalization group transformation. - Understand the concept of RG flows and RG fixed points. - Perform perturbative renormalization group computations. - Explain what the Kondo effect is. - Use bosonization to understand properties of low-dimensional quantum systems. - Explain how the Keldysh formalism is used to study non-equilibrium phenomena. - Explain what an instanton is. Follow current research topics and use the toolbox of renormalization group methods to start independent research.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 61 Quantum Information Processing

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 61.1 Quantum Information Processing (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 61.2 Quantum Information Processing (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Quantum Information offers an introduction to the theoretical foundations of Quantum Science and Technology. The course starts with a brief motivation and an introduction to fundamental concepts and the basic formalism (pure/mixed states, evolution, completely positive maps, measurements Schmidt decomposition, tomography, quantum estimation, hypothesis testing). Then the concept of entanglement is discussed in detail, including the distinction between pure and mixed-state entanglement, entanglement entropy, quantification and conversion. Subsequently, some of the revolutionary promises of exploiting entanglement are presented, including dense coding, quantum teleportation and quantum cryptography. Next the Bell inequalities, characterizing the quantum weirdness of entanglement and non-locality, are introduced and discussed in detail. Subsequent chapters cover central applications of quantum information theory: quantum computation, quantum algorithms such as those of Deutsch, Shor and Grover, quantum simulation, and quantum metrology. Final core topics are decoherence, Lindbladian descriptions thereof, and error correction schemes to counteract the consequences of decoherence and protect fragile quantum information. The module will typically also include one or more optional topics, such as many-body

	entanglement, topological quantum computation, quantum complexity, or tensor networks, which link quantum information theory to many-body physics.
Learning outcomes	After participation in the Module the student is able to: - Explain fundamental concepts such as the distinction between pure and mixed states, quantum evolution, completely positive maps, and quantum measurements. - Explain and quantify the notion of entanglement in various contexts (pure states, mixed states, purification, Bell inequalities). - Understand and explain central applications of quantum information theory, such as quantum cryptography, quantum computation, quantum simulation, and quantum metrology. - Understand the central ideas underlying different quantum algorithms. - Understand the notion and the consequences of decoherence, model it using Lindbladians, and explain central elementary error correction strategies. Competently perform quantum mechanical computations relevant for the above topics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 62 Quantum Field Theory on Curved Space-Time

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 62.1 Quantum Field Theory on Curved Space-Time (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 62.2 Quantum Field Theory on Curved Space-Time (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: From harmonic oscillators to classical fields, quantization of fields, particles in curved space-time, quantum fields in expanding universe, Quantum fields in de Sitter space, accelerated observer and Unruh effect, Hawking effect, Casimir effect, path integral and effective action, heat kernel method, vacuum polarization and renormalization, conformal anomaly.
Learning outcomes	The module aims to convey familiarity with the basic concepts of quantum effects in an external gravitational field and familiarity with the most important concepts of quantum field theory.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Viatcheslav Mukhanov
Language(s)	English
Additional information	None

Module: WP 63 Stochastic Processes in Physics and Biology

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 63.1 Stochastic Processes in Physics and Biology (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 63.2 Stochastic Processes in Physics and Biology (Exercise Course)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Markov chains and population genetics, branching processes, continuous time Markov processes and molecular motors, gene regulation, rate equations, Master equation and Fokker-Planck equation, Kramers-Moyal expansion, Smoluchowski equation, phase separation kinetics, Langevin equations and non-equilibrium growth processes, diffusion limited aggregation, directed percolation, diffusion-reaction models, linear response theory, Onsager relations, mode-coupling theory and glass transition.
Learning outcomes	The module aims to convey fundamental abilities in modeling and analyzing complex biological systems, using the methods of physics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English
Additional information	None

Module: WP 64 Current Research Topics in Advanced and Applied Quantum Mechanics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 64.1 Current Research Topics in Advanced and Applied Quantum Mechanics 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 64.2 Current Research Topics in Advanced and Applied Quantum Mechanics 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of advanced and applied quantum mechanics.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of advanced and applied quantum mechanics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Deft

Language(s)	English
Additional information	None

Module: WP 65 Current Research Topics in Quantum Field Theory and Gauge Theories I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 65.1 Current Research Topics in Quantum Field Theory and Gauge Theories 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 65.2 Current Research Topics in Quantum Field Theory and Gauge Theories 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of Quantum Field Theory and Gauge Theories.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of Quantum Field Theory and Gauge Theories.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Georgi Dvali

Language(s)	English
Additional information	None

Module: WP 66 Current Research Topics in Cosmology, General Relativity, and Differential Geometry I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 66.1 Current Research Topics in Cosmology, General Relativity, and Differential Geometry 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 66.2 Current Research Topics in Cosmology, General Relativity, and Differential Geometry 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fieds of Cosmology, General Relativity, and Differential Geometry.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of Cosmology, General Relativity, and Differential Geometry.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Viatcheslav Mukhanov

Language(s)	English
Additional information	None

Module: WP 67 Current Research Topics in String Theory and Geometry I

Programme — Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 67.1 Current Research Topics in String Theory and Geometry 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 67.2 Current Research Topics in String Theory and Geometry 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of String Theory and Geometry.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of String Theory and Geometry.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst
Language(s)	English

Additional information	None

Module: WP 68 Current Research Topics in Statistical Physics and Stochastics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 68.1 Current Research Topics in Statistical Physics and Stochastics 1 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 68.2 Current Research Topics in Statistical Physics and Stochastics 1 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of Statistical Physics and Stochastics.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of Statistical Physics and Stochastics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English

Additional information	None

Module: WP 69 Selected Topics in Theoretical and Mathematical Physics III

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 69.1 Lecture on Selected Topics in Theoretical and Mathematical Physics 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In this module, selected special topics in theoretical and mathematical physics are presented. Special attention is paid to recent developments in research.
Learning outcomes	This module provides an in-depth discussion of a specific topic aiming to make contact with ongoing research.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 70 Advanced Research Topics in Advanced and Applied Quantum Mechanics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 70.1 Advanced Research Topics in Advanced and Applied Quantum Mechanics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 70.2 Advanced Research Topics in Advanced and Applied Quantum Mechanics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of advanced research topics in advanced and applied quantum mechanics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft

Language(s)	English
Additional information	None

Module: WP 71 Advanced Research Topics in Quantum Field Theory and Gauge Theories

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 71.1 Advanced Research Topics in Quantum Field Theory and Gauge Theories (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 71.2 Advanced Research Topics in Quantum Field Theory and Gauge Theories (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of advanced research topics in quantum field theory and gauge theories. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Georgi Dvali
Language(s)	English
Additional information	None

Module: WP 72 Advanced Research Topics in Cosmology, General Relativity, and Differential Geometry

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 72.1 Advanced Research Topics in Cosmology, General Relativity, and Differential Geometry (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 72.2 Advanced Research Topics in Cosmology, General Relativity, and Differential Geometry (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of advanced research topics in cosmology, general relativity and differential geometry. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Viatcheslav Mukhanov
Language(s)	English
Additional information	None

Module: WP 73 Advanced Research Topics in String Theory and Geometry

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 73.1 Advanced Research Topics in String Theory and Geometry (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 73.2 Advanced Research Topics in String Theory and Geometry (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of advanced research topics in string theory and geometry. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst

Language(s)	English
Additional information	None

Module: WP 74 Advanced Research Topics in Statistical Physics and Stochastics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 74.1 Advanced Research Topics in Statistical Physics and Stochastics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 74.2 Advanced Research Topics in Statistical Physics and Stochastics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of advanced research topics in statistical physics and stochastics. This includes topics from the fields of quantum systems, complex many-body systems, soft and living matter, and biological systems. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English
Additional information	None

Module: WP 75 Prospective Advanced Research Topics in Theoretical and Mathematical Physics

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 75.1 Prospective Advanced Research Topics in Theoretical and Mathematical Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 75.2 Prospective Advanced Research Topics in Theoretical and Mathematical Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of prospective advanced research topics in theoretical and mathematical physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of the discussed topics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 76 Presentation of Basic Concepts and Methods of Advanced Astrophysics

Programme	Master’s Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 76.1 Presentation of Basic Concepts and Methods of Advanced Astrophysics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an overview of basic concepts and methods of advanced astrophysics. The students will present seminar talks, selected from a variety of topics covered by the working groups of the University Observatory and collaborating institutes. In this respect, the seminar talks also offer an opportunity to become familiar with the various research activities of the University Observatory, and to facilitate the choice of a topic for the upcoming Master's thesis.
Learning outcomes	Participating students will learn how specific astrophysical concepts and methods can be used to investigate a wide range of current astrophysical questions. The presentations will be prepared by the students supported by experienced supervisors, and they will learn (besides the actual topic of the talk) how to give a scientific presentation, and how to use modern visual media.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Daniel Grün
Language(s)	English
Additional information	None

Module: WP 77 Presentation of Current Topics in Advanced Biophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Seminar	WP 77.1 Presentation of Current Topics in Advanced Biophysics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced biophysics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English
Additional information	None

Module: WP 78 Presentation of Current Topics in Advanced Solid State Physics and Nanophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 78.1 Presentation of Current Topics in Advanced Solid State Physics and Nanophysics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced solid state physics and nanophysics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Theobald Lohmüller
Language(s)	English

Additional information	None

Module: WP 79 Presentation of Current Topics in Advanced Elementary Particle Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 79.1 Presentation of Current Topics in Advanced Elementary Particle Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced elementary particle physics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr
Language(s)	English
Additional information	None

Module: WP 80 Presentation of Current Topics in Advanced Artificial Intelligence

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 80.1 Presentation of Current Topics in Advanced Artificial Intelligence (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced artificial intelligence, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Daniel Grün, Prof. Dr. Thomas Kuhr
Language(s)	English
Additional information	None

Module: WP 81 Presentation of Current Topics in Advanced Laser Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 81.1 Presentation of Current Topics in Advanced Laser Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced laser physics and its applications, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Ferenc Krausz
Language(s)	English
Additional information	None

Module: WP 82 Presentation of Current Topics in Advanced Medical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Seminar	WP 82.1 Presentation of Current Topics in Advanced Medical Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced medical physics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 83 Presentation of Current Topics in Advanced Quantum Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 83.1 Presentation of Current Topics in Advanced Quantum Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	An overview of current methods, publications and results will be discussed related to advanced quantum physics topics. Techniques and methods for presenting scientific data and results will be also discussed.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English

Additional information	None

Module: WP 84 Advanced Course on Selected Topics in Theoretical and Mathematical Physics I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 84.1 Seminar on Selected Topics in Theoretical and Mathematical Physics 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	In this course, selected topics in theoretical and mathematical physics are presented by the student participants. Special attention is paid to recent developments in research. Participants extend their previously acquired presentation skills
Learning outcomes	This course provides an in-depth discussion of a specific topic aiming to make contact with ongoing research. Students further improve and extend their abilities to present an advanced scientific topic using appropriate methods.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies

Language(s)	English
Additional information	None

Module: WP 85 Insights into Applied Physics Research I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lab course	WP 85.1 Insights into Applied Physics Research 1 (Lab Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Advanced experiments on current research areas of the Faculty of Physics.
Learning outcomes	Students are able to become independently acquainted with several defined research areas of physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Martin Benoit
Language(s)	English
Additional information	None

Module: WP 86 Introduction to the Application of Physical Research Methods and Instruments I

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lab course	WP 86.1 Introduction to the Application of Physical Research Methods and Instruments 1 (Lab Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Tutorial	WP 86.2 Introduction to the Application of Physical Research Methods and Instruments 1 (Tutorial)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Advanced experiments on current research areas of the Faculty of Physics.
Learning outcomes	Students are able to become independently acquainted with several defined research areas of physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dr. Martin Benoit
Language(s)	English
Additional information	None

Module: WP 87 Project-based Application of Physical Research Methods and Instruments

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lab course	WP 87.1 Project-based Application of Physical Research Methods and Instruments (Lab Course)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Tutorial	WP 87.2 Project-based Application of Physical Research Methods and Instruments (Tutorial)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The successful completion of the module takes 1 semester.
Content	Independent project-based work on a current research area from experimental or theoretical physics and carrying out scientific experiments with analysis and documentation of the results obtained.
Learning outcomes	Students are able to independently familiarise themself with a current field of research in experimental or theoretical physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 88 Advanced Particle Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 88.1 Advanced Particle Physics (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 88.2 Advanced Particle Physics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of the experimental foundations of High Energy Elementary Particle Physics with essentials on the theoretical concepts. The module expands to recent developments, advances and discoveries.
Learning outcomes	Students acquire advanced knowledge and understanding of the Standard Model of Particle Physics, its theoretical concepts, its predictions, its experimental verification, its shortcoming. Students will also acquire the skills for experimentally and theoretically relevant calculations.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr

Language(s)	English
Additional information	None

Module: WP 89 Advanced Statistical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 89.1 Advanced Statistical Physics (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 89.2 Advanced Statistical Physics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module includes the following topics: • Polymers, Surfaces, and Membranes; • Liquid Matter and Hydrodynamics; • Liquid Crystals; • The Ising Model; • The Scaling Hypothesis; • Ginzburg-Landau Theory; • Renormalization Group Theory; • Goldstone Modes and Topoligical Defects; • Broken Continuous Symmetries and Kosterlitz-Thouless Transition; • Percolation Theory; • Onsager Theory of Irreversible Thermodynamics
Learning outcomes	Solid understanding and knowelgde of the theoretical concepts in the above list of content. Ability to develop models for complex statistical many-body systems and solve them using methods taught in class.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English
Additional information	None

Module: WP 90 Stars, Planets, Star Formation II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 90.1 Stars, Planets, Star Formation 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 90.2 Stars, Planets, Star Formation 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of stellar and/or planetary structure and evolution and/or of star formation. The contents discussed in the lecture are practised by means of typical applications. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the properties of stars and/or planets, and/or into the various processes controlling and affecting the formation of stars. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should

	learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Preibisch
Language(s)	English
Additional information	None

Module: WP 91 Circumstellar Disks and Planet Formation II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 91.1 Circumstellar Disks and Planet Formation 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 91.2 Circumstellar Disks and Planet Formation 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of circumstellar disks and the formation of planets. The contents discussed in the lecture are practised by means of typical applications. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the properties and evolution of circumstellar disks, and the formation of planets. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Til Birnstiel
Language(s)	English
Additional information	None

Module: WP 92 Radiative Processes in the Atmospheres of Planets, Stars, and the Interstellar Medium II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 92.1 Radiative Processes in the Atmospheres of Planets, Stars, and the Instellar Medium 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 92.2 Radiative Processes in the Atmospheres of Planets, Stars, and the Instellar Medium 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research of radiative processes in astrophysics, particularly in the atmospheres of planets, stars, and in the Interstellar Medium. The contents discussed in the lecture are practised by means of typical applications. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the the approaches and methods of radiative transfer in astrophysics. Important radiative processes and their effects within the atmospheres of planets, stars, and in the Interstellar Medium should be understood. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the

	exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Kevin Heng
Language(s)	English
Additional information	None

Module: WP 93 Structure and Evolution of Galaxies II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 93.1 Structure and Evolution of Galaxies 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 93.2 Structure and Evolution of Galaxies 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research on the structure and evolution of galaxies. The contents discussed in the lecture are practised by means of typical applications. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into the structure and evolution of galaxies. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Klaus Dolag
Language(s)	English
Additional information	None

Module: WP 94 Cosmology and Large Scale Structures II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 94.1 Cosmology and Large Scale Structures 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 94.2 Cosmology and Large Scale Structures 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and methods used within the research on Cosmology, as well as studies of the design and properties of large-scale structures. The contents discussed in the lecture are practised by means of typical applications. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	The lecture shall provide the students with basic knowledge and insights into Cosmology and Large Scale Structures. From this knowledge, and the concrete interpretation of corresponding theoretical predictions, students should develop the ability to transfer the content presented in the lecture to current astrophysical problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should learn to apply the content discussed in the lecture to practical tasks.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jochen Weller
Language(s)	English
Additional information	None

Module: WP 95 Specific Research Approaches in the Application of Experimental and Observational Methods II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 95.1 Specific Research Approaches in the Application of Experimental and Observational Methods 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 95.2 Specific Research Approaches in the Application of Experimental and Observational Methods 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and applications of selected experimental and observational methods in astrophysics. The contents discussed in the lecture are practised by means of typical examples. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	By providing basic knowledge and insights into experimental and observational methods in astrophysics as well as their concrete applications, students should develop the ability to transfer the content presented in the lecture to current problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way,

	students should learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joseph Mohr
Language(s)	English
Additional information	None

Module: WP 96 Specific Research Approaches in the Application of Theoretical and Numerical Methods II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 96.1 Specific Research Approaches in the Application of Theoretical and Numerical Methods 2 (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 96.2 Specific Research Approaches in the Application of Theoretical and Numerical Methods 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module (lecture plus exercise course) provides the students with an overview of concepts and applications of selected theoretical and numerical methods in astrophysics. The contents discussed in the lecture are practised by means of typical examples. This module is recommended to be selected if its contents comply with the focus of the students' forthcoming Master's Thesis.
Learning outcomes	By providing basic knowledge and insights into theoretical and numerical methods in astrophysics as well as their concrete applications, students should develop the ability to transfer the content presented in the lecture to current problems and questions. During the exercise course, simple problem solutions shall be independently developed, specified and implemented, both using analytic and, if required, computational approaches. In this way, students should

	learn to apply the content discussed in the lecture to practical tasks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Klaus Dolag
Language(s)	English
Additional information	None

Module: WP 97 Biophysics of the Cell

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 97.1 Biophysics of the Cell (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 97.2 Biophysics of the Cell (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture series covers diverse topics in biophysics, from cellular membrane dynamics and neuronal signaling to photosynthesis, cell mechanics, and the physics of cancer. Sessions delve into membrane properties, neuronal signal propagation, single-cell mechanics, tissue mechanics, and cancer physics.
Learning outcomes	Participants will deepen their understanding of cellular structures and functions, including membrane dynamics and neuronal signaling.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler

Language(s)	English
Additional information	None

Module: WP 98 Soft Matter Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 98.1 Soft Matter Physics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 98.2 Soft Matter Physics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture series provides a comprehensive overview of condensed matter physics, focusing on topics such as colloids, polymers, gels, liquid crystals, molecular self-assembly, and active matter. Sessions cover fundamental concepts such as colloidal interactions, polymer thermodynamics, phase transitions, liquid crystal phases, and the behavior of active particles.
Learning outcomes	Attendees will understand the fundamental principles of condensed matter physics, gaining insights into colloidal phenomena, polymer behavior, liquid crystal phases, and the dynamics of active matter. They will also become acquainted with experimental techniques and theoretical models pertinent to soft matter physics and its practical applications.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English
Additional information	None

Module: WP 99 Current Research Topics in Advanced Biophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 99.1 Current Research Topics in Advanced Biophysics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 99.2 Current Research Topics in Advanced Biophysics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced biophysics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced biophysics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English

Additional information	None

Module: WP 100 Selected Research Topics in Advanced Biophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 100.1 Selected Research Topics in Advanced Biophysics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced biophysics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced biophysics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English

Additional information	None

Module: WP 101 Optoelectronics II: Organic Materials

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 101.1 Optoelectronics 2: Organic Materials (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 101.2 Optoelectronics 2: Organic Materials (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides an understanding of fundamentals and advanced concepts of electronic and optical properties of molecular (organic) nanosystems. Topics include: Molecular physics; Ground and excited states; Spectroscopy; Coupled molecules; Excitons; Energy transfer; Extended pi-systems; Polarons; Transport; Molecular excitations; Interfaces and injection; Organic and hybrid solar cells; OLEDs; Organic lasers and more.
Learning outcomes	The students acquire knowledge of the electronic and optical properties of organic semiconductors and are able to describe related physical phenomena. A solid foundation is created for the course participants to understand the working principles of optoelectronic devices based on organic semiconductors.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jochen Feldmann
Language(s)	English
Additional information	None

Module: WP 102 Electronics II: Digital Electronics in the Lab

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 102.1 Electronics 2: Digital Electronics in the Lab (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 102.2 Electronics 2: Digital Electronics in the Lab (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module teaches the basic concepts of digital electronics related to applications in science laboratories. Topics include: • Number systems and operations • Logic gates and combinational logic • Code converters and multiplexers • Sequential logic, registers, and data storage • AD converters and DA converters • Interfaces and bus systems • Microcontrollers Live experiments and simulations will address the fundamental properties of the presented circuits. With the homework assignments, the students are engaged to verify the circuits' functionalities by computer simulations with public-domain software.
Learning outcomes	The module will provide the students with the understanding of the most important concepts of digital electronics, their applications, and potential error sources. After successful completion of the course, the students will have

	acquired the skills for designing digital circuitry on their own, in particular for applications in a science laboratory.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Roland Kersting
Language(s)	English
Additional information	Literature: • The students will receive lecture notes, which cover the fundamental concepts of digital electronics. More than 80 circuit layouts will provide the students with an extensive library for their own design of digital electronics. • T. L. Floyd, Digital Fundamentals, Pearson, 2015 P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press

Module: WP 103 Quantum Optoelectronics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 103.1 Quantum Optoelectronics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 103.2 Quantum Optoelectronics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides an introduction to quantum phenomena in condensed matter systems with reduced dimensionality. The course starts with a short repetition of the fundamental aspects of condensed matter physics in general and conventional semiconductors in particular. In due course, topics of transport and optical phenomena in semiconductors with reduced effective dimensions will be introduced with emphasis to quantum effects. To this end, fabrication methods for low-dimensional conventional semiconductors and heterostructures will be discussed and extended by the notion of modern low-dimensional materials such as graphene or layered two-dimensional semiconductors. Finally, building on these aspects, quantum optical and quantum electronic functions, applications and devices will be addressed. Overall, this course will provide the student with a broad understanding of quantum optical and quantum electronic phenomena in low-dimensional and nanoscale condensed matter systems relevant for applications in quantum technologies.

Learning outcomes	Understanding of quantum optoelectonic phenomena in low-dimensional and nanoscale semiconductors in various material classes and realizations of low-dimensional systems; understanding the relation between quantum optoelectronic phenomena and material properties (crystal structure, band structure), dimensions (0D, 1D or 2D) and geometries (e.g. quantum dots, quantum wires, quantum wells); understanding the application potential of solid-state systems for quantum technologies (such as spintronics, valleytronics, quantum information processing and sensing).
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Alexander Högele
Language(s)	English
Additional information	None

Module: WP 104 Semiconductor Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 104.1 Semiconductor Physics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 104.2 Semiconductor Physics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module broadens and deepens special professional knowledge in the field of semiconductors, specifically to enable students to carry out up-to-date research projects within this field. Specifically, students will gain expertise in: • Semiconductor basics (processing, lattice vibrations, doping, charge carrier statistics, optical properties) • Semiconductor devices (pn-junction, bipolar and field effect transistors, solar cells, lasers) • Modern materials (Organic semiconductors, Halide Perovskites, Nanocrystals) Fabrication (semiconductor processing, nanofabrication, clean room technology, nanocrystal synthesis).
Learning outcomes	After successful participation in this module, students will have a detailed understanding of up-to-date topics of current research and methods in the field of semiconductors. Students are able to tackle research problems typical of master student level research projects, to understand current literature on these topics and apply this knowledge to active research projects.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Alexander Urban
Language(s)	English
Additional information	None

Module: WP 105 Nanostructures and Nanomaterials

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 105.1 Nanostructures and Nanomaterials (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 105.2 Nanostructures and Nanomaterials (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The lecture content unfolds in a structured progression, initiating with an exploration of the properties of bulk materials and subsequently delving into a deeper examination of defects and local properties. This sets the stage for a comprehensive understanding, leading to the fabrication and characterization of nanomaterials and their interactions with light, current, and magnetic fields. The course extends its coverage to mechanics and fluidics at the nanoscale, unraveling the nuanced behaviors within these realms. Finally, the lecture culminates in a review of diverse applications, ranging from biology and sensing to energy. This holistic approach equips students with a broad perspective on nanoscale science and technology, encompassing both fundamental principles and practical applications.
Learning outcomes	This course focuses on providing students with foundational knowledge of physics at the nanoscale. The goal is to enhance understanding of phenomena at this scale and explore practical applications in everyday life and research. Students aquire knowledge on the physical and chemical basis of nanoscale science, material properties, and applications spanning from bio to energy. Successful completion

	of the course enables students to grasp the intricacies of nanoscale physics and its real-world implications.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Emiliano Cortes
Language(s)	English
Additional information	None

Module: WP 106 Materials Science II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 106.1 Functional Materials (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 106.2 Functional Materials (Exercise)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Chemie; MSc Geomaterials and Geochemistry
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	-fundamental differences between macroscopic and nanoscopic objects -microscopy of nanostructures (limitations and basic principles) -bottom-up vs. top down approaches for the fabrication of nanostructures -thin film preparation: physical vapor deposition (PVD) vs. molecular beam epitaxy (MBE) -fabrication and properties of GaAs-AlGaAs heterostructures -basic principles, fundamentals, and implications of quantum mechanics -synthesis, properties, and applications of carbon nanomaterials: fullerenes, graphene, and single wall vs. multi wall carbon nanotubes -metal & semiconductor nanoparticles: synthesis, functionalization, size-selection, and properties & applications

	-self-assembly: basic mechanisms and selected examples
Learning outcomes	actively attending students: -acquire an overview over the vast variety of prevalent nanostructures that are relevant for applications and / or provided fundamental insights -are able to categorize various and partly complementary approaches for the synthesis and fabrication of nanostructures -become familiar with the concepts and the implications of size and shape dependent material properties -are able to assess principal differences when matter approaches nanoscopic dimensions
Type of examination	Exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Markus Lackinger
Language(s)	English
Additional information	None

Module: WP 107 Current Research Topics in Advanced Solid State Physics and Nanophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 107.1 Current Research Topics in Advanced Solid State Physics and Nanophysics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 107.2 Current Research Topics in Advanced Solid State Physics and Nanophysics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced solid state physics and nanophysics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced solid state physics and nanophysics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and

	potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Theobald Lohmüller
Language(s)	English
Additional information	None

Module: WP 108 Selected Research Topics in Advanced Solid State Physics and Nanophysics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 108.1 Selected Research Topics in Advanced Solid State Physics and Nanophysics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced solid state physics and nanophysics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced solid state physics and nanophysics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bert Nickel

Language(s)	English
Additional information	None

Module: WP 109 Heavy Quarks Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 109.1 Heavy Quarks Physics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 109.2 Heavy Quarks Physics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in elementary particle physics of heavy quarks. Special attention is paid to recent developments in bottom and top quark physics research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics and results in heavy quark elementary particle physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Kuhr
Language(s)	English

Additional information	None

Module: WP 110 Advanced Methods of Machine Learning

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 110.1 Advanced Methods of Machine Learning (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 110.2 Advanced Methods of Machine Learning (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The course introduces the theoretical foundation of supervised machine learning as well as the most prominent methods in this field. In the first part, an introduction to the mathematical framework of ML is given and principles already covered in the Bachelor's programme are deepened. It covers the basic principles of risk minimization and an introduction to information-theory and its connection to ML. Furthermore, the curse of dimensionality is explained and popular methods of regularization and their proper- ties are introduced. In the second part, different prominent learning algorithms such as support vector machines, Gaussian processes and boosting are explained.
Learning outcomes	Students understand the foundations of risk minimization, information theory, learning theory and regularization, and their differ- ences and relationships to classical statistical models. The stu- dents become familiar with the inner workings of advanced ma- chine learning approaches, providing them both with the theoreti- cal background and the means of a sound application. The over- view over different algorithms furthermore enables

	participants to choose appropriate modelling approaches in different scenarios.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernd Bischl
Language(s)	English
Additional information	Current information and course materials are provided under the appropriate section at https://moodle.lmu.de/course/index.php?categoryid=38. In order to ensure the suitable background needed on machine learning, basic programming (ideally in R or Python), matrix alge- bra, and basic optimization, consult the requirements of the ad- mission procedure by the topic list and literature recommenda- tions under https://www.statistik.uni-muenchen.de/studium/studieninfos/statistik_im_master/selectioninterview/index.html. The required background in machine learning is also covered by the online course I2ML under https://slds-lmu.github.io/i2ml/team/.

Module: WP 111 Data Mining with Artificial Intelligence Methods in Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 111.1 Data Mining with Artificial Intelligence Methods in Physics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 111.2 Data Mining with Artificial Intelligence Methods in Physics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students learn about contemporary datasets in physics and how to apply AI methods on such datasets. This includes methods involving many parameters.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current datasets and advanced artificial intelligence methods applicable to those datasets.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Kuhr

Language(s)	English
Additional information	None

Module: WP 112 Current Research Topics in Advanced Artificial Intelligence

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 112.1 Current Research Topics in Advanced Artificial Intelligence (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 112.2 Current Research Topics in Advanced Artificial Intelligence (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced artificial intelligence. Special attention is paid to recent developments in research. Theoretical aspects and their practical implementation are covered.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced artificial intelligence. They gain an understanding of the theoretical background and how to apply such methods in practice.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Daniel Grün
Language(s)	English
Additional information	None

Module: WP 113 Photonics II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 113.1 Photonics 2 (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 113.2 Photonics 2 (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This course introduces students to the advanced topics in photonics. It covers the generation, manipulation and measurement of ultrashort pulses, modelocking in laser systems, and optical interactions with semiconductors. It also discusses laser spectroscopy and its applications in probing the structure and dynamics of matter.
Learning outcomes	Upon successful completion of this module, students will be able to comprehend the fundamental principles of ultrashort pulse generation, manipulation, and measurement. They will be able to apply various ultrashort pulse measurement techniques, including time-domain and frequency-domain methods. Students will be able to explain the concept of modelocking and its role in generating and shaping ultrashort pulses. They will also be able to design and analyze ultrafast pulse amplification systems that preserve the pulses' temporal and spectral properties.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Ferenc Krausz
Language(s)	English
Additional information	None

Module: WP 114 Applied Laser Physics II

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 114.1 Applied Laser Physics 2 (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 114.2 Applied Laser Physics 2 (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module introduces the students to the field of relativistic laser-matter interaction physics. Starting with the behaviour of a single electron in an ultraintense laser field, it points out the profoundly unexpected dynamics the electron exhibits due to its relativistic motion, leading to a plethora of novel phenomena. After discussing basic multiparticle dynamics in a plasma, the lecture focuses on nonlinear light propagation effects. These give rise to ultra-high-gradient electron and ion acceleration by laser light, making these processes a promising candidate for future compact particle accelerators and a wide range of applications. By their unprecedented particle density, such sources are ideally suited as drivers for high-brightness X-ray sources with applications in e.g. biology, medicine or solid-state physics.
Learning outcomes	The students will gain a good basic and practical knowledge of relativistic laser-matter interaction physics, high-gradient accelerators and free-electron X-ray emission processes, allowing them to join groups working in related fields and build a career in this highly dynamic field.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Stefan Karsch
Language(s)	English
Additional information	None

Module: WP 115 Interdisciplinary Topics in Laser Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 115.1 Interdisciplinary Topics in Laser Physics (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module introduces current topics in systems biology aided by spectroscopic techniques. Students discuss modern physical techniques, methodologies, and data analytics to understand, e.g., molecular systems for analytical human health and disease characterization.
Learning outcomes	Students are introduced to up-to-date (laser)-spectroscopic techniques. Students acquire basic knowledge and overview in the field of systems biology and learn how analytical methods are used to tackle health related research questions.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Ferenc Krausz
Language(s)	English

Additional information	None

Module: WP 116 Current Research Topics in Advanced Laser Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 116.1 Current Research Topics in Advanced Laser Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 116.2 Current Research Topics in Advanced Laser Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced laser physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced laser physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Apl. Prof. Dr. Vladislav Yakovlev

Language(s)	English
Additional information	None

Module: WP 117 Selected Research Topics in Advanced Laser Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 117.1 Selected Research Topics in Advanced Laser Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced laser physics such as precision spectroscopy, atomic and ion traps, and ultra-stable lasers. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced laser physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Thomas Udem

Language(s)	English
Additional information	None

Module: WP 118 Imaging in Medical Physics

Programme	Master's Programme: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 118.1 Imaging in Medical Physics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 118.2 Imaging in Medical Physics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture introduces the fundamentals of imaging techniques used in medical physics, from their physical principles to their instrumentation and dedicated data processing. It addresses conventional imaging techniques used in radiology and nuclear medicine, along with dedicated and novel instrumentation tailored to the needs of radiotherapy. Practical insights are provided by different lecturers who are also practitioners at the LMU University hospital, thus providing several examples of relevant clinical applications.
Learning outcomes	The students will learn the different imaging methods used in radiation therapy, radiology and nuclear medicine. They will understand what are the quantities visualized by the different introduced imaging techniques, and what are the relevant metrics used to quantify image quality. This will also enable them to understand the rationale for the usage of different imaging procedures in different medical areas, and learn what are the most exciting new developments in the respective fields. Although tailored to medical imaging, many of the introduced methods and techniques can also find application outside medicine.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 119 Radiation Detectors for Medical Applications

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 119.1 Radiation Detectors for Medical Applications (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of state-of-the-art radiation detection techniques used for medical imaging applications. Topics include a comparative overview of medical imaging detection devices, the fundamental physical interactions of charged particles and radiation with matter and an introduction to gas-filled ionization detectors, scintillators, semiconductor detectors and non-electronic passive detector systems. Also, electronic readout and signal processing will be covered.
Learning outcomes	Students learn the physics background, methodological realization and practical implementation of optimized radiation detection systems for different medical physics applications. The lecture prepares students to apply this knowledge in the laboratory during subsequent practical phases of their studies or professional applications.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Peter G. Thirolf
Language(s)	English
Additional information	None

Module: WP 120 Medical Physics Aspects of Ion Beam Therapy I

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 120.1 Medical Physics Aspects of Ion Beam Therapy (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture provides a comprehensive introduction to ion beam therapy, from the physical, biological and clinical rationale (including a review of charged particle interaction in matter) to the main techniques used for production, acceleration and delivery of ion beams to a patient, along with several medical physics aspects of treatment planning and quality assurance.
Learning outcomes	The students will learn the fundamentals of ion beam therapy, understanding the promise, the challenges and the ongoing developments of this modern radiotherapy technique. This will equip them with in-depth knowledge that they can use later in the many research projects offered at LMU around this topic.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 121 Medical Physics Aspects of Ion Beam Therapy II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 121.1 Medical Physics Aspects of Ion Beam Therapy (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 121.2 Medical Physics Aspects of Ion Beam Therapy (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture provides a comprehensive introduction to ion beam therapy, from the physical, biological and clinical rationale (including a review of charged particle interaction in matter) to the main techniques used for production, acceleration and delivery of ion beams to a patient, along with several medical physics aspects of treatment planning and quality assurance. The theoretical concepts are applied and deepened in the accompanying exercises, focused on analytical calculations and approximations of particle interactions, particle beam behavior and of technological aspects.
Learning outcomes	The students will learn the fundamentals of ion beam therapy, understanding the promise, the challenges and the ongoing developments of this modern radiotherapy technique. Moreover, the exercises allow the students to use the theoretical concepts in concrete hands-on calculations and thus deepen their understanding of the technology and the underlying physics processes and methods. This will equip them with in-depth knowledge that can later be used in the many research projects offered at LMU around this topic.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 122 Radiation Biology and Brachytherapy

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 122.1 Radiation Biology and Brachytherapy (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This lecture provides an in-depth understanding of biological mechanisms underlying radiation interaction in tissue and their possible exploitation in radiation therapy. Moreover, it provides an in-depth description of brachytherapy and intraoperative therapy, from the basic principles to the relevant medical physics aspects for effective implementation of these dedicated radiotherapy techniques.
Learning outcomes	The students will learn fundamentals of radiation biology which will equip them with the necessary knowledge to understand the different strategies used to maximize tumour cell damage and normal tissue protection in radiotherapy. Moreover, they will get an in-depth overview of dedicated radiotherapy treatments like brachytherapy and intraoperative radiation therapy.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 123 Digital Image Processing in Medical Physics I

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 123.1 Digital Image Processing in Medical Physics (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of the theoretical basis of digital image processing applications. The content of this module concentrates on the use of digital image processing techniques that are relevant for medical physics applications, namely image enhancement, segmentation, and registration techniques. The covered techniques include also approaches based on artificial intelligence to further expand the performance of traditional methods.
Learning outcomes	Students acquire knowledge in basic and advanced quantitative methods for digital image processing, with a specific focus on medical physics applications. At the end of this module, all students will be on a homogeneous level of expertise in the theoretical aspects of the most advanced methods for digital image processing
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Marco Riboldi
Language(s)	English
Additional information	None

Module: WP 124 Digital Image Processing in Medical Physics II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 124.1 Digital Image Processing in Medical Physics (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 124.2 Digital Image Processing in Medical Physics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of the theoretical basis and practical implementation of digital image processing applications. The content of this module concentrates on the use of digital image processing techniques that are relevant for medical physics applications, namely image enhancement, segmentation, and registration techniques. The covered techniques include also approaches based on artificial intelligence to further expand the performance of traditional methods. The module will also introduce basic skills essential for the implementation of such image processing techniques in Python.
Learning outcomes	Students acquire knowledge in basic and advanced quantitative methods for digital image processing, with a specific focus on medical physics applications. With this knowledge, students have the abilities to understand the theoretical basis of digital image processing techniques relevant in medical physics. Furthermore, after successful participation in this module students are in the position to implement

	Python code for the development of advanced digital image processing algorithms.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Marco Riboldi
Language(s)	English
Additional information	None

Module: WP 125 Radiation Protection for Medical Applications

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 125.1 Radiation Protection for Medical Applications (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module covers physical, legal and practical aspects of radiation protection in the context of medical applications. Radiation physics basics and biological effects of ionizing radiation exposure will be introduced. The international and national legal framework of radiation protection will be presented together with the role of the Medical Physics Expert in Germany. In-depth knowledge of radiation protection in nuclear medicine, brachytherapy and external beam radiotherapy will be provided. Natural and medical-induced radiation risks, deterministic and stochastic radiation damage, risk mitigation and accident prevention strategies, shielding design and radioactive waste handling concepts will be discussed.
Learning outcomes	Students acquire knowledge in various complementary fields related to radiation protection in different medical application scenarios. The learning outcome of the module covers the scope of basic expertise expected from the academic curriculum for medical physics experts.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Peter G. Thirolf
Language(s)	English
Additional information	None

Module: WP 126 Current Research Topics in Advanced Medical Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 126.1 Current Research Topics in Advanced Medical Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 126.2 Current Research Topics in Advanced Medical Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced medical physics. Special attention is paid to recent developments in research, including possibilities of practical insights.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced medical physics. Moreover, they acquire practical skills relevant to such recent research areas.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 127 Selected Research Topics in Advanced Medical Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 127.1 Selected Research Topics in Advanced Medical Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced medical physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced medical physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English

Additional information	None

Module: WP 128 Atmospheric Modeling

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 128.1 Atmospheric Modeling (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 128.2 Atmospheric Modeling (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module is designed to provide students with an overview of important dynamical, physical and chemical processes on various scales in the atmosphere. This can include fundamental insights into numerical methods for Numerical Weather Prediction (NWP) and an understanding of its different components. The basics on how climate on Earth is determined by thermodynamic and dynamical processes (Energy balance, and redistribution of Energy by dynamical circulations) are included. Methods how to model the Earth's climate are introduced spanning a hierarchy of models from simple models to coupled Atmosphere-Ocean Models (GCMs).
Learning outcomes	Students can explain well-founded dynamical principles and apply relationships on various spatial and temporal scales in the atmosphere on the basis of physical laws and solve meteorological problems mathematically and numerically.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. George Craig
Language(s)	English
Additional information	None

Module: WP 129 Theoretical Meteorology from the Weather to the Climate Scale

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 129.1 Theoretical Meteorology from the Weather to the Climate Scale (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 129.2 Theoretical Meteorology from the Weather to the Climate Scale (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module is designed to provide students with an overview of important dynamical, physical and chemical processes on various scales in the atmosphere. This can include fundamental insights into numerical methods for Numerical Weather Prediction (NWP), the basics on how climate on Earth is determined by thermodynamic and dynamical processes.
Learning outcomes	Students can explain well-founded dynamical principles and apply relationships on various spatial and temporal scales in the atmosphere on the basis of physical laws and solve meteorological problems mathematically and numerically.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. George Craig
Language(s)	English
Additional information	None

Module: WP 130 Experimental Meteorology - Clouds, Aerosols, Gases

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 130.1 Experimental Meteorology - Clouds, Aerosols, Gases (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 130.2 Experimental Meteorology - Clouds, Aerosols, Gases (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	In this module the roles and interaction of trace gases, clouds, precipitation and aerosol are introduced and analysed. General physical backgrounds are covered as well as the in-depth examination of these aspects in observational data and the related data analysis approaches.
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English
Additional information	None

Module: WP 131 Atmospheric Data Analysis Methods

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 131.1 Atmospheric Data Analysis Methods (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 131.2 Atmospheric Data Analysis Methods (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	In this module methods for the interpretation of remote sensing data and environmental measurements of the atmospheric different constituents are introduced and applied to real data. Methods include mathematical and statistical optimization procedures as well as data processing methods. Observation data and its theoretical background covered can include clouds, aerosol, soil properties or pollutant and greenhouse gas distributions as observed from different measurement platforms (satellite, ground based, airborne), provided by lab-experiments, in-situ or remote sensing sensors.
Learning outcomes	The learning objectives are to gain an in-depth understanding of various data analysis methods that enable the evaluation and analysis of extensive and complex measurement data sets. This way students will be able to assess the relevance of derived results and drawn conclusions based on scientific theory and state-of-the-art techniques.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Mark Wenig
Language(s)	English
Additional information	None

Module: WP 132 Current Research Topics in Theoretical Meteorology

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 132.1 Current Research Topics in Theoretical Meteorology (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 132.2 Current Research Topics in Theoretical Meteorology (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current research topics in Theoretical Meteorology. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in Theoretical Meteorology.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. George Craig

Language(s)	English
Additional information	None

Module: WP 133 Radiative Transfer

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 133.1 Radiative Transfer (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	In this module all aspects of radiative transfer are covered. This can be theoretical mathematical aspects, modelling approaches and model application, retrieval theory and methods for active and passive remote sensing as well as observation or more general discussions of its role in weather and climate.
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field as well as to apply the methods of the field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer

Language(s)	English
Additional information	None

Module: WP 134 Specific Aspects of Climate Change

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 134.1 Specific Aspects of Climate Change (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Different aspects of future changes of the Earth's climate system composed of its parts land surface, atmosphere and its specific height layers, as well as ocean circulation are considered. Also included can be aspects of interaction of these nature components and human society (e.g. economy, technology, land use).
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Georg Craig
Language(s)	English

Additional information	None

Module: WP 135 Applied Meteorology

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 135.1 Applied Meteorology (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	In this module applied aspects of meteorology are covered, be it application for neighboring fields of science or society: e.g. traffic, energy production, energy market, insurance industry, biology, medicine, but also application of its mathematical and physical basis for all types of evaluation or modelling approaches.
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English

Additional information	None

Module: WP 136 Meteorology, Climate, Society

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 136.1 Meteorology, Climate, Society (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	All aspects of interaction over different time and spatial scales of meteorology and climate and the interaction with society and economy are part of this module. The atmosphere shapes the environment of human life and, at the same time, is shaped by human activities. This interplay is focus here.
Learning outcomes	Students can explain well-founded principles of the field and apply this knowledge on various spatial and temporal scales in the atmosphere on the basis of physical laws and are enabled to assess validity and relevance of research in this field.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English

Additional information	None

Module: WP 137 Applied Quantum Systems

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 137.1 Applied Quantum Systems (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 137.2 Applied Quantum Systems (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module provides insight into the practical aspects of creating and using quantum systems. Techniques used to realize quantum systems are presented, discussed and analyzed. This can also include techniques for data analysis or numerical optimization.
Learning outcomes	Students learn about technical methods needed to implement or apply quantum technologies in the real world. The focus is on fundamental methods both on the experimental and theoretical side. This can for example include methods for error analysis, methods for detecting light and quantum states, methods to control light or magnetic fields with high precision, as well as existing technologies to shape pulses in time or space.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Monika Aidelsburger
Language(s)	English
Additional information	None

Module: WP 138 Advanced Atomic Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 138.1 Advanced Atomic Physics (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 138.2 Advanced Atomic Physics (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module discusses modern results in quantum physics, quantum optics, quantum simulation and quantum information. It aims to provide an overview into one or more of the subfields with the aim of providing an introduction to advanced concepts and important methods used in modern atomic and quantum physics.
Learning outcomes	Students will obtain an in-depth understdaning of some of the important methods, approaches and arguments in modern atomic and quantum physics research. This includes recent research results and publications, and the application of central advanced methods to quantum physics problems.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English
Additional information	None

Module: WP 139 Current Research Topics in Advanced Quantum Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 139.1 Current Research Topics in Advanced Quantum Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 139.2 Current Research Topics in Advanced Quantum Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of current topics in advanced quantum physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of current research topics in advanced quantum physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch

Language(s)	English
Additional information	None

Module: WP 140 Selected Research Topics in Advanced Quantum Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 140.1 Selected Research Topics in Advanced Quantum Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in advanced quantum physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in advanced quantum physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English

Additional information	None

Module: WP 141 Plasma Physics II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 141.1 Plasma Physics 2 (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 141.2 Plasma Physics 2 (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The course covers basic knowledge on nuclear fusion including inertial confinement fusion and magnetic confinement fusion, while emphasis is put on the latter. It teaches the basics of • Nuclear fusion as an energy source of the sun and stars • Nuclear fusion on earth as a mean of producing energy, implications Coloumb repulsion and collision physics • Inertal confinement fusion: Conditions for ignition and burn, Concepts and status of research, achieved mile stones • Magnetic confinement fusion: Conditions for ignition and burn, Concepts and status of research, achieved mile stones • Transport in magnetically confined plasmas: Collisional transport, contributions to transport by special particle trajectories (banana particles), turbulence, scaling towards future devices

	• Diagnostics of magnetically confined fusion plasmas: Measuring basic parameters, Spatial and Temporal resolution, active and passive diagnostics
Learning outcomes	The students are able to describe the physical fundamentals of nuclear fusion and are able to connect these to fundamentals of mechanics, electrodynamics, thermodynamics and nuclear physics. The application of these contents is exercised in the tutorials.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Thomas Pütterich, PD Dr. Jörg Stober
Language(s)	English
Additional information	None

Module: WP 142 Hydrodynamics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 142.1 Hydrodynamics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 142.2 Hydrodynamics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Fluids make up a large part of our everyday lives, from the air we breathe to water flowing out of a tap. This course builds a mathematical framework to describe fluid motion and instabilities, starting from microscopic particle motion, all the way to instabilities and fluid turbulence. Various physical phenomena will be investigated along the way, including how waves propagate in a fluid and how a wing actually generates lift. The following topics are treated: • Ideal fluid equations (continuity, Euler, hydrostatics, Bernoulli) • Potential flows • Fluid waves (gravitational and sound waves) • Compressible flow • Viscous fluids (Navier-Stokes equation, laminar flow, boundary layer theory) • Hydrodynamic instabilities (Rayleigh-Taylor and Kelvin-Helmholz • instabilities) • Fluid turbulence (eddy formation, fully developed turbulence) • The Korteweg-deVries equation

Learning outcomes	After successful completion of the course, students will have a solid understanding of how many body systems are described in a continuum (fluid) theory and be familiar with the mathematical concepts of linear and nonliear stability. The course also treats a variety of phenomena governing fluids around us in everyday life, such as air and water, giving a solid understanding of how these media move under various forces and how thermodynamics plays a role in determining how fluids flow.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr.-Hartmut Zohm
Language(s)	English
Additional information	None

Module: WP 143 Prospective Advanced Research Topics in Modern Experimental Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 143.1 Prospective Advanced Research Topics in Modern Experimental Physics (Lecture)	WiSe and SoSe	45 h (3 SWS)	75 h	(4)
Exercise course	WP 143.2 Prospective Advanced Research Topics in Modern Experimental Physics (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Astrophysics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of prospective advanced topics in modern experimental physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of prospective advanced topics in modern experimental physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 144 Selected Research Topics in Prospective Fields of Advanced Modern Experimental Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 144.1 Selected Research Topics in Prospective Fields of Advanced Modern Experimental Physics (Lecture)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module provides an in-depth discussion of selected topics in prospective fields of advanced modern experimental physics. Special attention is paid to recent developments in research.
Learning outcomes	Students acquire in-depth knowledge and gain an understanding of selected research topics in prospective fields of advanced modern experimental physics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies

Language(s)	English
Additional information	None

Module: WP 145 Mesoscopic Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 145.1 Mesoscopic Physics (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 145.2 Mesoscopic Physics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module covers the following topics: Electrical conductance as scattering problem and conductance quantization, quantum Hall effect, quantum dots as “artificial atoms”, tunneling, Coulomb blockade and single electron transistor, disorder effects (random matrix theory and weak localization), shot noise and full counting statistics of electronic transport, dephasing and partially coherent transport, mesoscopic superconductivity (e.g. Josephson arrays and qubits), interacting electrons in one dimension (“Luttinger liquid”), spin effects (e.g. spin-orbit scattering and Kondo effect), relation to quantum optics and the physics of ultracold atoms. This module offers an introduction to one of the central modern areas of theoretical condensed matter physics.
Learning outcomes	The main goal is to acquire a fundamental understanding of how the behavior of electrons in meso- and nanoscopic systems is governed by the interplay of quantum mechanical interference, the Coulomb interaction and fluctuations.
Type of examination	Written exam or oral examination or term paper

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 146 Many Body Theory

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 146.1 Many Body Theory (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 146.2 Many Body Theory (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The aim of this module is to learn basic methods of modern quantum many-body theory and to apply them to various problems in condensed matter physics. The contents of this module vary somewhat from year to year, depending on the preferences of the lecturer; interested students are advised to contact the lecturer in advance for details. A typical module could be structured as follows: It starts with an introduction to second quantization and its application to paradigmatic models of interacting electrons, such as the Hubbard- and Heisenberg models, the Bogoliubov theory of weakly interacting bosons, Hartree-Fock mean-field theory and the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity. The subsequent, main part of this module develops functional integral techniques for bosons and fermions in the finite-temperature Matsubara formalism, discusses Green's functions and their analytic properties, and introduces perturbation theory using Feynman diagrams and elementary non-perturbative methods such as the Hubbard-Stratonovich transformation. These methods are then used to study properties of interacting electron systems (random-phase approximation, screening and plasmon excitations) and to discuss Fermi liquid theory. The next chapter covers the linear

	response formalism (Kubo formula) as the central tool to establish a connection between theoretically computable correlation functions and experimental observables. The final core topic is an extended discussion of the BCS theory of superconductivity, starting from the functional integral representation.
Learning outcomes	After completing the Module the student is able to: - Understand and apply the formalism of second quantization to study interacting quantum many-particle systems. - Explain the main ideas behind common approximation schemes, in particular mean-field theory and the Bogoliubov transformation. - Understand the functional integral representation of partition functions, manipulate functional integrals, and apply a Hubbard-Stratonovich decoupling. - Explain the properties of Green's functions and their use in diagrammatic perturbation theory. - Understand and use the linear response formalism to compute experimental observables of interacting many-particle systems. - Understand the theory of BCS superconductivity. Follow current research topics and use the toolbox of many-body methods to start independent research.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 147 Quantum Optics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 147.1 Quantum Optics (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 147.2 Quantum Optics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The following systems will be considered: trapped ions, neutral atoms in magnetic and optical traps, thermal ensembles of atoms and photons. Applications in the field of quantum information processing as well as in Bose-Einstein condensation will also be described. Quantum optics deals with the interaction of light and matter (atoms and molecules). During the last few years, this topic has acquired a renewed interest through the experimental achievements made in atomic physics, and the possibility of controlling and manipulating atomic quantum states using light. This module will review the theoretical techniques used to describe the interactions of light with atoms, as well as the physical phenomena observed in actual experiments dealing with cold atoms.
Learning outcomes	The main goal is to acquire an overview over the multitude of quantum optical effects and the most important methods for their theoretical description.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Delft
Language(s)	English
Additional information	None

Module: WP 148 Quantum Chromodynamics and the Standard Model of Elementary Particle Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 148.1 Quantum Chromodynamics and the Standard Model of Elementary Particle Physics (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 148.2 Quantum Chromodynamics and the Standard Model of Elementary Particle Physics (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Quarks and leptons, symmetry principles, non-abelian gauge theories, path integral quantization, quantum chromodynamics, asymptotic freedom, deep inelastic scattering, Higgs mechanism, electroweak interactions, flavor physics, anomalies.
Learning outcomes	This module aims to convey the fundamentals of quantum chromodynamics and the standard model.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Georgi Dvali
Language(s)	English
Additional information	None

Module: WP 149 Supersymmetry

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 149.1 Supersymmetry (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 149.2 Supersymmetry (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module introduces the fundamental properties of Supersymmetry. It covers supersymmetric quantum mechanics, SUSY algebra and its representations, supersymmetric field theories and superfield formalism, supersymmetric gauge theories. It explains the special features of supersymmetric theories compared to ordinary theories. This includes a discussion of the Witten index in SUSY quantum mechanics, path integral localization in SUSY QM, as well as applications in quantum field theories, such as non-renormalization arguments, role of BPS sectors, Seiberg-Witten theory.
Learning outcomes	After successful completion of this course the students are able to: 1. State basic definitions: Lie algebra, graded Lie algebra, vector space, graded vector space, representation. 2. Construct spinor representations and (extended) SUSY algebras 3. Construct supersymmetric Lagrangians 4. Compute the Witten index in SUSY QM, explain its invariance under deformations. 5. Compute path integrals in simple SUSY QM models. 6. Compute classical moduli spaces of SUSY gauge theories

Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst
Language(s)	English
Additional information	None

Module: WP 150 Cosmology

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 150.1 Cosmology (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 150.2 Cosmology (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Kinematics and dynamics of the expanding universe. This includes propagation of light and horizons, hot universe, nucleosynthesis, recombination, the very early universe, inflation, gravitational instability in the Newtonian theory, small perturbations according to general relativity, quantum fluctuations as the origin of the large scale structure of the universe, CMB fluctuations.
Learning outcomes	The module aims to convey acquaintance with the basic concepts of cosmology.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Viatcheslav Mukhanov

Language(s)	English
Additional information	None

Module: WP 151 String Theory II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 151.1 String Theory 2 (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 151.2 String Theory 2 (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module begins by developing important concepts such as D-branes, supersymmetric compactifications on orientifolds, orbifolds and Calabi-Yau spaces. Further topics are the computation of string amplitudes (tree-level, 1-loop, automorphic functions), string dualities (M-theory, S-duality, mirror symmetry) and extra dimensions.
Learning outcomes	The main goals of this module are to master perturbative superstring theory and to understand basic non-perturbative properties.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst

Language(s)	English
Additional information	None

Module: WP 152 Instantons

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 152.1 Instantons (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 152.2 Instantons (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	After an introduction of the mathematical concepts (topological charge, solitons), the basic examples non-perturbative classical solutions in various dimensions like monopoles (Dirac, t'Hooft-Polyakov) and instantons are discussed. Then their role in quantized theories is highlighted, in particular for symmetry breaking, anomalies and CP-violation. In the following, the properties of solitons and instantons in supersymmetric theories (BPS states) are treated.
Learning outcomes	Students can reason about field theories beyond perturbation theory. They can successfully apply notions from topology to classical and quantum theories.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst

Language(s)	English
Additional information	None

Module: WP 153 Black Holes

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Lecture	WP 153.1 Black Holes (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 153.2 Black Holes (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The course derives classical black hole solutions (Schwarzschild, Reissner-Nordström, Kerr and their higher dimensional generalizations) and discusses their conformal structure. Global techniques are presented and used to discuss singularity theorems and black hole thermodynamics.
Learning outcomes	Students are familiar with axisymmetric and stationary solutions to Einstein's equations and their physical properties. They can derive Penrose diagrams and use them to argue about global structure of a space-time solution. They have mastered the basic notions about global techniques and how they can be used to obtain singularity theorems. They can reason about black holes as thermodynamic objects.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and

	potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst
Language(s)	English
Additional information	None

Module: WP 154 Physics of Soft Condensed Matter and Critical Phenomena

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 154.1 Physics of Soft Condensed Matter and Critical Phenomena (Lecture)	SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 154.2 Physics of Soft Condensed Matter and Critical Phenomena (Exercise Course)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The module covers the following topics: Mean-field theory, field theories, critical phenomena and renormalization group, generalized elasticity (XY model, liquid crystals, gels), hydrodynamics, topological defects, walls, kinks and solitions, response theory and nonequilibrium thermodynamics.
Learning outcomes	The module aims to convey a fundamental understanding the collective phenomena occurring in macroscopic particle systems in condensed matter.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English
Additional information	None

Module: WP 155 Current Research Topics in Advanced and Applied Quantum Mechanics II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 155.1 Current Research Topics in Advanced and Applied Quantum Mechanics 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 155.2 Current Research Topics in Advanced and Applied Quantum Mechanics 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fied of advanced and applied quantum mechanics.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of advanced and applied quantum mechanics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jan von Deft

Language(s)	English
Additional information	None

Module: WP 156 Current Research Topics in Quantum Field Theory and Gauge Theories II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 156.1 Current Research Topics in Quantum Field Theory and Gauge Theories 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 156.2 Current Research Topics in Quantum Field Theory and Gauge Theories 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	The successful completion of the module takes 1 semester.
Learning outcomes	This module treats current research topics in the fied of Quantum Field Theory and Gauge Theories.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Georgi Dvali
Language(s)	English

Additional information	None

Module: WP 157 Current Research Topics in Cosmology, General Relativity, and Differential Geometry II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 157.1 Current Research Topics in Cosmology, General Relativity, and Differential Geometry 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 157.2 Current Research Topics in Cosmology, General Relativity, and Differential Geometry 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fied of Cosmology, General Relativity, and Differential Geometry.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of Cosmology, General Relativity, and Differential Geometry.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Viatcheslav Mukhanov
Language(s)	English
Additional information	None

Module: WP 158 Current Research Topics in String Theory and Geometry II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 158.1 Current Research Topics in String Theory and Geometry 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 158.2 Current Research Topics in String Theory and Geometry 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of String Theory and Geometry.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of String Theory and Geometry.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Dieter Lüst
Language(s)	English

Additional information	None

Module: WP 159 Current Research Topics in Statistical Physics and Stochastics II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 159.1 Current Research Topics in Statistical Physics and Stochastics 2 (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 159.2 Current Research Topics in Statistical Physics and Stochastics 2 (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	This module treats current research topics in the fields of Statistical Physics and Stochastics.
Learning outcomes	The module aims to convey advanced methods and knowledge in a selected area of Statistical Physics and Stochastics.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Erwin Frey
Language(s)	English

Additional information	None

Module: WP 160 Discussion of Current Research Questions on Advanced Biophysics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 160.1 Discussion of Current Research Questions on Advanced Biophysics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced biophysics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Joachim Rädler
Language(s)	English
Additional information	None

Module: WP 161 Discussion of Current Research Questions on Advanced Solid State Physics and Nanophysics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Seminar	WP 161.1 Discussion of Current Research Questions on Advanced Solid State Physics and Nanophysics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced solid state physics and nanophysics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Alexander Urban
Language(s)	English

Additional information	None

Module: WP 162 Discussion of Current Research Questions on Advanced Elementary Particle Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 162.1 Discussion of Current Research Questions on Advanced Elementary Particle Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced elementary particle physics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Otmar Biebel, Prof. Dr. Thomas Kuhr
Language(s)	English

Additional information	None

Module: WP 163 Discussion of Current Research Questions on Advanced Artificial Intelligence

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 163.1 Discussion of Current Research Questions on Advanced Artificial Intelligence (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced artificial intelligence, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Jochen Weller
Language(s)	English

Additional information	None

Module: WP 164 Discussion of Current Research Questions on Advanced Laser Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 164.1 Discussion of Current Research Questions on Advanced Laser Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced laser physics and its applications, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Ferenc Krausz
Language(s)	English
Additional information	None

Module: WP 165 Discussion of Current Research Questions on Advanced Medical Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 165.1 Discussion of Current Research Questions on Advanced Medical Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of advanced medical physics, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Katia Parodi
Language(s)	English
Additional information	None

Module: WP 166 Discussion of Current Research Questions on Advanced Meteorology

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 166.1 Discussion of Current Research Questions on Advanced Meteorology (Seminar)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Meteorology
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Students work on a topic in the field of Meteorology, present it to the class and discuss conclusions.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Bernhard Mayer
Language(s)	English
Additional information	None

Module: WP 167 Discussion of Current Research Questions on Advanced Quantum Physics

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 167.1 Discussion of Current Research Questions on Advanced Quantum Physics (Seminar)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	An overview of current methods, publications and results will be discussed related to advanced quantum physics topics. Techniques and methods for presenting scientific data and results will be also discussed.
Learning outcomes	Students develop their skills to learn a new topic independently by reviewing scientific literature. They deepen their abilities to present content in a clear and comprehensible way.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Immanuel Bloch
Language(s)	English

Additional information	None

Module: WP 168 Advanced Course on Selected Topics in Theoretical and Mathematical Physics II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Seminar	WP 168.1 Seminar on Selected Topics in Theoretical and Mathematical Physics 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	MSc Theoretical and Mathematical Physics
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	In this module, selected special topics in theoretical and mathematical physics are presented. Special attention is paid to recent developments in research.
Learning outcomes	This module provides an in-depth discussion of a specific topic aiming to make contact with ongoing research.
Type of examination	Presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Module: WP 169 Insights into Applied Physics Research II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lab course	WP 169.1 Insights into Applied Physics Research 2 (Lab Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Advanced experiments on current research areas of the Faculty of Physics.
Learning outcomes	Students are able to become independently acquainted with several defined research areas of physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Martin Benoit
Language(s)	English
Additional information	None

Module: WP 170 Introduction to the Application of Physical Research Methods and Instruments II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lab course	WP 170.1 Introduction to the Application of Physical Research Methods and Instruments 2 (Lab Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Tutorial	WP 170.2 Introduction to the Application of Physical Research Methods and Instruments 2 (Tutorial)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Advanced experiments on current research areas of the Faculty of Physics.
Learning outcomes	Students are able to become independently acquainted with several defined research areas of physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dr. Martin Benoit
Language(s)	English
Additional information	None

Module: WP 171 Advanced Application of Physical Research Methods and Instruments

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lab course	WP 171.1 Advanced Application of Physical Research Methods and Instruments (Lab Course)	WiSe and SoSe	90 h (6 SWS)	180 h	(9)
Tutorial	WP 171.2 Advanced Application of Physical Research Methods and Instruments (Tutorial)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 12 ECTS credits have to be acquired. Class attendance averages about 8 contact hours. Including time for self-study, 360 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be selected in compliance with the following rules: See Annex II.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The successful completion of the module takes 1 semester.
Content	Independent project-based work on a current research area from experimental or theoretical physics and carrying out scientific experiments with analysis and documentation of the results obtained.
Learning outcomes	Students are able to independently familiarise themself with a current field of research in experimental or theoretical physics and to carry out scientific experiments, analyse them and document the results obtained.
Type of examination	Scientific protocol
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Modul: P 1 Research Project in Physics: Phase I

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Training	P 1.1 Scientific Training in Physics: Literature Search	WiSe and SoSe	-	90 h	(3)
Training	P 1.2 Scientific Training in Physics: Induction into the Field of Research	WiSe and SoSe	-	360 h	(12)

For successful completion of the module, 15 ECTS credits have to be acquired. Class attendance averages about 0 contact hours. Including time for self-study, 450 hours have to be invested.

Module type	Mandatory module
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The successful completion of the module takes 1 semester.
Content	Students get familiar with a physical problem, research approaches and their adequate presentation within one of the research areas of the Faculty of Physics. The topic of Research Project: Phase 1 is agreed between the student and a lecturer according to the area of his/her research group.
Learning outcomes	Students develop skills for the self-directed acquisition of in-depth knowledge and of concepts and methods relating to the discussed research topic. Competences in scientific work, e.g. for literature search and the presentation of content are acquired.
Type of examination	Oral examination or presentation or term paper or scientific protocol
Type of assessment	The successful completion of the module will not be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Dean of Studies
Language(s)	English
Additional information	None

Modul: P 2 Research Project in Physics: Phase II

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Training	P 2.1 Scientific Work in Physics: Selection and Application of Scientific Methods within the Scope of the Research Project	WiSe and SoSe	-	90 h	(3)
Training	P 2.2 Scientific Work in Physics: Self-directed Research	WiSe and SoSe	-	360 h	(12)

For successful completion of the module, 15 ECTS credits have to be acquired. Class attendance averages about 0 contact hours. Including time for self-study, 450 hours have to be invested.

Module type	Mandatory module
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The successful completion of the module takes 1 semester.
Content	Students continue the work on a physical problem started in Research Project: Phase I. The focus is on the selection and development of suitable research methods and scientific research activity.
Learning outcomes	Students develop skills, for scientific documentation and writing, for structured scientific work and for critical evaluation of results.
Type of examination	Oral examination or presentation or term paper or scientific protocol
Type of assessment	The successful completion of the module will not be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies

Language(s)	English
Additional information	None

Modul: P 3 Final Module

Programme	Masterstudiengang: Physics (Master of Science, M.Sc.)

Zugeordnete Modulteile

Course type	Course (mandatory)	Rota-tion	Contact hours	Self-study hours	ECTS
Master‘s thesis	P 3.1 Master's Thesis	WiSe and SoSe	-	900 h	(30)

For successful completion of the module, 30 ECTS credits have to be acquired. Class attendance averages about 0 contact hours. Including time for self-study, 900 hours have to be invested.

Module type	Mandatory module
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	Successful participation in P 1 and P 2
Semester	Recommended semester: 4
Duration	The successful completion of the module takes 1 semester.
Content	Within the chosen research area, students complete the Master's thesis as a continuation of the Research Project: Phase I and II. The Master's thesis is an independent research project.
Learning outcomes	In the Master's thesis, students independently apply the conceptual and methodological knowledge acquired during their studies, develop it further, find their own questions, gain new insights, evaluate them critically, communicate them and present them in accordance with the scientific standards.
Type of examination	Master’s thesis
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dean of Studies

Language(s)	English
Additional information	None

Annex I: Rules for the selection of compulsory elective modules WP 1 to WP 3

One compulsory elective module must be chosen from the compulsory elective modules WP 1 to WP 3. For the compulsory elective module WP 3, at least the following languages are available in different levels: Arabic, Chinese, French, Italian, Japanese, Dutch, Norwegian, Portuguese, Swedish, Spanish, Thai and Turkish.

Annex II: Rules for the selection of compulsory elective modules WP 4 to WP 171

From the compulsory elective modules WP 4 to WP 171, compulsory elective modules amounting to a total of 57 ECTS credits must be selected.

For this purpose
1. one compulsory elective module from the compulsory elective modules WP 4 and WP 88 must be selected.
2. one compulsory elective module from the compulsory elective modules WP 5 and WP 89 must be selected.
3. one compulsory elective module from the compulsory elective modules WP 76 to WP 84 and WP 160 to WP 168 must be selected.
4. from the compulsory elective modules WP 4 to WP 75 and WP 88 to WP 159 further compulsory elective modules amounting to 15 ECTS credits must be selected.
5. from the compulsory elective modules WP 4 to WP 84 and WP 88 to WP 168 further compulsory elective modules amounting to 9 ECTS credits must be selected.
6. from the compulsory elective modules WP 4 to WP 75, WP 85 to WP 159 and WP 169 to WP 171 further compulsory elective modules with a total of 12 ECTS credits must be selected.

Students who choose the compulsory elective module WP 38 may not choose the compulsory elective module WP 39.
Students who choose the compulsory elective module WP 39 may not choose the compulsory elective module WP 38.
Students who choose the compulsory elective module WP 120 may not choose the compulsory elective module WP 121.
Students who choose the compulsory elective module WP 121 may not choose the compulsory elective module WP 120.
Students who choose the compulsory elective module WP 123 may not choose the compulsory elective module WP 124.
Students who choose the compulsory elective module WP 124 may not choose the compulsory elective module WP 123.

In the 1st semester, elective modules with a total of 30 ECTS credits and in the 2nd semester elective modules with a total of 27 ECTS credits are to be selected.