Universität Bremen

Faculty 1 Physics/Electrical Engineering

Summersemester 26

Module Guide

for the study of

Astrophysics and Space Science

Master of Science

valid in connection with the examination regulations MPO 2022

Generated: February 17, 2026

Index by areas of study

1) Specialization I (30 CP)

a) Compulsory Modules (24 CP)

All modules must be taken

b) Elective Module (6 CP)

Students have to achieve a total of 6 CP out of the elective modules.

2) Specialization II (30 CP)

a) Compulsory Modules (6 CP)

The module must be taken

b) Elective Modules (24 CP)

Students have to achieve a total of 24 CP out of the elective modules.

3) Master Thesis (30 CP)

Module 01-PHY-MA-ExGrav: Experimental Gravitation
Experimental Gravitation

Assignment to areas of study:
- Specialization I / Compulsory Modules

Content-related prior knowledge or skills:
Bachelor, Experimental Physik, Allgemeine Relativitätstheorie

Learning content:
Orbitpropagation, orbit disturbances, orbit transfers, modelling of satellites and subsystems, weak equivalence principle, detection of gravitational waves, gravitational redshift, satellite geodesy and -gravimetry, project management, missions: MICROSCOPE, LISA, GRACE/GRACE-Follow ON, Galileo, GP-A, LAGEOS

Learning outcomes / competencies / targeted competencies:
- Distinction between foundations and consequences of General Relativity
- Overview and principles of modern experimental methods (especially in space) and appropriate mission and orbit design
- Overview over important and best experiments carried out so far

Calculation of student workload:
68 h Exam preparation
56 h SWS / presence time / working hours
56 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. Meike List

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Experimental Gravitation

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Literature:
C. Will: Theory and Experiments in Gravitational Physics, Cambridge University Press, Cambridge 2018.

E. Fischbach and C.L. Talmadge: Search for Non-Newtonian Gravity, Springer, 1999.

Y. Chen and A. Cook: Gravitational Experiments in the Laboratory, Cambridge University Press, Cambridge 1993.

M. List and C. Lämmerzahl: Das Äquivalenzprinzip – Grundlagen, Tests und neueste Messungen, Springer-Essentials, Springer-Nature 2021.

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-StAst: Stellar Astrophysics
Stellar Astrophysics

Assignment to areas of study:
- Specialization I / Compulsory Modules

Content-related prior knowledge or skills:
Bachelorstudium Mathematik/Physik o.ä.

Learning content:
Basics of celestial mechanics, heliophysics (origin of the sun, inner structure, development of the sun and other stars, solar wind), molecular clouds, formation of stars of larger mass, stellar clusters, galaxy classification

Learning outcomes / competencies / targeted competencies:
The students get to know the basics of classical (non-relativistic) stellar astrophysics and basic calculation methods.

Calculation of student workload:
56 h SWS / presence time / working hours
68 h Exam preparation
56 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
N.N.

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Module courses

Course: Stellar Astrophysics

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Literature:
An Introduction to Modern Astrophysics
Cambridge University Press, 2nd Edition
ISBN-10/13 : 1108422160 / 978-1108422161

Principles Of Heliophysics: a textbook on the universal processes behind planetary habitability, https://arxiv.org/abs/1910.14022.

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-InGRC: Introduction to General Relativity and Cosmology
Introduction to General Relativity and Cosmology

Assignment to areas of study:
- Specialization I / Compulsory Modules

Content-related prior knowledge or skills:
Bachelor, Theoretische Physik

Learning content:
- Manifolds, coordinate systems
- metric, Lie derivative
- covariant derivative, parallel transport
- geodesic equation
- covariant wave equation, Maxwell equations
- Einstein's field equation
- Schwarzschild solution
- weak field approximation
- Description of the evolution of the Universe, the observational status of cosmology, and the future of the Universe. In more detail:
- historical introduction
- cosmology in the framework of Einstein's General Relativity, Robertson-Walker models
- Friedmann-Lemaitre equations and their solutions
- observations (COBE, WMAP, Planck, SN Ia), restriction of the cosmological parameters
- the early Universe, inflation
- the late Universe, dark energy
- cosmology beyond Robertson-Walker models: perturbation theory, Bianchi models

Learning outcomes / competencies / targeted competencies:
Students should get a first introduction into the mathematics underlying General Relativity, and learn the equations motion motion for point particles and light rays, the electromagnetic field, and the Einstein equations.

Understanding the evolution of the Universe in the framework of General Relativity. Overview of the observations and their implications for the cosmological model

Calculation of student workload:
102 h Exam preparation
84 h Preparation / follow-up work
84 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
PD Dr. Volker Perlick

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
9 / 270 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Module courses

Course: Introduction to General Relativity and Cosmology

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
6,00

Literature:
Ch. W. Misner, K. S. Thorne, and J.A. Wheeler: Gravitation, Freeman and Co., San Francisco 1973

R. Wald: General Relativity, University of Chicago Press, Chicago and London 1984.

H. Stephani: Relativity – an Introduction to Special and General Relativity, Cambridge University Press, Cambridge 2004.

V. Mukhanov: "Physical foundations of cosmology" Cambridge UP (2005)

G. Ellis, R. Maartens, M. MacCallum: "Relativistic Cosmology" Cambridge UP (2012)

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-SAEM: Science, Astronomy and Exploration Missions
Science, Astronomy and Exploration Missions

Assignment to areas of study:
- Specialization I / Compulsory Modules

Content-related prior knowledge or skills:
Bachelorstudium

Learning content:
Refresh of orbital dynamics: Coordinate systems, Kepler problem, Lagrange points, perturbation theory for satellite orbits, decomposition of arbitrary gravity fields. Geodesy missions (Champ, GOCE, GRACE, GRACE FO, LAGEOS), mission description. Quantum technologies for space, quantum communication, quantum sensors.

Baseline principles and history of the exploration of the solar system (Voyager, Pioneer, Lunar exploration, Galileo); design and results of modern exploration missions (Dawn, Juno, Chandrayaan, Chang-e).

Learning outcomes / competencies / targeted competencies:
A number of theoretical prerequisites are provided in order to understand basics of satellite missions. A number of missions will be presented, with the mission scenario and the scientific outcome. The students learn about design and development principles of exploration missions of all kind.

Calculation of student workload:
28 h Preparation / follow-up work
34 h Exam preparation
28 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Science, Astronomy and Exploration Missions

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-GNSS: The Global Navigation Satellite System
The Global Navigation Satellite System

Assignment to areas of study:
- Specialization I / Elective Module

Content-related prior knowledge or skills:
Newtonian mechanics

Learning content:
Understanding of the working principles of global navigation satellite systems (GNSS).

This consists on (i) the physical requirements regarding the main working principles. Here the Earth's gravity field, satellite orbits, clocks, electromagnetic signal propagation in the Earth's atmosphere, and the targeted accuracy are discussed.
In the second step (ii) the theoretical analysis of the whole problem has to be carried through. This includes basic effects on moving clocks (special relativistic time dilation) and clocks in gravitational fields (gravitational redshift) and the calculation of the position from the clock signals. Moreover, theoretical concepts within geodesy regarding reference surfaces and coordinate systems such as WGS84 will be introduced.
In the third part (iii) the technological realization is studied.

Learning outcomes / competencies / targeted competencies:
Physical and theoretical principles of positioning, navigation, GNSS satellites, payloads, clocks; Technology requirements of GNSS operation; Scientific use of GNSS

Calculation of student workload:
28 h Preparation / follow-up work
28 h SWS / presence time / working hours
34 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
PD Dr. Eva Hackmann

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 24 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Module courses

Course: The Global Navigation Satellite System

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Literature:
Werner Mansfeld: Satellitenortung und Navigation. Grundlagen, Wirkungsweisen und Anwendung globaler Satellitennavigationssysteme. Vieweg, Wiesbaden 2010.
Manfred Bauer: Vermessung und Ortung mit Satelliten. Globale Navigationssysteme (GNSS) und andere satellitengestu¨tzte Navigationssysteme. Wichmann, Berlin 2011

B. Hoffmann-Wellenhof, H. Lichtenegger, and J. Collins: GPS - Theory and Practice, (Springer, Wien and New York, 2001)

N. Ashby “Relativity in the Global Positioning System”, Living Reviews in Relativity

P. Teunissen, O. Montenbruck “Springer Handbook of Global Navigation Satellite Systems”, Springer

B. Hoffmann-Wellenhoff, H. Lichtenegger, E. Wasle “GNSS – Global Navigation Satellite Systems”, Springer

ESA “GNSS data processing”, https://gssc.esa.int/navipedia/GNSS_Book/ESA_GNS S-Book_TM-23_Vol_I.pdf

Teaching format(s):
Lecture

Associated module examination:
Modulprüfung

Module 01-ET-MA-SAMS(a): Sensors and Measurement Systems
Sensors and Measurement Systems

Assignment to areas of study:
- Specialization I / Elective Module

Content-related prior knowledge or skills:
none

Learning content:
The class will cover fundamentals of sensor science starting at the underlying physical mechanisms, different sensor devices, and integrated sensor systems. Process technology used to fabricate sensors will be discussed.

The following sensors will be addressed:

• Thermal Sensors

• Force and Pressure Sensors

• Inertial Sensors

• Magnetic Sensors

• Flow Sensors

Reference:

Walter Lang: Sensors and Measurement systems, ISBN-10: 877022028X

Learning outcomes / competencies / targeted competencies:
Students will gain an overview on different sensor technologies that will enable them to select a particular sensor for a defined application. They will be able to understand the working mechanism of various sensors and to make suggestions on how to improve their performance. Furthermore, they will be able to understand and optimize the different processing steps of a complex sensor module.

Calculation of student workload:
56 h SWS / presence time / working hours
56 h Preparation / follow-up work
68 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr.-Ing. Björn Lüssem

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 24 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
- / - / -

Language(s) of instruction:
English

Description:
Anzahl der Prüfungsleistungen: 1

Module courses

Course: Sensors and Measurement Systems

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Literature:
Walter Lang: Sensors and Measurement systems, ISBN-10: 877022028X

Teaching format(s):
Lecture
Tutorial

Associated module examination:
Modulprüfung

Module 01-PHY-MA-RemS: Remote Sensing
Remote Sensing

Assignment to areas of study:
- Specialization I / Elective Module

Content-related prior knowledge or skills:
No formal requirements.

Learning content:
The course introduces the theoretical background of remote sensing methods (interaction of electromagnetic radiation with matter (spectroscopy), radiative transfer, principles of satellite remote sensing). Mostly passive (thermal emission, backscattered light) but also active (radar used in sea ice) remote sensing techniques and their data analysis (retrievals) are explained. This is illustrated by a large number of examples available and in use in the different research groups in the Institute of Environmental Physics (IUP).

A list of references will be provided in the course.

Learning outcomes / competencies / targeted competencies:
Basics of radiative transfer, spectroscopy, retrieval techniques. Overview of remote sensing from satellite, ground and airborne platforms in MW, IR and UV-VIS spectral range. Techniques in atmospheric remote sensing, sea ice remote sensing, ocean color remote sensing

Calculation of student workload:
28 h SWS / presence time / working hours
30 h Exam preparation
32 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. Astrid Bracher

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 20/21 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: combination exam

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / 1 / -

Language(s) of instruction:
English

Description:
Examination performance: written exam (or as announced by the respective lecturer)

Course performance: portfolio (series of exercise sheets or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Remote Sensing

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Teaching format(s):
Lecture
Tutorial

Associated module examination:
Kombinationsprüfung

Module 01-PHY-MA-SpTel: Space Telescopes
Space Telescopes

Assignment to areas of study:
- Specialization I / Elective Module

Content-related prior knowledge or skills:
Basic optics

Learning content:
Introduction of completed and planned space telescope missions, payloads and instruments

Possible space telescopes to be discussed are (i) Hubble Space Telescope, (ii) James Webb Space Telescope, (iii) Telescopes searching for Exo-planets such as Kepler or PLATO (iv) X-Ray telescopes such as Chandra, XMMNewton and Athena (v) Gamma-Ray Telescopes such as Fermi and INTEGRAL (vi) CMB observatories such as Planck (vii) LISA for the observation of gravitational waves

The aim is to discuss for each Space Telescope

- the science objectives of the mission,
- the mission scenario and operational aspects,
- the design of the telescope and requirements driving the design,
- the instruments and the underlying technologies.

References:

- Max Born, Emil Wolf: Principles of Optics

Learning outcomes / competencies / targeted competencies:
- Understand the basic aspects of science cases for several space telescopes
- Learn about mission scenarios for completed, ongoing and planned space telescopes operating in various regions of the electromagnetic spectrum
- Learn about operation principles and technological aspects of space telescope payloads

Calculation of student workload:

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 20 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Announcement at the beginning of the semester

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Space Telescopes

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Teaching format(s):
Lecture

Associated module examination:
Modulprüfung

Module 01-PHY-MA-RingSp: Fascination Space
Fascination Space

Assignment to areas of study:
- Specialization I / Elective Module

Content-related prior knowledge or skills:
none

Learning content:
Overview over a number of actual topics in space sciences and fundamental physics

- Global biochemical cycles of elements, important biophysical processes in atmosphere and ocean, carbon-, methane-, nitrogen and water cycle, greenhouse gases
- Quantum technologies in space
- Test of the Equivalence principle
- The Pioneer Anomaly
- Satellite based geodesy
- Clocks in space – fundamental physics and practical applications
- Exoplanets
- Asteroids

Learning outcomes / competencies / targeted competencies:
Overview over a number of actual topics in space sciences

Calculation of student workload:
30 h Exam preparation
28 h SWS / presence time / working hours
32 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. Annette Ladstätter-Weißenmayer

Frequency:
summer semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 26 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
- / - / -

Language(s) of instruction:
English

Module courses

Course: Fascination Space

Frequency:
summer semester, yearly

Language(s) of instruction:
German

Contact hours:
2,00

Teaching format(s):
Lecture

Associated module examination:
Kombinationsprüfung

Module 01-PHY-MA-InternThs: Internship for Thesis
Internship for Thesis

Assignment to areas of study:
- Specialization II / Compulsory Modules

Content-related prior knowledge or skills:
54 CPs including all compulsory modules from the 1st and 2nd semester are required for the start of the internship.

Learning content:
Together with the student, a sub-topic of the respective discipline is selected, which represents a contribution to current research work. After getting familiar with the literature, the students present a scientific question derived from the topic with a work plan, which is then intensively discussed and agreed upon. The main part is the processing. The work includes as many typical subject-related working techniques as possible. The focus is set according to the students' abilities and depending on the topic. The results are presented in a research report.

Learning outcomes / competencies / targeted competencies:
The students should be able to define a scientific question based on an outlined topic, to define a scientific question, derive hypotheses from it and develop a work plan to confirm or refute these hypotheses or disprove these hypotheses with suitable experiments. Furthermore, they should learn to write a research report in a structured, comprehensible and linguistically appropriate manner.

Calculation of student workload:
120 h SWS / presence time / working hours
30 h Exam preparation
30 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. Annette Ladstätter-Weißenmayer

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Project report

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Internship for Thesis

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Teaching format(s):
Laboratory class

Associated module examination:

Module 01-PHY-MA-GR: General Relativity
General Relativity

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
Knowledge of Special Relativity

Learning content:
Incompatibility of Newtonian Gravity and Special Relativity, Equivalence Principle, differential geometry and spacetime structure, geodesic equation, Einstein field equation, Newtonian limit, Schwarzschild metric, relativistic effects on particles and light, interior Schwarzschild solution, black holes, gravitational waves

Learning outcomes / competencies / targeted competencies:
Physical understanding of general relativistic theory from its basic concepts to modern applications, competent application of mathematical techniques and equations

Calculation of student workload:
56 h Preparation / follow-up work
84 h SWS / presence time / working hours
130 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Dr. Eva Höne

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 24/25 / -

Credit points / Workload:
9 / 270 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
See description

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Description:
written or oral examination

Module courses

Course: General Relativity

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
6,00

Literature:
Sean Carroll “Spacetime and Geometry: Introduction to General Relativity”
B. Schutz: “A first course in General Relativity”
C. Misner, K. Thorne, J. Wheeler: “Gravitation”
S. Chandrasekhar ”The mathematical theory of black holes”

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-BH: Black Holes
Black Holes

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
Basic knowledge of the general theory of relativity

Learning content:
Introduction of black hole solutions of the Einstein field equation (Schwarzschild, Kerr, etc), spherically symmetric Black Holes, uniqueness theorems, introduction of various coordinate systems (e.g. Eddington-Finkelstein, Kruskal-Szekeres), definition of event horizons, definition of spherical and axial symmetries in space-times, Killing vectors, analytical extension of Black Hole space-times, effects on light rays and particle motion in Black Hole space-times, observation scenarios of Black Holes (e.g. via light effects, stellar orbits, shadows, gravitational waves, accretion disks)

Learning outcomes / competencies / targeted competencies:
Students understand the physical and mathematical properties of Black Holes. They are able to calculate important effects relevant for observations, in particular related to light rays and particle trajectories

Calculation of student workload:
56 h SWS / presence time / working hours
68 h Exam preparation
56 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Module courses

Course: Black Holes

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Literature:
Ch. W. Misner, K. S. Thorne, and J.A. Wheeler: „Gravitation“
S. Chandrasekhar ”The mathematical theory of black holes”
I. Novikov and V. Frolov: „Physics of Black Holes - Basic Concepts and New Developments“
O’Neill: “The Geometry of Kerr Black Holes”

Teaching format(s):
Lecture
Tutorial

Associated module examination:

Module 01-PHY-MA-QTSP: Quantum Technologies in Space
Quantum Technologies for Space

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
Bachelor, Quantum Mechanics, Atomic Physics

Learning content:
Overview of quantum technologies with application in space.
This requires a short repetition of

- the postulates of quantum mechanics
- in particular of the measurement process with its statistical interpretation
- atomic physics, atomic energy level structures, atom light interaction

The technologies include

- laser cooling
- laser sources and technology
- neutral atom traps
- evaporative coolingatom interferometry
- ion traps and atomic clocks
- quantum key distribution

Each of these will be described in some detail. Finally the space
condition and operation will be discussed

- exploiting large gravitational potential differences and microgravity
- technical boundaries of quantum experiments on space-based platforms: operations, automization, data management

Learning outcomes / competencies / targeted competencies:
basic understanding of operating principles of quantum sensors, atomic clocks and other quantum technologies, understanding the quantum advantage of these instruments, understanding the specific benefit of space-based operation, as well as of boundary conditions in space-based operation

Calculation of student workload:
28 h Preparation / follow-up work
34 h Exam preparation
28 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
PD Dr. rer. nat. Sven Herrmann

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 24/25 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Quantum Technologies for Space

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Additional comments:
Lernziele de

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-GeoGra: Geodesy and Gravity
Geodesy and Gravity

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
none

Learning content:

Classical geodesy

- Repetition of Newtonian gravitational theory
- Multipole moments of the Earth and the gravitational field of the Earth
- Definition of the geoid on the rotating Earth
- Equation of motion for satellites
- Calculation of satellite orbits
- Description of orbits for satellite formation flight and extraction of the gravitational field

Relativistic geodesy

- Elements of relativistic gravity theory
- Post-Newtonian solution for the gravitational field of the Earth
- Definition of the geoid
- Clocks in the gravitational field: clock geodesy
- Relativistic satellite orbits, basic effects

Learning outcomes / competencies / targeted competencies:
The students gain knowledge of notions of nonrelativistic gravity theory, knowledge of basic notions of geodesy, an understanding of methods to measure the gravitational fields, knowledge of basic principles of relativistic gravity and an understanding of clock geodesy.

Calculation of student workload:
20 h Exam preparation
28 h SWS / presence time / working hours
42 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 24 / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:
Announcement at the beginning of the semester

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
- / - / -

Language(s) of instruction:
English

Description:
Gemäß MPO-Space-ST-02-24, Anzahl Prüfungsleistung: 1

Module courses

Course: Geodesy and Gravity

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Teaching format(s):
Lecture

Associated module examination:
Modulprüfung

Module 01-PHY-MA-CelMe: Celestial Mechanics
Celestial Mechanics

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
Bachelorstudium Mathematik/Physik o.ä

Learning content:
Basics of celestial mechanics, Keplerian laws, Kepler equation, orbital elements, one-body problem, two-body problem, three-body problem (special cases, libration points), multi-body problems, conservation laws, spaceflight mechanics, estimation of orbital elements

Learning outcomes / competencies / targeted competencies:
The students get to know the basics of classical (non-relativistic) celestial mechanics and some basic calculation methods.

Calculation of student workload:
68 h Exam preparation
56 h SWS / presence time / working hours
56 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Dr. Marco Scharringhausen

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
WiSe 22/23 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Oral examination (single)

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English / German

Module courses

Course: Celestial Mechanics

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Teaching format(s):
Lecture

Associated module examination:

Module 01-PHY-MA-PCSS: Philosophy of Cosmology, Space and Space Travel
Philosophy of Cosmology, Space and Space Travel

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
None

Learning content:
This course covers philosophical questions about cosmology and about the exploration of terra incognita related to space. First, we cover the meaning of exploration for mankind in general (exploration of new territories as well as of laws of the physical world and laws in general). Second, we specialize to questions related to space: What is the idea behind a finite or infinite world? What does the exploration of space mean for the “position” of mankind within the Universe, for the world view of human beings? What would it mean for mankind if the search for extraterrestrial life will be successful? In what sense can cosmology missions “uncover” the dynamics of the universe from the Big Bang to the far future? What concept of time is involved here and what counts as evidence and why?

Learning outcomes / competencies / targeted competencies:
• Knowledge of basic notions from the philosophy of the natural sciences (natural law, space, time, infinity, …)

• Basic insights into the aims of scientific inquiry and the generation of scientific knowledge (by means of examples from the history of cosmology)

• Ideas involved in human self-understanding related to “other worlds” or extraterrestrial life

• Basic knowledge of cosmology.

Calculation of student workload:

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
- / -

Credit points / Workload:
3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
English

Module courses

Course: Philosophy of Cosmology, Space and Space Travel

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
2,00

Literature:
Will be announced at the beginning of the course.

Teaching format(s):
Seminar

Associated module examination:
Modulprüfung

Module 01-ET-MA-ComSp: Communication Technologies for Space
Communication Technologies for Space

Assignment to areas of study:
- Specialization II / Elective Modules

Content-related prior knowledge or skills:
Basics in linear algebra, calculus, differential equations, fourier transformation and physics (basics in electromagnetic waves) are recommended.

Learning content:
- Introduction to communications: history of wireless communication and space communication
- Basic concepts and terminology in communications
- Recap of Fourier transformation
- Introduction to system theory (signals, linear time invariant systems, convolution, statistic process, etc.)
- Passband-Baseband transformation and receiver concepts
- Wireless channel basics (linear and non-linear distortions, noise, Nyquist, etc.)
- Analog modulation
- Basics in sampling theory and discrete systems and signals
- Digital modulation
- Introduction to channel coding

Learning outcomes / competencies / targeted competencies:
As outcome, the students should be able to:

- explain basic communications concepts and theoretical foundations;
- apply mathematical tools and concepts relevant in communications;
- explain and apply analog and digital modulation.

Calculation of student workload:
56 h Self-study
68 h Exam preparation
56 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:
English

Responsible for the module:
Dr.-Ing. Carsten Bockelmann

Frequency:
winter semester, yearly

Duration:
1 semester[s]

The module is valid since / The module is valid until:
SoSe 20 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:
Written examination

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
- / - / -

Language(s) of instruction:
English

Description:
Gemäß MPO-Space-ST-02-24, PL:1

Module courses

Course: Communication Technologies for Space

Frequency:
winter semester, yearly

Language(s) of instruction:
English

Contact hours:
4,00

Teaching format(s):

Associated module examination:
Modulprüfung

Module 01-PHY-MA-ThsMSc-SpaceST-DD: Master Thesis (incl. Colloquium)

Master Thesis (incl. Colloquium)

Assignment to areas of study:

- Master Thesis

Content-related prior knowledge or skills:

78 CPs including all compulsory modules and the internship as well as the amount of elective courses of 18 CPs are required for the registration of the master thesis.

Learning content:

The content is related to the respective area of research of the Master's Thesis.

Learning outcomes / competencies / targeted competencies:

• Transfer of a scientific problem/question into an experimental and/or theoretical study
• Successful strategies for the planning and conducting of scientific studies
• Ability for a critical evaluation, assessment and discussion of own scientific results
• Summarize and present scientific results in a Master's Thesis

Calculation of student workload:

900 h Self-study

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Annette Ladstätter-Weißenmayer

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

30 / 900 hours

Module examinations

Module examination: Colloquium

Type of examination:

Form of examination:

Colloquium

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

German

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Module examination: Masterthesis

Type of examination:

Form of examination:

The examination is ungraded?
no

Number of graded components / ungraded components / prerequisites of the examination:
- / - / -

Language(s) of instruction:
German

Module courses

Course: Master Thesis

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
0,00

Teaching format(s):

Associated module examination:
Masterthesis

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Course: Colloquium

Frequency:
summer semester, yearly

Language(s) of instruction:
English

Contact hours:
0,00

Teaching format(s):

Associated module examination:
Colloquium