

Faculty of Physics and Astronomy

Preliminary modul manual

Master of Science (M.Sc.) in Physics

PO 2021

Ruhr-Universität Bochum

Warning: Preliminary version, changes may still apply!

The Master of Science in Physics programme has a standard period of study of 4 semesters and a total of 120 credit points (CP). The study programme is divided into different areas. Compulsory modules amounting to 60 CP cover the subject-specific and interdisciplinary preparation and execution of the final thesis. The compulsory elective area includes in-depth modules from experimental and theoretical physics (15-36 CP) as well as diverse modules from the minor subject (5-18 CP). For the specialisation, courses amounting to 15-25 CP must be chosen in one subject area (astronomy/astrophysics, biophysics, solid state physics, nuclear and particle physics, plasma physics). In the area of key competences, further modules of up to 10 CP can be selected. A list of the approved modules can be found in this module handbook.

The division of the 120 CP to be completed into the modules in the physics degree programme is illustrated in the following table (see end of document for full size).



This overview is structured as follows:

- 1. counselling and information services
- 2. study plan
- 3. modularisation concept and examination forms
- 4. list of individual compulsory and elective modules

1. Counselling and information services at the Faculty of Physics and Astronomy

If you have any questions in connection with the subject of physics, please contact the student advisory service for physics. They offer appointments five days a week. There are no regular office hours, so you must make an appointment in person, by phone or by e-mail in advance.

Our student advisors for the Master's programme in Physics:

| Dr. Ivonne Möller (General Questions) | Dr. Andreas Kreyssig (for International Students |
|---------------------------------------|--|
| NB 02/172 | NB 4/ |
| Fon.: +49(0)234-32-29105 | Fon.: +49(0)234-32 |
| master-international@physik.rub.de | master-international@physik.rub.de |

Before starting their studies, every student must attend a counselling appointment. In addition to individual appointments, group appointments are also offered. The students are informed about the appointments by e-mail.

General information and forms are provided in the Moodle course "Physics Study Info". After enrolment all students get access to the course.

2. Study plan:

| Modul | Description | Semester | Exam |
|-----------------------|---|----------|--|
| Modul 1.x 9 -18 CP | One (or two) elective module(s) from one of the following subject areas from experimental physics: astrophysics, biophysics, solid state physics, nuclear and particle physics or plasma physics. Each module consists of a lecture with exercise as well as experiments from the advanced practical course from the respective subject area. | 1.+2. | graded, the partial performances achieved are weighted with the CP in the module grade. One module from 1a to 1e (of choice) must be completed. A further module can be taken. |
| Modul 2.x 6 -12 CP | One (or two) module(s) from "Statistical Physics", "Advanced Quantum Mechanics" and "General Theory of Relativity | 1.+2. | Graded, via a module final examination or an oral examination. One module from 2a to 2c (at choice) must be completed. A further module can be taken. Graded, the partial performances achieved are weighted with the CP in the module grade. |
| Modul 3.x 0-12 CP | One (or two) elective module(s) from one of the following subject areas from experimental physics: astrophysics, solid state physics or plasma physics. Each module consists of a lecture with exercises. | 1.+2. | Graded, the partial performances achieved are weighted with the CP in the module grade. One or two module(s) from 3a to 3c (at choice) can be completed. |
| Modul 4.x 15-25 CP | One compulsory elective module from one of the following subject areas: Astrophysics, Biophysics, Solid State Physics, Nuclear and Particle Physics or Plasma Physics. Courses from experimental and/or theoretical physics from the respective subject area can be selected | 3.+4. | Graded, via a final oral module examination (2 CP). A seminar (2 CP) and practicals (advanced lab work) (min. 5 CP) must be proven. |

| Modul 5.x 5-18 CP | Elective modules of 5- 18 CP from the catalogue of minor subjects (e.g. mathematics, chemistry, geosciences, ICAMS, neuroscience, engineering science). A complete list of all modules can be found further on in the module handbook. | 14. | Graded, via a final module examination, final oral module examination, seminar lecture, study-related exercises and active participation, protocols, practical exercises or homework. |
|----------------------|--|-------|--|
| Modul 6.x 0-10 CP | Elective modules in the amount of 0-10 CP from the area of key competences | 2.+3. | Graded, via a module final examination, oral module final examination, seminar lecture, study-related exercises and active participation, protocols, practical exercises or term paper. |
| Modul 7 5 CP | Projektmanagement | 1.+2. | ungraded, via active participation |
| Modul 8 15 CP | Methodology and Project Planning (M.Sc.) | 3. | ungraded, via active participation |
| Modul 9 15 CP | Project seminar for the Master's thesis | 3.+4. | graded, via active participation and seminar talk |
| Modul 10 30 CP | Master thesis | 3.+4. | graded, via two expert reports |

3. Modularisation concept and forms of examination:

Examinations can take the form of a written examination, an oral examination, a seminar paper, a presentation, a term paper, a written report, a project, a practical exercise or a tutorial. The form of examination for each module can be found in the module descriptions. In the case of alternative options, a form of examination is determined by the lecturer at the beginning of the module.

All modules are completed with an examination. The compulsory modules "Project Management" and "Methodological Knowledge and Project Planning" remain ungraded. All graded modules are weighted with the CP in the final grade.

The "focus module" (compulsory elective modules 4.a to 4e) concludes with an oral examination, which is credited with 2 CP. The following applies to all courses in the specialisation module: semester hour per week = CP.

The current range of courses offered by the Faculty of Physics and Astronomy can be found in CampusOffice.

All examinations at the Faculty take place in fixed examination periods. The first examination period is at the end of the lecture period, the second at the end of the lecture period.

4. List of all modules:

Modul 1 (Wahlpflichtmodule aus der Experimentalphysik)

| • | Modul 1a Einführung in die Astrophysik | 6 |
|---|---|---|
| | Modul 1b Einführung in die Biophysik | |
| | Modul 1c Einführung in die Festkörperphysik | |
| | Modul 1d Einführung in die Kern- und Teilchenphysik | |
| | Modul 1e Einführung in die Plasmaphysik | |

Modul 2 (Wahlpflichtmodule aus der Theoretischen Physik)

| ٠ | Modul 2a Allgemeine Relativitätstheorie | 13 |
|---|---|----|
| • | Modul 2b Quantenmechanik II | 14 |
| • | Modul 2c Statistische Physik | 15 |

Modul 3 (Wahlmodule aus der Theoretischen Physik)

| • | Modul 3a Einführung in die theoretische Astrophysik | .16 |
|---|--|-----|
| • | Modul 3b Einführung in die theoretische Festkörperphysik | .18 |
| • | Modul 3c Einführung in die theoretische Plasmaphysik | .20 |

Modul 4 (Wahlpflichtmodule für den Schwerpunkt)

| • | Modul 4a Astrophysik | 21 |
|---|-----------------------------------|----|
| | Modul 4b Biophysik | |
| | Modul 4c Festkörperphysik | |
| | Modul 4d Kern- und Teilchenphysik | |
| | Modul 4e Plasmaphysik | |
| | | |

Modul 5 (Wahlpflichtmodule für das Nebenfach)

| • | Angebot aus der Fakultät für Chemie und Biochemie | 29 |
|---|---|----|
| | Angebot aus der Fakultät für Geowissenschaften | |
| | Angebot aus der Fakultät für Elektrotechnik und Informationstechnik | |
| | Angebot aus der Fakultät für Maschinenbau | |
| | Angebot aus der Fakultät für Mathematik | |
| | Angebot aus dem Institut für Neuroinformatik | |
| • | Angebot aus dem ICAMS | 32 |

Modul 6 (Wahlmodule für den Bereich Schlüsselkompetenzen)

| • | Modul 6a Computational Physics I | 33 |
|---|-------------------------------------|----|
| | Modul 6b Computational Physics II | |
| • | Modul 6c Scientific English | 35 |
| • | Modul 6z Liste mit weiteren Modulen | 36 |

Pflichtmodule

| • | Modul 7 Projektleitung | 38 |
|---|---|----|
| | Modul 8 Methodenkenntnis und Projektplanung (M.Sc.) | |
| | Modul 9 Projektseminar zur Masterarbeit | |
| • | Modul 10 Masterarbeit | 41 |

| Module 1a | Credits | Workload | Semester | Cycle | Duration |
|-----------------------------------|-----------------------------|-------------------|--------------------------------|---------------------|-------------------------|
| | 9 CP | 270 h | from 1. Sem. | Summer Term | 1-2 Semesters |
| Courses | | | Contact Hours | Self Study | Group Size |
| a) Lecture Intr | oduction to | | a) 44 h | 183 h | Students |
| Astrophysic | | | b) 22 h | | a) unbegrenzt |
| b) Exercises fo | <mark>r Introduction</mark> | <mark>i to</mark> | c) 21 h | | b) 30 |
| <mark>Astrophysic</mark> | | | | | c) 2 |
| c) Advanced L | • | | | | |
| | Three experi | | | | |
| Astrophysic | s/Astronomy) | | | | |
| | | | | | |
| Requirements | for Participat | ion | | | |
| Formal: none | | | | | |
| Content-Wise: | Basic knowle | dge of Physics I- | III (Bachelor) are h | nighly appreciated | |
| Preparation: n | one | | | | |
| Learning Outco | omes | | | | |
| • | | g this module, th | ne students | | |
| | | - | | elds of modern n | nulti-wavelength and |
| | nessenger ast | | | | - |
| are abl | le to apply the | e different metro | ological and mode | lling methods of a | strophysics to simple |
| examp | les. | | - | - | |
| analyse | e and evaluate | e relevant scien | tific contents and | communicate the | m in a differentiated |
| manne | er, both orally | and written. | | | |
| know a | and motivate t | the significance | of physics and ast | ronomy for societ | y and the importance |
| of inte | rnationally co | operative resea | rch. | | |
| Contents | | | | | |
| Methods and | results of asti | rophysics are in | troduced using se | elected observation | onal phenomena and |
| presented in c | onnection wit | th the results fr | om current resea | rch. The topics ta | ught include, among |
| others: Basics | of observatior | nal cosmology, s | structure formatio | on in the cosmos, a | active galactic nuclei, |
| | | | | | ellar dynamics, state |
| variables of sta | ars, solar neut | rinos, phases of | the interstellar m | nedium, accretion | disk physics, pulsars. |
| | - | | entific computing a | and programming | skills are acquired on |
| the basis of cor | ncrete probler | ms. | | | |
| | <u> </u> | <u> </u> | | | |
| | | | tical Exercises (Lab | | - f f |
| | | | | | e form of examination |
| - | | | | | ertificate with week |
| | | | | cture. The advance | ed laboratory course i |
| | | ises and protoco | | | <u> </u> |
| • | | | • | | form of examination |
| - | | | - | • | points in the week |
| | | | | | e form of examinatio |
| | - | - | | | atory course must b |
| | mpleted. Both | n grades go into | the module grade | with the CP-weig | hted. |
| successfully co | | | | | |
| | he Module Co | ompulsory-Elect | ive Module | | |
| Utilisation of t | | | ive Module Weighed accordin | g to credit points | |
| Utilisation of t Importance of | the Mark for | | Weighed accordin | g to credit points | |

| Introduction | Introduction to Biophysics | | | | | | |
|----------------------------|--|--------------------------|---------------------|------------------------|----------------------|--|--|
| Module 1b Credits Workload | | | Semester | Cycle | Duration | | |
| 9 CP 270 h | | from 5. Sem. | Winter Term | 1-2 Semesters | | | |
| Courses | | | Contact Hours | Self Study | Group Size | | |
| a) Lecture Intro | duction to Bio | ophysics | a) 44 h | 183 h | Studierende | | |
| b) Exercises for | | | b) 22 h | | a) unbegrenzt | | |
| c) Advanced La | boratory Cour | ses for | c) 21 h | | b) 30 | | |
| | ree experimer | nts in | | | c) 2 | | |
| Biophysics) | | | | | | | |
| Requirements f | ro Participatio | n | | | | | |
| Formal: none | | | | | | | |
| | | ge in Physics I-II | l (Bachelor) will t | be highly appreciated | 1 | | |
| Preparation: no | | | | | | | |
| Leaning Outcom | | | | | | | |
| After successful | | | | | | | |
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| | | | - | m experimental and | | | |
| reactions | xamination of | Diological system | ins, and they car | use them to describ | e equilibriums and | | |
| | ar with the ha | sic physical met | hods for examini | ng molecular biolog | ical processes | | |
| | | | | biophysical experim | | | |
| | s in the scient | | | siophysical experim | | | |
| | | | search topics of | molecular biophysics | s at Ruhr-University | | |
| Bochum | 0 | | | . , | , | | |
| can acqui | re relevant sci | entific contents | , theories, and n | nethods, both guided | d and independent, | | |
| | | | both orally and | | | | |
| | | | | | | | |
| | | | | | | | |
| Contents | | | | | | | |
| | - | ter: from the ato | om to the protei | n | | | |
| - Spectroscopi | | c | | | | | |
| | - | | | tallography, NMR, el | ectron microscopy) | | |
| - Fundamenta | is of reaction i | kinetics and elec | trochemistry | | | | |
| Format of Teach | ninglecture F | xercises Practic | al Exercises (Lah | oratory Course) | | | |
| | | | | | form of examination | | |
| | | 0 0 | - | | tificate with weekly | | |
| | | | | | laboratory course is | | |
| | • • | | • | | | | |
| charmed via pr | examined via practical exercises and protocols. | | | | | | |
| Requirements f | or the attribu | tion of Credit F | Points Dependin | g on the specified for | orm of examination: | | |
| | | | | | points in the weekly | | |
| - | | | - | so compulsory. The f | • | | |
| | - | - | | | ory course must be | | |
| | - | - | | with the CP-weight | - | | |
| | Utilisation of the Module Compulsory-Elective Module | | | | | | |
| Importance of t | he Mark for t | ne Final Mark W | /eighed accordin | g to credit points | | | |
| Module Supervi | isor and Instru | ictor Prof. Dr. G | erwert, Prof. Dr. | Hofmann | | | |
| Further Informa | Further Information | | | | | | |
| | | | | | | | |

| Module 1c | Credits | Workload | Semester | Cycle | Duration |
|---|--|---|--|--|--|
| | 9 CP | 270 h | from 5. Sem. | Winter Term | 1-2 Semesters |
| Courses | | - | Contact Hours | Self Study | Group Size |
| a) Lecture Inti | oduction to So | <mark>olid</mark> | a) 44 h | 183 h | Students |
| <mark>State Physic</mark> | <mark>cs I</mark> | | b) 22 h | | a) unlimited |
| b) Exercises fo | r Introduction | to Solid | c) 21 h | | b) 30 |
| <mark>State Physic</mark> | <mark>cs I</mark> | | | | c) 2 |
| c) Advanced L | aboratory Cou | irses for | | | |
| Physicists (1 | hree experime | ents in | | | |
| solid state p | physics) | | | | |
| | Basic knowle | | III (Bachelor) will t | pe highly apprecia | ited |
| Preparation: n | | | | | |
| macro Are av electro at leas Know Are av Can se | scopic and mic vare of the p onic properties t a qualitive u the fundamen vare of scatter e and apply re | croscopic charac ossibilities of the of solid state r nderstanding of tal concepts of a ing phenomena | teristics of solid s ne general concep natter from the b those concepts applying quantum in the position an atomic and solid | tate matter ots to derive the asic methods of p mechanics to sol ad momentum spa | |
| (ideal crysta phenomena Dynamics o (lattice osc scattering e Electrons in (Classical fr conductors of band gap and faults, (klassisches Eigenschaft experiment | als, misorder, r a) f the crystallin illations, phon experiments) solid state ma ee electron ga metallic bonc os, semi-condu on-junction freies Elektr en von Leiter elle Bestimmu | e lattice ions, Bose-Einst atter as, Fermi-Dirac- ling, charges in r ictors, thermal e onengas, Fermi n, metallische ing der Bandlück | , determining crys ein-distribution, f Distribution, elect magnetic fields, ba excitation of charg i-Dirac-Verteilung Bindung, Ladungs | thermal propertie tric conductivity, and model, experi ges, effective mas , elektrische Leit sträger im Magne ermische Anregun | via diffraction, bonding es of non-conductors, thermal properties of mental determination s, conducting by holes cfähigkeit, thermische etfeld, Bändermodell, g von Ladungsträgern, |
| | | | ical Exercises (Lab | | |
| (written exam | ination of 90 dactive partici | min, oral exam pation in the ex | ination of 45 mir ercises) for the lee | n or an exercise of | he form of examinatio certificate with weekl red laboratory course |

Requirements for the attribution of Credit Points Depending on the specified form of examination: Passing the written/oral examination or obtaining at least 50% of the possible points in the weekly exercises. In this case, active participation in the exercise is also compulsory. The form of examination is determined at the beginning of the course. In addition, the advanced laboratory course must be successfully completed. Both grades go into the module grade with the CP-weighted.

Utilisation of the Module Compulsory-Elective Module

Importance of the Mark for the Final Mark Weighed according to credit points

Module Supervisor and Instructor Prof. Dr. Böhmer

| Module 1d | Credits | Workload | Semester | Cylce | Duration |
|---|---|--|---|---|---|
| | 9 CP | 270 h | from 5. Sem. | Winter Term | 1-2 Semesters |
| Courses a) Lecture Int | roduction to N | luclear and | Contact Hours a) 44 h | Self Study 183 h | Group Size Students |
| Particle Phy | | | b) 22 h | | a) unlimited |
| | r Introduction | <mark>i to Nuclear</mark> | c) 21 h | | b) 30 |
| and Particle | e Physics I | | | | c) 2 |
| c) Advanced L | aboratory Cou | urses for | | | |
| Physicists (| three experime | ents in | | | |
| nuclear and | l particle phys | ics) | | | |
| Requirements | for Participat | ion | | | |
| Formal: none | Knowladge | f Dhusies I III (De | cholor) will be over | a a t a d | |
| Preparation: r | - | T Physics I-III (Ba | chelor) will be exp | Dected | |
| • | | | | | |
| Learning Outo | | - 41-: | | | |
| | , , , | g this module, th | | attan and its int | have the second shall a |
| | a basic under pactivity | rstanding of the | e structure of m | atter and its in | teractions as well a |
| | • | ossible applicat | tions of nuclear | nhysical process | es in technology an |
| | licine | | | | es in teenhology and |
| | | | | | |
| | the fundamen | tal concepts of e | electromagnetic, v | veak, and strong i | interaction |
| • know | | | electromagnetic, v | - | |
| knoware fail | miliar with gen | ieral measureme | ent techniques and | methods and ca | |
| know are fail and | niliar with gen disadvantages | ieral measurements of nuclear phys | ent techniques and ical and radioactiv | l methods and car ve processes | n evaluate advantage |
| know are fai and see co | niliar with gen disadvantages rrelations bety | eral measureme s of nuclear phys ween processes | ent techniques and ical and radioactiv in the universe an | l methods and ca ve processes d in nuclear and j | n evaluate advantage particle physics |
| know are fai and see co | niliar with gen disadvantages rrelations bety | eral measureme s of nuclear phys ween processes | ent techniques and ical and radioactiv in the universe an | l methods and ca ve processes d in nuclear and j | n evaluate advantage |
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| know are far and see co can ev | niliar with gen disadvantages rrelations bety | eral measureme s of nuclear phys ween processes | ent techniques and ical and radioactiv in the universe an | l methods and ca ve processes d in nuclear and j | n evaluate advantage particle physics |
| know are far and see co can ex | niliar with gen disadvantages rrelations betw aluate the pla | eral measureme s of nuclear phys ween processes ce into context t | ent techniques and ical and radioactiv in the universe an the results of nucle | d methods and car ve processes d in nuclear and p ear physical and r | n evaluate advantage particle physics adioactive processes |
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| know are far and see co can ev Contents Nuclear physic model of part | niliar with gen disadvantages rrelations betv aluate the pla s processes in icle physics, st | the universe, str tructure and des | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atom | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics |
| know are far and see co can ex Contents Nuclear physic model of part interaction of | niliar with gen disadvantages rrelations betv aluate the pla s processes in icle physics, st ponds with ma | the universe, str tructure and detect | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis n, introduction to | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory |
| know are far and see co can ev Contents Nuclear physic model of part interaction of processes of | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an | the universe, str tructure and detected d electroweak | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatte | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis h, introduction to ering and decay | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl |
| know are far and see co can ev Contents Nuclear physic model of part interaction of processes of accelerators, and | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of | the universe, str tructure and detected d electroweak nuclear and part | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatter cicle physics in tech | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis h, introduction to ering and decay | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl |
| know are far and see co can ev Contents Nuclear physic model of part interaction of processes of accelerators, and | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of | the universe, str tructure and detected d electroweak | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatter cicle physics in tech | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis h, introduction to ering and decay | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl |
| know are far and see co can ev Contents Nuclear physic model of part interaction of processes of accelerators, a radiation exponential | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of sure, evaluatio | the universe, str the universe, str tructure and detected d electroweak nuclear and part on of experimen | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatter cicle physics in tech | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p c nuclei, relativis n, introduction to ering and decay nnology and medi | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl |
| know are far and see co can ex Contents Nuclear physic model of part interaction of processes of accelerators, a radiation expose Format of Tea | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of sure, evaluations ching Lecture, | the universe, str tructure and detect d electroweak nuclear and part on of experimen | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatte ticle physics in tech ts. | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p ic nuclei, relativis h, introduction to ering and decay nnology and medi | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl cine, radioactivity and |
| know are far and see co can ev Contents Nuclear physic model of part interaction of processes of accelerators, a radiation exponent Format of Tea | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of sure, evaluation ching Lecture, mination At th | the universe, str the universe, str tructure and detect d electroweak nuclear and part on of experimen Exercises, Pract | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatte ticle physics in tech ts. | d methods and car ve processes d in nuclear and p ear physical and r rom elementary p ic nuclei, relativis n, introduction to ering and decay nnology and medi oratory Course) urer determines t | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl cine, radioactivity and he form of examinatio |
| know are far and see co can ex Contents Nuclear physic model of part interaction of processes of accelerators, a radiation expose Format of Tea Format of Example (written example) | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of sure, evaluation ching Lecture, mination At th ination of 90 | the universe, str the universe, str tructure and detected d electroweak nuclear and part on of experimen Exercises, Pract min, oral exam | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatte cicle physics in tech ts. <u>ical Exercises (Lab</u> he course, the lect ination of 45 min | a methods and car ve processes d in nuclear and p ear physical and r rom elementary p ic nuclei, relativis n, introduction to ering and decay nnology and medi orratory Course) urer determines t | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory |
| know are far and see co can ex Contents Nuclear physic model of part interaction of processes of accelerators, a radiation export Format of Tea Format of Example (written example | niliar with gen disadvantages rrelations betw aluate the pla s processes in icle physics, st ponds with ma the strong an pplications of sure, evaluation ching Lecture, mination At th ination of 90 d active partici | the universe, str the universe, str tructure and detected d electroweak nuclear and part on of experimen Exercises, Pract min, oral exam | ent techniques and ical and radioactiv in the universe an the results of nucle ucture of matter f scription of atomi ors based on them interaction, scatte ticle physics in tech ts. ical Exercises (Lab ne course, the lect ination of 45 min ercises) for the lect | a methods and car ve processes d in nuclear and p ear physical and r rom elementary p ic nuclei, relativis n, introduction to ering and decay nnology and medi orratory Course) urer determines t | n evaluate advantage particle physics adioactive processes particles - the standar tic heavy ion physics quantum field theory experiments, particl cine, radioactivity and he form of examination certificate with week |
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Utilisation of the Module Compulsory-Elective Module

Importance of the Mark for the Final Mark Weighed according to credit points

Module Supervisor and Instructor Prof. Dr. Wiedner

| Modul 1e | Credits | Workload | Semester | Cycle | Duration |
|--|---|---|---|--|---|
| | 9 CP | 270 h | from 4. Sem. | Summer Term | 1-2 Semesters |
| Courses | | | Contact Hours | Self Study | Group Size |
| a) Lecture Int | troduction to P | <mark>Plasma Physics I</mark> | a) 44 h | 183 h | Students |
| | or Introduction | <mark>n to Plasma</mark> | b) 22 h | | a) unlimited |
| Physics I | | _ | c) 21 h | | b) 30 |
| - | Laboratory Co | | | | c) 2 |
| physicists (| (three experim | ents in plasma | | | |
| physics | | | | | |
| Requirement | s for Participat | tion | | | |
| Formal: none | • | | | | |
| Content-Wise | : Knowledge c | of Physics I-III (Ba | chelor) will be ap | preciated | |
| Preparation: | none | | | | |
| Learning Out | comes | | | | |
| After success | fully completin | g this module, th | e students | | |
| Have | a basic unders | standing of the ir | nportant characte | eristics of a plasma | a and of the forms of |
| descr | ibing of plasma | a in the single pa | rticle model, and | of the kinetic and f | fluid description |
| | • | | | • | heir locking concepts |
| | | • • | olasma equilibriur | n | |
| | | e dynamics of pla | | | |
| | ee correlation | s between plasm | na heating and pl | asma properties a | nd can apply physica |
| | | | | • • | |
| meas | urement techr | niques to known | | | |
| meas | urement techr | niques to known | | | |
| meas | urement techr | niques to known | | | |
| | urement techr | niques to known | | | |
| Contents | | | problems | | |
| Contents Basic concep | ts and plasm | a definition, sin | problems gle particles in | magnetic fields, | collision interactions s in plasmas, basics o |
| Contents Basic concep hydrodynamid | ts and plasm cs, magnetohy | a definition, sin | problems gle particles in netic theory, bour | magnetic fields, | collision interactions |
| Contents Basic concep hydrodynamic controlled fus | ts and plasm cs, magnetohy ion, special for | a definition, sin drodynamics, kir rms of discharge. | problems gle particles in netic theory, bour | magnetic fields, adary layers, waves | collision interactions |
| Contents Basic concep hydrodynamic controlled fus Format of Tea | ts and plasm cs, magnetohy ion, special for aching Lecture | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract | problems gle particles in netic theory, bour ical Exercises (Lat | magnetic fields, idary layers, waves poratory Course) | collision interactions |
| Contents Basic concep hydrodynamic controlled fus Format of Tea (written exan | ts and plasm cs, magnetohy ion, special for aching Lecture imination At th nination of 90 | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract ne beginning of th min, oral exam | problems gle particles in hetic theory, bour ical Exercises (Lak he course, the lect ination of 45 mir | magnetic fields, adary layers, waves poratory Course) urer determines th o or an exercise co | collision interactions s in plasmas, basics o e form of examination ertificate with week |
| Contents Basic concep hydrodynamic controlled fus Format of Tea format of Exa (written exan homework an | ts and plasm cs, magnetohy ion, special for aching Lecture mination At the nination of 90 ad active partic | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract ne beginning of th min, oral exami ipation in the exe | problems gle particles in netic theory, bour ical Exercises (Lak ne course, the lect ination of 45 mir ercises) for the lect | magnetic fields, adary layers, waves poratory Course) urer determines th o or an exercise co | collision interactions s in plasmas, basics o e form of examination ertificate with week |
| Contents Basic concep hydrodynamic controlled fus Format of Tea format of Exa (written exan homework an examined via | ts and plasm cs, magnetohy ion, special for aching Lecture mination At th nination of 90 id active partic practical exerc | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract ne beginning of th min, oral exami ipation in the exe cises and protoco | problems gle particles in hetic theory, bour ical Exercises (Lak he course, the lect ination of 45 mir ercises) for the lec | magnetic fields, adary layers, waves poratory Course) urer determines th or an exercise co cture. The advance | collision interactions s in plasmas, basics o e form of examination ertificate with weekh ed laboratory course i |
| Contents Basic concep hydrodynamic controlled fus Format of Tea (written exan homework an examined via Requirement | ts and plasm cs, magnetohy ion, special for aching Lecture mination At th nination of 90 ad active partic practical exerc s for the attril | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract ne beginning of th min, oral exami ipation in the exe cises and protoco bution of Credit | problems gle particles in netic theory, bour ical Exercises (Lak ne course, the lect ination of 45 mir ercises) for the lect ls. Points Dependin | magnetic fields, idary layers, waves poratory Course) urer determines th or an exercise co cture. The advance g on the specified | collision interactions s in plasmas, basics o e form of examinatio ertificate with weekl ed laboratory course i form of examinatior |
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| Contents Basic concep hydrodynamic controlled fus Format of Tea format of Exa (written exam homework an examined via Requirement Passing the w exercises. In t is determined | ts and plasm cs, magnetohy ion, special for aching Lecture mination At the nination of 90 of active partice practical exerce s for the attril written/oral ex- his case, active d at the begin | a definition, sin drodynamics, kir rms of discharge. , Exercises, Pract ne beginning of th min, oral exami ipation in the exe cises and protoco bution of Credit amination or obj e participation in ning of the cours | problems gle particles in netic theory, bour ical Exercises (Lak ne course, the lect ination of 45 mir ercises) for the lect is. Points Depending taining at least 50 the exercise is all se. In addition, th | magnetic fields, adary layers, waves poratory Course) urer determines th or an exercise co cture. The advance g on the specified 0% of the possible so compulsory. The | collision interactions s in plasmas, basics of e form of examination ertificate with weekly ed laboratory course i form of examination e points in the weekly e form of examination atory course must b |
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| General Rela | ativity | | | | |
|--|---|--|--|--|---|
| Modul 2a | Credits | Workload | Semester | Cycle | Duration |
| | 6 CP | 180 h | from 6. Sem. | Summer Term | 1 Semester |
| Courses | • | | Contact Hours | Self Study | Group Size |
| a) Lecture Gene | eral Relativity | | a) 44 h | 114 h | Students |
| b) Exercises Ge | - | / | b) 22 h | | a) unlimited |
| | | | | | b) 30 |
| Requirements f | or Participatio | on | | | |
| Formal: none | | | | | |
| Content-Wise: | | | | | |
| Preparation: no | one | | | | |
| Learning Outco | | | | | |
| After successful | | | | | |
| | | | y as curvature of | • | |
| | • | | rential-geometric | | |
| | | | ravity and their a | • • | |
| Can see | connections b | between physic | al ideas and can a | apply their mathem | latic form |
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| expanding un Curvature: co symmetries a Gravitation: cosmological The Schwarzs of the Schwa Cosmology: | niverse; Causa ovariant deriva and Killing vect physics in cu constant; alte schild solution rzschild solution Maximally syr | lity; Tensor den ative; parallel tr tors; maximally urved spacetin ernative theorie : the Schwarzsc on; black holes; mmetric univer | sities; Dif-ferenti ransport and geo symmetric space ne; Einstein equ s hild metric; Birkh ; the maximally e rse; Robertson-W | al forms; Integratic desics; the Rieman es; geodesic diverge ations; Lagrangian off's theorem; sing xtended Schwarzsc | n curvature tensor; ence formulation; the ularities; geodesics |
| Format of Teac | | | | | <u> </u> |
| | | | | | e form of examination |
| | | | nation of 30 min) | | |
| Utilisation of th | | | oints Passing the | | |
| | | | | g to Credit Points | |
| Module Superv | | | - | | |
| | | | | at the DUD to aver | mor conceter 22 |
| | | • | | at the RUB in sum | mer semester 22. |
| Alternatively, th | ie module can | De Laken at TU | Dorumuna. | | |

| | Quantum N | | | | |
|--|---|---|---|--|---|
| Modul 2b | Credits | Workload | Semester | Cycle | Duration |
| | 6 CP | 180 h | ab 5. Sem. | Winter Term | 1 Semester |
| Courses | | | Contact Hours | • | Group Size |
| a) Lecture Adv | anced Quant | um | a) 44 h | 114 h | Students |
| Mechanics | | | b) 22 h | | a) unlimited |
| | | ntum Mechanics | | | b) 30 |
| Requirements | for Participat | tion | | | |
| Formal: none | | | | | |
| | - | f the contents of | "Introduction to | Quantum Mecha | nics and Statistics" |
| (Bachelor) will | • | | | | |
| Preparation: n | ione | | | | |
| Learning Outc | omes | | | | |
| After successfu | ully completin | g this module, th | ne students | | |
| • Have | an understan | ding of advance | ed concepts of q | uantum mechani | cs, enabling them to |
| analys | e complex phy | ysical phenomen | а | | |
| Can se | e and apply fu | undamental corre | elations between | symmetries in qu | antum mechanics and |
| its unc | lerlying mathe | ematical form of | group theory | | |
| Have a | an overview o | f the most impor | tant approximativ | ve methods of qu | antum mechanics and |
| can ap | ply them inde | pendently to no | n-relativistic pher | nomena | |
| Are fa | miliar with s | cattering theory | and the quantu | im mechanical t | reatment of identical |
| particl | es | | | | |
| Gaine | d basic know | ledge of relativ | vistic field equati | ons and their qu | uantification |
| | | U | · | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Contents | | | | | |
| | quantum me | echanics, additio | n of angular mor | nentum, selectio | n rules, approximatior |
| Symmetries in | • | | - | | n rules, approximatior les, field quantisation |
| Symmetries in | their applicat | | - | | |
| Symmetries in methods and | their applicat ve equations | ions, scattering | - | | |
| Symmetries in methods and relativistic way Format of Tea | their applicat ve equations ching Lecture | ions, scattering , Exercises | theory, systems o | of identical partic | |
| Symmetries in methods and relativistic way Format of Tea Format of Exam | their applicat ve equations ching Lecture, mination At th | ions, scattering , Exercises ne beginning of th | theory, systems o | of identical partic | les, field quantisation |
| Symmetries in methods and relativistic way Format of Tea Format of Exan (written exami | their applicat ve equations ching Lecture mination At th nation of 180 | ions, scattering , Exercises ne beginning of th min or oral exan | theory, systems of the course, the lect | of identical partic urer determines t n) for the module | les, field quantisation |
| Symmetries in methods and relativistic way Format of Tea Format of Exam (written exami Requirements | their applicat ve equations ching Lecture mination At th nation of 180 for the attrib | ions, scattering , Exercises ne beginning of th min or oral exan | theory, systems of ne course, the lect nination of 45 min Points Passing the | of identical partic urer determines t n) for the module | les, field quantisation |
| Symmetries in methods and relativistic way Format of Tea Format of Exan (written exami Requirements Utilisation of t | their applicat ve equations ching Lecture, mination At th nation of 180 for the attrib the Module Co | ions, scattering , Exercises ne beginning of th min or oral exan ution of Credit P ompulsory-Electi | theory, systems of ne course, the lect nination of 45 min Points Passing the | of identical partic urer determines t n) for the module examination | he form of examination |
| Symmetries in methods and relativistic way Format of Tea Format of Exan (written exami Requirements Utilisation of t Importance of | their applicat ve equations ching Lecture mination At the ination of 180 for the attrib the Module Co the Mark for | ions, scattering , Exercises ne beginning of th min or oral exan ution of Credit P ompulsory-Electi | theory, systems of ne course, the lect nination of 45 min Points Passing the ve Module Weighed accordin | of identical partic urer determines t n) for the module examination | he form of examination |

| Statistical | Physics | | | | |
|---|---------------------------------------|---------------------------------------|--|--------------------|--|
| Modul 2c | Credits | Workload | Semester | Cycle | Duration |
| | 6 CP | 180 h | from 6. Sem. | Summer Term | 1 Semester |
| Courses | | | Contact Hours | Self Study | Group Size |
| a) Lecture Sta | atistical Physics | | | 114 h | Students |
| b) Exercises S | tatistical Physi | ics | b) 22 h | | a) unlimited |
| | | | | | b) 30 |
| Formal: none Content-Wise (Bachelor) wil | e: knowledge o I be expected | | f "Introduction to | Quantum Mechan | ics and Statistics" |
| Preparation: | | | | | |
| Know Are fair physic | the fundamer amiliar with fu cs | ntal concepts of o undamental defi | oncepts of statistic quantum statistics initions of classica teracting multi-pa | al and quantum r | nechanical statistical |
| the simple st statistics with | atistics of mai applications. | ny particles, the | • | | tions. Starting point is Afterwards quantum |
| | aching Lecture | | | | |
| | | ten examination | | | |
| | | | Points Passing the | examination | |
| | | ompulsory-Elect | | | |
| | | | Weighed accordin | g to Credit Points | |
| | | ructor Prof. Dr. 1 | Sulpizi | | |
| Further Inform | mation | | | | |

| Introduction to Theoretical Astrophysics | | | | | | |
|--|---------------|--|---|---|--|--|
| Astrophysics b) Exercises Int | 6 CP 180 h | | Semester From 5. Sem. Contact Hours a) 44 h b) 22 h | Cycle Summer Term Self Study 114 h | Dauer 1 Semester Group Size Students a) unlimited b) 30 | |
| Requirements f Formal: none Content-Wise: I Preparation: no | Basic knowled | | al physics (Bachel | or level) is highly ap | opreciated | |

Learning Outcomes

After successfully completing this module, the students

- Have a basic understanding of theoretical astrophysics
- Are aware of the possibilities of the used mathematisation and modelling
- Know the fundamental concepts for describing astrophysical environments
- Are familiar with different theoretical methods
- Can see and successfully apply correlations between astrophysics, respective examples and different branches of physics (nuclear and particle physics, plasma physics)

Contents

Methods and results of astrophysics are introduced for selected astrophysical systems and discussed in connection with current research results. Focal points are selected from the following topics: Astrophysics: definition and fundamentals (the latter are provided in short digressions as required); Stars: state variables, formation, structure, evolution and final states; Stellar winds: acceleration, structure and interaction with the interstellar medium; Stellar atmospheres: Structure and radiative transfer; Stellar winds: acceleration, structure and interaction with the interstellar medium; Milky Way, galaxies: structure; Cosmic rays: acceleration and transport.

Format of Teaching Lecture, Exercises

Format of Examination At the beginning of the course, the lecturer determines the form of examination (written examination of 90 min, oral examination of 45 min or an exercise certificate with weekly homework and active participation in the exercises) for the lecture.

Requirements for the attribution of Credit Points Depending on the defined form of examination: Passing the written/oral examination or obtaining at least 50 % of the possible points in the weekly exercises. In this case, active participation in the exercises is also compulsory. The form of examination is determined at the beginning of the course.

Utilisation of the Module Compulsory-Elective Module

Importance of the Mark for the Final Mark Weighed according to Credit Points

Module Supervisor and Instructor Prof. Dr. Tjus

| Modul 3b | Credits | Workload | Semester | Cycle | Duration |
|------------------|------------------|-------------------------------|-------------------------|---------------------|--------------------------|
| | 6 CP | 180 h | from 5. Sem. | Winter Term | 1 Semester |
| Courses | | | Contact Hours | • | Group Size |
| | | <mark>heoretical Solid</mark> | a) 44 h | 114 h | Students |
| State Physi | | | b) 22 h | | a) unlimited |
| b) Exercises In | | Theoretical | | | b) 30 |
| Solid State | Physics | | | | |
| Requirements | for Participti | on | | | · |
| Formal: none | | fthoorotical phy | sion including the | contonts of "Intr | aduation to Quantum |
| | - | Bachelor), will be | - | contents of intr | oduction to Quantum |
| Preparation: | - | achelor, will be o | expected | | |
| Learning Outo | | | | | |
| - | | g the module, the | e students | | |
| | | ital concepts of s | | | |
| | | • | • | perties with reg | ards to structure, th |
| prope | rties of oscilla | tion, and the elec | ctronic properties | and their influer | nce on the macroscop |
| behav | iour of the sol | lid state | | | |
| | | | • | | econd quantification |
| | - | | | entary excitation) | |
| | olve and interp | oret typical exerci | ises of solid state | theory | |
| Contents | | | | | |
| | c structure of | | | | han diffine et an handin |
| ratios) | stals, disorder | , reciprocal lattic | e, crystal structu | re determination | by diffraction, bondir |
| | of the crystal | lattice | | | |
| • | • | | in distribution. th | nermal properties | of the non-conducto |
| - | experiments) | | | | |
| Electrons | • | ate | | | |
| (classical | free electron | gas, Fermi-Dirac (| distribution, elect | trical conductivity | , thermal properties |
| conductors | , metallic boi | nding, charge ca | rriers in the ma | gnetic field, band | d model, experiment |
| | | gaps, semicondu | ictors, thermal e | excitation of char | rge carriers, scatterir |
| experimen | - | 66 | | | |
| | | | ss, hole conductio | on, impurity cond | uction, pn junction). |
| Format of Tea | | | a coursa tha lact | urer determines t | he form of examinatio |
| | | | | | certificate with week |
| - | | ipation in the exe | | | |
| Requirements | for the Attrik | oution of Credit P | Points Depending | on the specified | form of examination: |
| - | | | | • | le points in the week |
| - | | | - | - | ne form of examinatio |
| | | ing of the course. | | | |
| | Ŭ | - | | | |
| Itilisation of t | ne Module Co | mpulsory-Elective | e Module | | |
| mportance of | the Mark for t | bo Einal Mark W | aighed according | to Cradit Daints | |

Importance of the Mark for the Final Mark Weighed according to Credit Points

Module Supervisor and Instructor Prof. Dr. Eremin

| | Credits | Workload | Semester | Cycle | Duration |
|--|--|--|--|--|--|
| _ | 6 CP | 180 h | from 5. Sem. | Winter Term | 1 Semester |
| Courses | | | Contact Hours | • | Group Size |
| a) Lecture Intro | | heoretical | a) 44 h | 114 h | Students |
| Plasma Physi | | | b) 22 h | | a) unlimited |
| b) Exercises Int Plasma Physi | | Theoretical | | | b) 30 |
| Requirements f Formal: none | or Participat | ion | | | I |
| | Basic knowled | dge of theoretical | I physics, especia | ally electrodynamics | (Bachelor level), is |
| highly appreciat | | | | | |
| Preparation: no | | | | | |
| Lernziele (learn | | s) | | | |
| = | - | 3, g the module, the | students | | |
| | | - | | heoretical model bu | ilding for a complex |
| | article systen | | | | |
| | • | | asmas on the ba | sis of kinetic and flui | id dynamic theorie |
| | | ss the possibilities | | | |
| know tł | he basic matl | hematical technic | ques for working | g within the framew | ork of the theories |
| | ped in the mo | | | | |
| are fam | iliar with res | pective plasma-p | hysical application | ons of the theories a | and methods in the |
| context | of astrophys | sics and space pl | nysics and have | an insight into the | parameter regime |
| found t | here | | | | |
| - | | • | | ling of plasma-physi | • |
| | of the pra | actical experime | nts and have | carried out corres | |
| | | • | ints and nave | | ponding computer |
| context simulat | ions. | | | | ponding computer |
| simulat | ions. | | | | ponding computer |
| simulati Contents | | | | | |
| simulati Contents Basic concepts | of classical | plasma physics, | single particle | motion, kinetic th | eory, fluid theory |
| simulati Contents Basic concepts magnetohydroc | of classical dynamics, equ | plasma physics, uilibrium theory, | single particle waves and instak | | eory, fluid theory |
| simulati Contents Basic concepts magnetohydroc physical context | of classical dynamics, equ t, numerical r | plasma physics, uilibrium theory, v nodelling of plasr | single particle waves and instat nas. | motion, kinetic th pilities, applications i | eory, fluid theory |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teac | of classical dynamics, equ t, numerical r hing Lecture, | plasma physics, uilibrium theory, nodelling of plasr Exercises, numer | single particle waves and instat nas. rical computer si | motion, kinetic th pilities, applications i mulation | eory, fluid theory in astro- and space |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teac Format of Exam | of classical dynamics, equ t, numerical r hing Lecture, iinarion At th | plasma physics, uilibrium theory, nodelling of plasr Exercises, numer e beginning of the | single particle waves and instat nas. rical computer si e course, the lect | motion, kinetic th bilities, applications i mulation urer determines the | eory, fluid theory in astro- and space form of examinatic |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examin | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 | plasma physics, uilibrium theory, v nodelling of plasm Exercises, numer e beginning of the min, oral examin | single particle waves and instat mas. rical computer si e course, the lect nation of 45 mir | motion, kinetic th bilities, applications i mulation urer determines the n or an exercise cer | eory, fluid theory in astro- and space form of examinatic |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examin | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 | plasma physics, uilibrium theory, nodelling of plasr Exercises, numer e beginning of the | single particle waves and instat mas. rical computer si e course, the lect nation of 45 mir | motion, kinetic th bilities, applications i mulation urer determines the n or an exercise cer | eory, fluid theory in astro- and space form of examinatic |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examir homework and | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 active partici | plasma physics, uilibrium theory, y modelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe | single particle waves and instat mas. rical computer si e course, the lect nation of 45 mir rcises) for the lec | motion, kinetic th bilities, applications i mulation urer determines the n or an exercise cer | eory, fluid theory in astro- and space form of examinatic tificate with week |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examir homework and Requirements f | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 active partici | plasma physics, uilibrium theory, modelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe ution of Credit Pe | single particle waves and instak mas. rical computer si e course, the lect nation of 45 mir rcises) for the lec | motion, kinetic th bilities, applications i mulation urer determines the n or an exercise cer cture. | eory, fluid theory in astro- and space form of examinatio tificate with week m of examination: |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teac Format of Exam (written examin homework and Requirements f assing the writt | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 active partici for the Attrib en/oral exam | plasma physics, uilibrium theory, nodelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe ution of Credit Pe ination or obtain | single particle waves and instat nas. rical computer sin e course, the lect nation of 45 min rcises) for the lect pints Depending ing at least 50% | motion, kinetic th pilities, applications i mulation urer determines the n or an exercise cer cture. on the specified for | eory, fluid theory in astro- and space form of examinatio tificate with week m of examination: ts in the weekly |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examir homework and Requirements f assing the writt xercises. In this | of classical dynamics, equ t, numerical r hing Lecture, hinarion At the nation of 90 active partici for the Attrib en/oral exam case, active p | plasma physics, uilibrium theory, y modelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe ution of Credit Pe ination or obtain participation in th | single particle waves and instat nas. rical computer sin e course, the lect nation of 45 min rcises) for the lect pints Depending ing at least 50% | motion, kinetic th bilities, applications i mulation urer determines the or an exercise cer cture. on the specified for of the possible point | eory, fluid theory in astro- and space form of examinatio tificate with week m of examination: ts in the weekly |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teac Format of Teac Format of Exam (written examin homework and Requirements f bassing the writte xercises. In this a determined at | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 active partici for the Attrib en/oral exam case, active p the beginnin | plasma physics, uilibrium theory, y modelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe ution of Credit Pe ination or obtain participation in th | single particle waves and instak mas. rical computer sin e course, the lect nation of 45 min rcises) for the lect pints Depending ing at least 50% e exercise is also | motion, kinetic th bilities, applications i mulation urer determines the or an exercise cer cture. on the specified for of the possible point | eory, fluid theory in astro- and space form of examinatio tificate with week m of examination: ts in the weekly |
| simulati Contents Basic concepts magnetohydroc physical context Format of Teacl Format of Exam (written examin homework and Requirements f assing the writt xercises. In this determined at Utilisation of th | of classical dynamics, equ t, numerical r hing Lecture, hinarion At th nation of 90 active partici for the Attrib en/oral exam case, active p the beginning the beginning | plasma physics, uilibrium theory, modelling of plasm Exercises, numer e beginning of the min, oral examin pation in the exe ution of Credit Pa ination or obtain participation in th g of the course. ompulsory-Electiv | single particle waves and instat mas. rical computer sin e course, the lect mation of 45 min rcises) for the lect Dints Depending ing at least 50% re exercise is also | motion, kinetic th bilities, applications i mulation urer determines the or an exercise cer cture. on the specified for of the possible point | eory, fluid theory in astro- and space form of examinatio tificate with week m of examination: ts in the weekly |

| Modul 4a | Credits | Workload | Semester | Cycle | Duration |
|--|---|--|---|--|---|
| | 15-25 CP | 450-750 h | 12. Sem. | Winter & Summer | 2 Semesters |
| | | | | Term | |
| Courses | | | Contact Hours | Self Study | Group Size |
| a) Lecture | | | Each at least. | mind. 309 h | Students |
| b) Exercises | | | a) 44 h | | a) unlimited |
| c) Seminar (at | least 2 CP) | | b) 44 h | | b) 30 |
| d) Advanced L CP) | aboratory Cou | irses (at least 5 | c) 22 h d) 35 h | | c) 30 d) 2 |
| A complete ov | erview of the o | courses can be | | | |
| found in the cu | irrent course d | atalogue. The CP | | | |
| of the individu | al courses resu | ult from the | | | |
| semester hour | s per week (1 | hour per | | | |
| semester weel | - | | | | |
| Requirements | for Participat | ion | | | |
| Formal: none | | | , | | |
| | | dge of astronomy | /astrophysics wi | III be expected | |
| Preparation: n | one | | | | |
| are infare ab | ormed about o le to read, und le to write the | current astrophys lerstand and class | ical issues sify astrophysica | omy and astrophysic l literature xperimental or theor | |
| of research'. T working group provided. Extra up a large amo medium, galac processes in o components o | his is done wi s in experimen agalactic astro ount of space. tic disk / halo our own Milky f the Milky Wa | th special empha ntal and theoretic nomy, up to (obs Interactions of d or galaxies / inter Way are presen | sis on the resea al astrophysics/a servational) cosr ifferent compon galactic medium ited in detail. H ion of stars and | he students are take arch foci of the partic astronomy, but a bro mology and astropar ments (such as phases h) are of particular im lere, the focus is on - linked to this - plar | cipating chairs and ad overview is also ticle physics, takes of the interstellan portance. But also the gas and dust netary systems, bu |
| | | ionships, such as and particle physic | | | |

Requirements for the Attribution of Credit Points Passing the oral examination. The specialisation module must include: advanced laboratory courses (5 CP), a seminar (2 CP). Including the final oral module examination (2 CP), 15-25 CP can be achieved. Achievements made after the final module examination no longer count towards the module. **Utilisation of the Module** Compulsory-Elective Module

Importance of the Mark for the Final Mark Weighed according to Credit Points

Module Supervisor Prof. Dr. Bomans

Examiners Prof. Dr. Bomans, Prof. Dr. Dettmar, Prof. Dr. Franckowiak, Prof. Dr. Hildebrandt, Prof. Dr. Tjus, PD Dr. Fichtner

Further Information For advice and coordination of the courses, please contact the module supervisor. Please see the <u>course list</u> below.

Winter Semester

| 160611 Cosmology (Lecture) | Hildebrandt, Hendrik | Lecture |
|---|------------------------------------|-----------------------------|
| 160612 Cosmology (Exercises) Hildeb | randt, Hendrik Ex | <i>cercises</i> |
| 160623 Astrophysical Fluids, Plasmas a | and Shocks Scherer, K | laus <i>Lecture</i> |
| 160613 Radio Astronomy | Adebahr, Björn Le | ecture |
| 160608 Stars, Winds, Nebulae Weis, K | Kerstin Le | ecture |
| 160602 The Milky Way and External G | alaxies Bomans, Dominik J. | Lecture |
| 160621 Selected Topics of Astronomy | Bomans, Dominik J.; Dettma | ar, Ralf- |
| Jürgen; Franckowiak, An | na; Hildebrandt, Hendrik <i>Se</i> | eminar |
| 160656 Selected Topics on High Energy | y Particle Astrophysics Tj | us, Julia |
| Seminar | | |
| 160624 Advanced Laboratory: Observa | ational Astronomy De | ettmar, Ralf- |
| Jürgen; Bomans, Dominil | k J.; Franckowiak, Anna | Laboratory |
| 160615 Fluid Dynamics in Astrophysics | Scherer, Klaus Lecture | |
| 160616 Theoretical Neutrino Astrophy | sics Tjus, Julia | Lecture |
| 160617 Theoretical Neutrino Astrophy | sics (Exercises) Tjus, Julia; | Merten, |
| Lukas <i>Exercises</i> | | |
| 160618 Introduction to Space Physics | Fichtner, Horst Lecture | |
| 160619 Introduction to Space Physics | (Exercises) Fichtner, I | Horst <i>Exercises</i> |
| 160609 Theoretical Heliophysics | Fichtner, Horst; Kleimann, | Jens <i>Seminar</i> |
| 160663 Research Topics in Heliophysic | s Fichtner, Horst Se | eminar |
| 160610 Methods in Theoretical Astrop | article Physics Tjus, Julia Se | eminar |
| 160661 Observational Cosmology | Hildebrandt, Hendrik | Seminar |
| 160665 Crossing the Desert | Rhode, Wolfgang | Seminar |
| 160666 Multi-Wavelength Astrophysic | s Franckowiak, Anna | a Seminar |
| 160250 Advanced Laboratory Course f | or Physics Students Krebs, I | Hermann; |
| Reicherz, Gerhard | Laboratory | |
| 160651 Extragalactic Astronomy | Dettmar, Ralf-Jürgen | Seminar |
| | | |
| Summer Semester: | | |
| | | |
| 160601 Interstellar Medium Astrophys | | |
| 160614 Astroparticle Physics | Franckowiak, Anna | |
| 160615 Astroparticle Physics (Exercise | | |
| 160660 Variabilities and Instabilities in | | Lecture |
| 160613 Introduction to Statistics for A | stronomers and Physicists | Wright, Angus |
| | | Lecture |
| 160511 Modeling of Atomic Population | • • • • | aboratory and Astrophysical |
| Plasmas II | Marchuk, Oleksandr | Lecture |
| 160512 Modeling of Atomic Population | | • • • |
| Plasmas II (Exercises) | Marchuk, Oleksandr | Exercises |
| 160664 Magnetohydrodynamic Turbul | ence and Reconnection So | |
| | | Lecture |
| 160620 Selected Topics of Astronomy | II (Seminar) Hildebran | dt, Hendrik; Dettmar, Ralf- |
| | | |

| Jürgen; Bomans, Dominik J.; Franckowiak, Anna | | Seminar |
|--|-------------------------|-----------------------|
| 160662 Multi-Wavelength Astrophysics | Franckowiak, Anna | Seminar |
| 160650 Observational Cosmology (Seminar) | Hildebrandt, Hendrik | Seminar |
| 160661 Crossing the Desert | Hildebrandt, Hendrik | Seminar |
| 160623 Methods in Theoretical Astroparticle | Physics (Seminar) | Tjus, Julia |
| | | Seminar |
| 160624 Theoretical Heliophysics (Seminar) | Fichtner, Horst; Kleima | ann, Jens |
| | | Seminar |
| 160626 Astronomisches Beobachtungs-Prakt | ikum / Laboratory: Obse | rvational astronomy |
| Bomans, Dominik J.; Dettmar, Ralf-Jürgen | | Laboratory |
| 160250 Fortgeschrittenen-Praktikum für Phys | sikerinnen und Physiker | / Advanced Laboratory |
| Course for Physics Students Reicherz, Gerhard; Kre | ebs, Hermann Labor | atory |
| 160610 X-ray Astronomy | Bomans, Dominik J. | Lecture |
| | | |
| | | |
| | | |
| | | |

| • are aware of th | ents o Astronomy essful participation | Kontak a) 33 b) 11 | h a) 70 | tstudium 5 h | Group size Students a) Unlimited b) 30 |
|---|--|---|---|--|---|
| Participation requireme Formal: none Content: Introduction to Preparation: Prior succe Learning outcomes After successful comple | ents o Astronomy essful participation tion of the modul | | | | |
| Formal: none Content: Introduction to Preparation: Prior succes Learning outcomes After successful comple | o Astronomy essful participation tion of the modul | n in an astronomy | I | | |
| After successful comple | | | introductory le | cture | |
| | e physics of the t | operties of a homo hermal history of t | the Universe, | | ious basilground |
| | | osmic structure for inflationary unive | | | al lensing, and galax |
| are ready to we | ork on a master th | nesis with a cosmo | logical topic. | | |
| Lemaitre-Robertson-Wa constrain such models covered, connecting ins isotropic world models. fluctuations all the way t is introduced and under galaxy evolution are cov | are discussed. St ights from particl Next, structure to the structures v stood based on tl | arting from the h e physics, thermo formation and ev ve see in the Unive nese concepts. Cos | ot big bang, th dynamics, and t olution are disc erse today. The C smic inflation, re | e thermal histo he above men ussed, starting Cosmic Microwa eionisation, gra | ory of the Universe tioned homogeneous from tiny primordia ave Background (CME vitational lensing, an |
| Teaching forms lecture, | exercise class | | | | |
| Forms of examination of | oral exam | | | | |
| Requirements for the a Active participation in the | - | | ion of the oral e | exam. | |
| Use of the module Cour | ses in Physics Ma | jor | | | |
| Importance of the grade | e for the final gra | de graded, but doe | es not contribut | e to the weight | ed average final grad |
| Module coordinator/fu | II-time lecturer P | rof. Dr. Hendrik Hi | ldebrandt | | |
| | | | | | |

| | Credits | Workload | Semester | Turnus | DURATION |
|--|--|---|------------------|--|--------------------|
| | 2 CP | 60 h | 3. / 4. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| a) Semi | nar "Extragala | actic Astronomy" | a) 22 h | a) 38 h | Students |
| | | | | | a) Unlimite |
| Participation | requirements | | | | d |
| Formal: privat | e inquiry | | | | |
| Content: none | ž | | | | |
| Preparation: | ntroductory le | ectures in astronor | my and astrophy | /sics | |
| Learning outc | | | | | |
| After successf | ul completion | of the modul | | | |
| studer | nts have a bas | ic understanding o | of current resea | rch projects at the o | chair of astronomy |
| studer | nts know the k | pasic concepts of r | esearch in the f | ield of extragalactic | astronomy |
| are fail | miliar with the | e various observati | ional and data r | eduction technique | s and methods use |
| stude | nts are able to | critically assess th | ne impact of a p | ublication and judg | e the importance |
| for the | eir own resear | ch project | | | |
| Content | | | | | |
| • | • • | • | | ed in the context of | 0 01 7 |
| conducted at t | the chair of as | tronomy. The imp | ortance of pape | ers is discussed with | regards to the |
| | cts. | | | | |
| ongoing proje | | | | | |
| ongoing proje Teaching form | | | | | |
| ongoing proje Teaching form Forms of exar | nination Prese | | | | |
| ongoing proje Teaching form Forms of exan Requirements | mination Prese s for the aware | d of credit points | Active participa | tion and presentation | on |
| ongoing proje Teaching form Forms of exan Requirements Use of the mo | mination Prese s for the awar odule Courses | d of credit points in Physics Major | | • | |
| ongoing proje Teaching form Forms of exan Requirements Use of the mo Importance of | nination Prese for the aware odule Courses f the grade for | d of credit points in Physics Major | | tion and presentation of contribute to t | |
| ongoing proje Teaching form Forms of exan Requirements Use of the mo Importance of average final g | nination Prese for the award dule Courses f the grade for grade | d of credit points in Physics Major r the final grade g | raded, but does | not contribute to t | |
| ongoing proje Teaching form Forms of exan Requirements Use of the mo Importance of average final g | nination Prese for the aware odule Courses f the grade for grade linator/full-tir | d of credit points in Physics Major | raded, but does | not contribute to t | |

| | Credits | Workload | Semester | Turnus | DURATION |
|--|---|---|--|--|--|
| | 3 CP | 90 h | 5. / 7. Sem. | WiSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| a) Lectur | e "The Milky | Way and | a) 33 h | a) 57 h | Students |
| Extern | al Galaxies" | | | | a) Unlimite |
| | | | | | d |
| Participation re | equirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| • | - | - | | ny is necessary, as it | • |
| | - | | ous attendance o | f the lecture "Introc | luction to |
| Astrphysics" is l | | not required. | | | |
| Learning outco | | | | | |
| | | | | ive gained a deeper | - |
| structure, kiner | natics, and e | volution of our N | /lilky Way galaxy. | Using these conce | pts, in the second |
| part of the lect | ure the prope | erties and evolut | ion of external ga | alaxies will explored | and a coherent |
| picture for evol | ution of gala | vies inside the ev | volving universe v | will be derived | |
| | a | xies inside the ev | volving universe v | viii be derived. | |
| | | | | | |
| Content The course con | sists of the tv | wo major parts: t | he exploration of | f the physical prope | • |
| Content The course con Galaxy and the | sists of the tw extension to | wo major parts: t the various type | the exploration of external gala | f the physical prope exies, both the unde | erlining goal to |
| Content The course con Galaxy and the derive a consist | sists of the ty extension to ent picture f | wo major parts: t the various type or the evolution | the exploration of es of external gala of galaxies from | f the physical prope exies, both the unde the early universe to | rlining goal to o today. Methods |
| Content The course con Galaxy and the derive a consist and results for | sists of the tw extension to ent picture f the structure | wo major parts: t the various type or the evolution , kinematics, sta | the exploration of s of external gala of galaxies from rformation histor | f the physical prope exies, both the unde the early universe to y, and chemical evo | rlining goal to o today. Methods olution will be |
| Content The course con Galaxy and the derive a consist and results for presented and | sists of the tw extension to ent picture f the structure | wo major parts: t the various type or the evolution , kinematics, sta | the exploration of s of external gala of galaxies from rformation histor | f the physical prope exies, both the unde the early universe to | rlining goal to o today. Methods olution will be |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. | sists of the tw extension to cent picture f the structure applied to th | wo major parts: t the various type or the evolution , kinematics, sta | the exploration of s of external gala of galaxies from rformation histor | f the physical prope exies, both the unde the early universe to y, and chemical evo | rlining goal to o today. Methods olution will be |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms | sists of the tw extension to ent picture f the structure applied to th s lecture | wo major parts: t the various type or the evolution , kinematics, sta e different galax | the exploration of es of external gala of galaxies from rformation histor y types and concl | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms | sists of the tw extension to ent picture f the structure applied to th s lecture | wo major parts: t the various type or the evolution , kinematics, sta e different galax | the exploration of es of external gala of galaxies from rformation histor y types and concl | f the physical prope exies, both the unde the early universe to y, and chemical evo | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam | sists of the tw extension to ent picture f the structure applied to th lecture ination usua | wo major parts: t the various type or the evolution e, kinematics, sta e different galax Ily a short oral pr | the exploration of es of external gala of galaxies from rformation histor y types and concl | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o | sists of the tw extension to ent picture f the structure applied to th lecture ination usua r an oral exa | wo major parts: t the various type or the evolution e, kinematics, sta e different galax Ily a short oral pr | the exploration of es of external gala of galaxies from rformation histor y types and concl resentation, alter | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o Requirements | sists of the tw extension to ent picture f the structure applied to th s lecture ination usua r an oral examples for the awar | wo major parts: t the various type or the evolution , kinematics, sta e different galax lly a short oral pr m | the exploration of es of external gala of galaxies from rformation histor y types and concl resentation, alter s | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o Requirements active participa | sists of the tw extension to ent picture f the structure applied to th s lecture ination usua for the awar tion and a su | wo major parts: t the various type or the evolution , kinematics, sta e different galax lly a short oral pr m d of credit point | the exploration of es of external gala of galaxies from rformation histor y types and concl resentation, alter s ation | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o Requirements active participa | sists of the tw extension to ent picture f the structure applied to th s lecture ination usua r an oral exam for the awar tion and a su | wo major parts: t the various type or the evolution the ev | the exploration of es of external gala of galaxies from t rformation histor y types and concl resentation, alter s ation | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu | rlining goal to o today. Methods olution will be ution of the galaxy onditions apply) a |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o Requirements active participa Use of the mod Importance of | sists of the tw extension to ent picture f the structure applied to th electure ination usua r an oral exa for the awar tion and a su lule Courses the grade for | wo major parts: t the various type or the evolution the ev | the exploration of es of external gala of galaxies from t rformation histor y types and concl resentation, alter s ation | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu natively (if special c | rlining goal to o today. Methods olution will be ution of the galaxy onditions apply) a |
| Content The course con Galaxy and the derive a consist and results for presented and types derived. Teaching forms Forms of exam written essay o Requirements active participa Use of the mod Importance of average final gr | sists of the tw extension to ent picture f the structure applied to th s lecture ination usua for the awar tion and a su lule Courses the grade for ade | wo major parts: t the various type or the evolution k kinematics, sta e different galax lly a short oral pr d of credit point iccessful examina in Physics Major r the final grade | the exploration of es of external gala of galaxies from t rformation histor y types and concl resentation, alter s ation | f the physical prope exies, both the unde the early universe to y, and chemical evo usions for the evolu natively (if special c | erlining goal to o today. Methods olution will be ution of the galaxy onditions apply) a |

| | Credits | Workload | Semester | Turnus | DURATION |
|------------------|--------------|--------------------|--------------------|----------------------|---|
| | 2 CP | 60 h | 1. / 2. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| b) Semina | ar "Multi-Wa | velength | b) 22 h | b) 38 h | Students |
| Astrop | hysics" | | | | b) Unlimite |
| | | | | | d |
| Participation re | quirements | | | | |
| | | | | elength astronomy g | |
| | | • | • • | cs" is recommended | l |
| • | | the module astro | nomy (master) | | |
| Learning outco | | 6 .1 | | | |
| | • | of the module st | | | |
| | | | • | ulti-messenger astro | ophysics |
| | | | an international g | | |
| | • • | | among internati | • | |
| | quired the s | killset to comple | te their bachelor | / master theses | |
| Content | | | | | |
| • | - | - | | ti-wavelength astro | |
| | | | | optical astronomy a | |
| - | - | | | | pic and members of her workings of large |
| | | | • | nal colleagues and p | v v |
| to the group. | | | | nai concagues and p | Jesent their work |
| Teaching forms | Seminar | | | | |
| - | | lar active partici | pation in the form | n of short presentat | ions of the |
| | - | • | • | sequent follow-up. | |
| | | d of credit point | | | |
| • | | • | | , students typically | do not require |
| • | | | - | if necessary for reg | • |
| participation as | • | • | | , . | |
| Use of the mod | ule Courses | in Physics Major | | | |
| Importance of | the grade fo | r the final grade | graded, but does | not contribute to t | he weighted |
| average final gr | ade | - | | | |
| average milargi | | | | | |
| | | me lecturer Prof. | Dr. Anna Franck | owiak | |

| | Credits 2 CP | Workload 60 h | Semester 3. / 4. Sem. | Turnus WiSe / SoSe | DURATION 1 Semester |
|--|---|--|---|--|--|
| Courses a) Semir | nar "Observati | onal Cosmology" | Kontaktzeit a) 22 h | Selbststudium a) 38 h | Group size Students a) Unlimited |
| Formal: Work Content: Lect Astronomy" (| ure "Cosmolog bachelor) | r/master thesis in | y also "Astrostat | al cosmology group istics" (master); lec | |
| • have | learned to pre | e interactions in a sent their work to fic discussions, res | their peers in a | , | id take on |
| professional a • have Content This weekly m progress, pro- the team, get | dvice for their acquired the s neeting brings blems, and cur input from the | work; killset to complete together all mem rent topics. It is e eir peers, and imp | e their bachelor, bers of the obse xpected that stu prove their work | /master theses. rvational cosmolog idents present their through new ideas, | y group to discuss weekly progress to , productive criticism |
| professional a • have Content This weekly m progress, pro the team, get and discussio giving the stu opportunities | dvice for their acquired the s beeting brings blems, and cur input from the ns. The work o dents first insi to interact wi | work; killset to complete together all mem rent topics. It is e eir peers, and imp f the group meml ghts into the inne | e their bachelor, bers of the obse xpected that stu prove their work pers in several ir r workings of su | /master theses. rvational cosmolog idents present their through new ideas, | y group to discuss weekly progress to productive criticism th teams is discussed otentially with |
| professional a • have Content This weekly m progress, pro- the team, get and discussio giving the stu opportunities Teaching form Forms of examples | idvice for their acquired the s beeting brings blems, and cur input from the ns. The work o dents first insig to interact wir ns Seminar mination Regu | work; killset to complete together all mem rent topics. It is e eir peers, and imp f the group meml ghts into the inne th international co | e their bachelor, bers of the obse xpected that stu prove their work pers in several ir r workings of su plleagues and pr ation in the forr | /master theses. rvational cosmolog idents present their through new ideas, nternational researc ch collaborations, p resent their work to n of short presentat | y group to discuss weekly progress to productive criticism t teams is discussed otentially with a wider audience. |
| professional a • have Content This weekly m progress, pro the team, get and discussio giving the stu opportunities Teaching form Forms of exam work, discuss Requirement At this stage, additional cre | advice for their acquired the s beeting brings blems, and cur input from the ns. The work o dents first insig to interact wir ns Seminar mination Regu ions with mem s for the awar i.e. after the st | work; killset to complete together all mem rent topics. It is e eir peers, and imp f the group mem ghts into the inne th international co lar active particip bers of the group d of credit points tart of the bachelo wever, points can | e their bachelor, bers of the obse xpected that stu prove their work pers in several ir r workings of su plleagues and pr ation in the forr b, and subsequer | /master theses. rvational cosmolog idents present their through new ideas, nternational researc ch collaborations, p resent their work to n of short presentat | y group to discuss weekly progress to productive criticism, th teams is discussed otentially with a wider audience. tions of the students' do not require |
| professional a • have Content This weekly m progress, pro the team, get and discussio giving the stu opportunities Teaching form Forms of exam work, discuss Requirement At this stage, additional cre participation | advice for their acquired the s beeting brings blems, and cur input from the ns. The work o dents first insig to interact wir ns Seminar mination Regu ions with mem s for the awar i.e. after the sid dit points. How as detailed abo | work; killset to complete together all mem rent topics. It is e eir peers, and imp f the group mem ghts into the inne th international co lar active particip bers of the group d of credit points tart of the bachelo wever, points can | e their bachelor, bers of the obse xpected that stu prove their work pers in several ir r workings of su plleagues and pr ation in the forr b, and subsequer | /master theses. rvational cosmolog idents present their through new ideas, nternational researc ch collaborations, p resent their work to n of short presentation ht follow-up. s, students typically | y group to discuss weekly progress to productive criticism, th teams is discussed otentially with a wider audience. tions of the students' do not require |
| professional a • have Content This weekly m progress, pro the team, get and discussio giving the stu opportunities Teaching form Forms of exam work, discuss Requirement At this stage, additional cre participation Use of the mo | advice for their acquired the s beeting brings blems, and cur input from the ns. The work o dents first insig to interact wir ns Seminar mination Regu ions with mem s for the awar i.e. after the sid dit points. How as detailed about | work; killset to complete together all mem rrent topics. It is e eir peers, and imp f the group mem ghts into the inne th international co lar active particip bers of the group d of credit points tart of the bachelo wever, points can ove. | e their bachelor, bers of the obse xpected that stu prove their work pers in several ir r workings of su polleagues and pr dation in the form ation in the form ation subsequent pr/master thesis still be awarded | /master theses. rvational cosmolog idents present their through new ideas, iternational researc ch collaborations, p resent their work to n of short presentation the follow-up. | y group to discuss weekly progress to productive criticism th teams is discussed otentially with a wider audience. tions of the students' do not require |

| Radio Astro | nomv | | | | |
|---|---|---|---|----------------------|---|
| | Credits | Workload | Semester | Turnus | DURATION |
| | 2 CP | 60 h | 1. / 2. Sem. | WiSe | 1 Semester |
| Courses | | • | Kontaktzeit | Selbststudium | Group size |
| a) Lecture "Rad | a) Lecture "Radio Astronomy" | | a) 22 h | a) 38 h | Students |
| | | | | | a) Unlimited |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: Int | troduction to | Astrophyiscs an | id a good unders | tanding of Fourier T | ransforms |
| Student student bodies in are fam student physics student Content The first half of receiver and content interferometric introduced as wear the second half mostly associated and time domain Teaching forms Forms of examination Requirements for Passing the oral Use of the mode | s have a basic s are aware o s know the b radiating in th iliar with radi s are able to and radio ast s are able to and radio ast s are able to the lecture w rrelator techn radio images. rell as method of the lecture ad with such a n radio astron Lecture nation oral e or the award exam ule Courses the grade for ade | a understanding f the capabilitie asic concepts of e radio regime o astronomical recognize con ronomy perform their M ill introduce stu ology and expla Data calibratio as to analyse rad gives an overv as magnetic field nomy. <u>xam 45 min</u> of credit points in Physics Majo the final grade | es of modern rad of emission and a polarisation mea nections betwee laster Thesis with dents to the tech ain the mathema in methods will b dio interferometr riew of the astror ds, star-formatio | surements | ceivers sms of astronomical high energy particle astronomy astronomy such as led for generating aging algorithms o astronomy is ive galactic nuclei |
| | - | e lecturer Dr. E | sjorn Adebahr | | |
| Other informat | ion | | | | |

| Research To | pics in He | liophysics | | | |
|----------------------|-------------------------|-------------------------|---------------------|-----------------------|------------------------------|
| | Credits | Workload | Semester | Turnus | DURATION |
| | 2 CP | 60 h | from 6th | WiSe & SoSe | 1 Semester |
| | | | Sem. | | |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| a) Semina Heliopł | ir "Research iysics" | Topics in | a) 22 h ? | a) 38 h | Students a) Unlimite d |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: no | ne | | | | |
| Learning outcor | | | | | |
| After successful | • | | | | |
| | | n overview of th | e research topics | currently being inv | estigated in the |
| | ysics group | | | | |
| | • | | wn ongoing work | (resulting in a B.Sc. | ., M.Sc., or Ph.D. |
| | | group members | | | |
| | | | an oral presentati | on of their current | work to a |
| • | zed audience | | | | |
| | | | • • | present, and to criti | cally discuss the |
| motivat | ion, method | ology and result | s of their work | | |
| Content | | | | | |
| | • | | | ent the motivations | |
| | | | | l topics. Thereby fo | |
| | | • • | • | ner/his work and giv | ve the specialized |
| | | other heliophysic | cal and related as | trophysical topics. | |
| Teaching forms | | | | | |
| Forms of exami | | | | | |
| | | | s oral presentation | n | |
| | | in Physics Major | | | |
| • | - | r the final grade | graded, but does | not contribute to t | he weighted |
| average final gra | | | | | |
| | | ne lecturer PD D | r. Horst Fichtner | | |
| Other information | ion | | | | |

| | Credits | Workload | Semester | Turnus WiSe /SoSe | DURATION |
|---|--|---|--|---|---|
| | 2 CP | 60 h | 5.,6.,7. Sem | | 1 Semester |
| Courses | | f. A t | Kontaktzeit | Selbststudium | Group size |
| a) Seminar "Se | elected lopics | s of Astronomy" | a) 22 h | a) 38 h | Students a) Unlimited |
| Dorticipation | auiromonto | | | | a) Uninnited |
| Participation re Formal: yes | equirements | | | | |
| Content: yes | | | | | |
| • | olid knowledg | e of the foundati | ons of Astronor | ny is needed, as pre | sented in |
| - | | - | | the lecture "Introdu | |
| | - | | | ore specialized Astr | |
| • • | | it not required. | | | ,, <u> </u> |
| Learning outco | | • | | | |
| | | give the students | exposure to cut | ting edge Astronom | ical/Astrophysical |
| | - | - | • | ne presentation of so | |
| | | | | | |
| knowledge lev | el of their fell | | | llowing each of the | |
| - | | | discuss them fo | ollowing each of the | |
| requires the pa | | ow students, and | discuss them fo | ollowing each of the | |
| requires the pa Content | articipation in | ow students, and at least most of t | discuss them fo the seminar dat | ollowing each of the | presentations. (Th |
| requires the pa Content In the seminar selected by the | articipation in the students e full-time lec | ow students, and at least most of t select from a list turers and therefo | discuss them for the seminar dat of topical paper ore reflect most | ollowing each of the es.) Ts the one to present ly the work topics a | presentations. (Th t. The topics are ctively persued at |
| requires the pa Content In the seminar selected by the the Astronomi | articipation in the students e full-time lec cal Institute. | ow students, and at least most of t select from a list turers and therefo With help of the i | discuss them for the seminar dat of topical paper ore reflect most respective advis | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre | presentations. (Th t. The topics are ctively persued at epare the topics to |
| requires the pa Content In the seminar selected by the the Astronomi be presented i | articipation in the students e full-time lec cal Institute. n their semina | ow students, and at least most of t select from a list turers and therefo With help of the n ar talk and are pro | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre- o for the actual pres | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of |
| requires the pa Content In the seminar selected by the the Astronomi be presented i presenting one | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list | ow students, and at least most of t select from a list turers and therefo With help of the ar talk and are pro- | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of |
| requires the pa Content In the seminar selected by the the Astronomi be presented i presenting one some topical re | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast | ow students, and at least most of t select from a list turers and therefo With help of the n ar talk and are pro | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre- o for the actual pres | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of |
| requires the pa Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast s Seminar | ow students, and at least most of t select from a list turers and therefo With help of the ar talk and are pro ening and discuss tronomy/Astrophy | discuss them for the seminar dat of topical paper ore reflect most respective advis povided with help sing the other ta ysics. | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre- o for the actual pres- alks of the seminar w | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of vill provide a view c |
| requires the pa Content In the seminar selected by the the Astronomi be presented i presenting one some topical ro Teaching form Forms of exam | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast s Seminar nination Oral | ow students, and at least most of t select from a list turers and therefo With help of the ar talk and are pro ening and discuss tronomy/Astrophy presentation and | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta ysics. | ollowing each of the es.) To the one to present ly the work topics ac ors the students pre- o for the actual pres | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of vill provide a view c |
| requires the part Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form Forms of exam Requirements | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast is Seminar nination Oral for the awar | ow students, and at least most of t select from a list turers and therefo With help of the r ar talk and are pro ening and discuss tronomy/Astrophy presentation and d of credit points | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta ysics. | bllowing each of the es.) Is the one to present by the work topics action ors the students pre- o for the actual pres- alks of the seminar work biscussions after the | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of <i>v</i> ill provide a view c |
| requires the part Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form Forms of exam Requirements successful present | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast s Seminar nination Oral for the awar sentation of t | ow students, and at least most of t select from a list turers and therefo With help of the ar talk and are pro ening and discuss tronomy/Astrophy presentation and d of credit points he seminar talk ar | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta ysics. activity in the o | bllowing each of the es.) Is the one to present by the work topics action ors the students pre- o for the actual pres- alks of the seminar works biscussions after the | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of vill provide a view c |
| requires the par Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Some topical re Forms of exam Requirements successful prese | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast is Seminar <u>nination Oral</u> for the awar sentation of the | ow students, and at least most of t select from a list turers and therefor With help of the ar talk and are pro- cening and discuss tronomy/Astrophy- presentation and d of credit points he seminar talk ar I Courses in Physi | discuss them for the seminar dat of topical paper ore reflect most respective advis by ided with help sing the other ta ysics. activity in the d nd active partici ics Major | bllowing each of the es.) The one to present by the work topics and ors the students pre- po for the actual present alks of the seminar work discussions after the pation | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of vill provide a view o talk |
| requires the part Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form Forms of exam Requirements successful presented Use of the mo Importance of | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast s Seminar nination Oral for the awar sentation of the dule required the grade for | ow students, and at least most of t select from a list turers and therefor With help of the ar talk and are pro- cening and discuss tronomy/Astrophy- presentation and d of credit points he seminar talk ar I Courses in Physi | discuss them for the seminar dat of topical paper ore reflect most respective advis by ided with help sing the other ta ysics. activity in the d nd active partici ics Major | bllowing each of the es.) Is the one to present by the work topics action ors the students pre- o for the actual pres- alks of the seminar works biscussions after the | presentations. (Th t. The topics are ctively persued at epare the topics to entation. Result of vill provide a view of talk |
| requires the part Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form Forms of exam Requirements successful presents Successful present Use of the mo Importance of average final g | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast seminar nination Oral for the awar sentation of the dule required the grade for grade | ow students, and at least most of t select from a list turers and therefor With help of the n ar talk and are pro- tening and discuss tronomy/Astrophy presentation and d of credit points he seminar talk ar I Courses in Physi r the final grade g | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta ysics. activity in the other hd active partici ics Major graded, but doe | ollowing each of the es.) rs the one to present ly the work topics ac ors the students pre- o for the actual pres- alks of the seminar w liscussions after the pation | presentations. (The topics are ctively persued at epare the topics to entation. Result of vill provide a view of talk |
| requires the part Content In the seminar selected by the the Astronomi be presented i presenting one some topical re Teaching form Forms of exam Requirements successful prese Use of the mo Importance of average final g | articipation in the students e full-time lec cal Institute. n their semina e talk, plus list esearch in Ast is Seminar nination Oral for the awar sentation of the dule required the grade for grade inator/full-tin | ow students, and at least most of t select from a list turers and therefor With help of the n ar talk and are pro- tening and discuss tronomy/Astrophy presentation and d of credit points he seminar talk ar I Courses in Physi r the final grade g | discuss them for the seminar dat of topical paper ore reflect most respective advis ovided with help sing the other ta ysics. activity in the d nd active partici ics Major graded, but doer Dr. Dominik Bor | bllowing each of the es.) The one to present by the work topics and ors the students pre- po for the actual present alks of the seminar work discussions after the pation | presentations. (The topics are ctively persued at epare the topics to entation. Result of vill provide a view of talk |

| | Con Itt | Physics | Semester | Turnus | DUDATION |
|---|--|---|---|--|--|
| | Credits | Workload | from 5th | WiSe | DURATION |
| | 3 CP | 90 h | Sem. | WISE | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| | roduction to | Space Physics | a) 22 h | a) 57 h | Students |
| (Lecture)" | | Space Fligsics | a) 2211 | | a) Unlimited |
| · · | traduction to | Space Physics | b) 11 h | | b) 30 |
| (Exercices)" | | space rilysics | D) 1111 | | b) 50 |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| | - | Theoretical Phys | ics | | |
| Preparation: no | one | | | | |
| Learning outcom | | | | | |
| After successfu | l completion o | f the module | | | |
| student | ts have a basic | understanding o | of Space Physics | 5 | |
| student | ts are aware | of the capabiliti | es of the corre | esponding mathem | atization and of the |
| modelli | ing | | | | |
| student | ts know the ba | sic concepts for | the quantitative | e description of space | e physical processes |
| and sys | tems and can | apply them succ | essfully | | |
| student | ts are able to | recognize conn | ections betwe | en space physics a | nd astrophysics and |
| | | | | | |
| plasma | physics | | | | |
| plasma Content | physics | | | | |
| Content | | physics will be p | presented for se | elected space physic | al systems and will |
| Content Methods and re | esults of space | | | elected space physic will be selected fron | |
| Content Methods and re be discussed in topics: the Sun, | esults of space the context of the quiet and | f current researc disturbed solar | h. Focus areas wind and its in | will be selected from teraction with the to | n the following errestrial |
| Content Methods and rebe discussed in topics: the Sun, environment (n | esults of space the context of the quiet and nagnetosphere | f current researc disturbed solar e as well as the ir | h. Focus areas v wind and its in nterstellar medi | will be selected from teraction with the to um (heliosphere), v | n the following errestrial |
| Content Methods and rebe discussed in topics: the Sun, environment (n | esults of space the context of the quiet and nagnetosphere | f current researc disturbed solar | h. Focus areas v wind and its in nterstellar medi | will be selected from teraction with the to um (heliosphere), v | n the following errestrial |
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| | Credits | Workload | Semester | Turnus | DURATION |
|--|--|--|--|---|---|
| | 2 CP | 60 h | 4./6. Sem. | SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| a) Lecture "Stars, Wind Nebulae" | | a) 22 h | a) 38 h | Students | |
| | | | | | a) Unlimited |
| Participation | requirements | | | | |
| Formal: non | e | | | | |
| Content: nor | ne | | | | |
| Preparation | : basic know how | v in astronomy (| e.g. Introduction | to Astronomy cour | se) neccessary |
| Learning out | comes | | | | |
| Students wil | l get a broader v | iew on the stella | ar evolution and | consequences of m | ass loss. Mainly fro |
| an observati | onal perspective | e but also theore | tical concepts ar | e introduced and d | scussed. |
| Content | | | | | |
| | | | | | |
| The course c | | | | asses. A focus is give | |
| The course c parameters | that influence th | e evolution – in | particular the st | ellar mass loss and i | ts consequences. |
| The course c parameters The lecture a | that influence th addresses the to | e evolution – in pic from an obse | particular the st ervational point of | ellar mass loss and i of view but also the | ts consequences. oretical models |
| The course of parameters of The lecture a presented. B | that influence th addresses the to seside the obser | e evolution – in pic from an obse vational characte | particular the st ervational point o eristics also the r | ellar mass loss and i of view but also the nechanism of stella | ts consequences. oretical models r winds are |
| The course of parameters of The lecture a presented. B addressed. T | that influence th addresses the to seside the obser 'he formation of | e evolution – in pic from an obse vational characte circumstellar ne | particular the st ervational point of eristics also the r ebula from stella | ellar mass loss and i of view but also the nechanism of stella r winds and possible | ts consequences. oretical models r winds are e shell ejections is |
| The course of parameters of The lecture a presented. B addressed. T another topi | that influence th addresses the to seside the obser the formation of c of the lecture. | e evolution – in pic from an obse vational characte circumstellar ne In this context t | particular the st ervational point of eristics also the r ebula from stella | ellar mass loss and i of view but also the nechanism of stella | ts consequences. oretical models r winds are e shell ejections is |
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| The course of parameters of The lecture a presented. B addressed. T another topi properties of Teaching for | that influence the addresses the to seside the obser the formation of c of the lecture. f the Interstellar ms lecture | e evolution – in pic from an obse vational characte circumstellar ne In this context t medium. | particular the st ervational point of eristics also the r ebula from stella he lecture briefly | ellar mass loss and i of view but also the nechanism of stella r winds and possible | ts consequences. oretical models r winds are e shell ejections is ncepts and |
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| The course of parameters of The lecture a presented. B addressed. T another topi properties of Teaching for Forms of exa Requiremen active partic | that influence the addresses the to seside the obser the formation of c of the lecture. f the Interstellar rms lecture amination possi ts for the aware ipation and a su | e evolution – in pic from an obse vational characte circumstellar ne In this context t medium. ble are an oral ex d of credit points | particular the st ervational point of eristics also the r ebula from stella he lecture briefly xam, a short oral | ellar mass loss and i of view but also the nechanism of stella r winds and possible y tackles several cor | ts consequences. oretical models r winds are e shell ejections is ncepts and |
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| Theoretical | Heliophys | sics | | | |
|----------------------------------|---------------------------------|--|---------------------------------------|--|---|
| | Credits | Workload | from 5th | Turnus | DURATION |
| | 2 CP | 60 h | Sem. | WiSe & SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| a) Seminar " Th | neoretical He | liophysics" | a) 22 h | a) 38 h | Students |
| - | | | - | | a) Unlimited |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: no | one | | | | |
| Learning outcor | mes | | | | |
| After successful | l completion | of the module | | | |
| student | ts will have a | basic insight into | o selected topics | of contemporary he | eliophysical research |
| student | ts will have f | amiliarized them | selves with one | topic in more detai | I on the basis of one |
| or more | e research ρι | ublication(s) | | | |
| student | ts will have le | earned to make a | an oral presenta | tion of a chosen scie | entific problem to an |
| interest | ted audience | | | | |
| student | ts are able to | o extract, to sun | nmarize, and to | critically discuss the | e essence of a given |
| researc | h paper | | | | |
| astrophysical st provided on the | udies are crite basis of top | tically discussed. ics that are in th | Thereby an intro e focus of curren | arious heliophysical oduction into theore It research activititie ation should be strue | etical heliophysics is es. Besides the |
| Teaching forms | Seminar | | | | |
| Forms of exami | ination The o | oral presentation | (or, in exception | nal cases, the term p | oaper) will be |
| evaluated. | | | | | |
| • | | d of credit points | S | | |
| Je nach festgele | | - | | | |
| | - | • | • | n mindestens 50 % d | • |
| | | ••• | | | aktive Beteiligung in |
| | - | - | - | er Veranstaltung fest | |
| | - | reich abgeschlos | ssen werden. Bei | de Noten gehen mit | t den CP-gewichtet |
| in die Modulno | | | | | |
| | | in Physics Major | | | |
| • | - | r the final grade | graded, but does | s not contribute to t | ne weighted |
| average final gr | | | | Da lana Klatara | |
| | | ne lecturer PD D | r. Horst Fichther | , Dr. Jens Kleimann | |
| Other informat | lion | | | | |

| | Nebulae | | Semester | Turnus | DUDATION |
|---|---|--------------------------|------------------|------------------------|---------------------|
| | Credits | Workload | 5./7. Sem. | WiSe | DURATION |
| | 2 CP | 60 h | , | | 1 Semester |
| Courses | | 1 | Kontaktzeit | Selbststudium | Group size |
| a) Lecture "Va | riability and | Instability in | a) 22 h | a) 38 h | Students |
| Stars" | | | | | a) Unlimited |
| Participation rec | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| • | | in astronomy (e | .g. Introduction | to Astronomy cours | se) neccessary |
| Learning outcor | | | | | |
| - | | | | stellar varibility and | - |
| • | | • • | | I concepts of are int | roduced and |
| discussed to cor | nnect the varia | bilty to instabili | ty processe. | | |
| Content | | | | | |
| | | | | asses. In this context | • |
| | | • | | A focus is given on tl | • |
| • | | | | the stability of a sta | |
| | • | • | | t also theoretical mo | odels are presented |
| and necessary t | • | | | | |
| • | - | | | ries and even exopla | • |
| this lecture. Ste | llar winds and | mass transfer be | etween stars are | e further issues in th | nis context. |
| | | | | | |
| | | | | | |
| Teaching forms | | | | | |
| | | | am, a short oral | presentation or wri | tten essay |
| woouromonte t | | of credit points | tion | | |
| • | lion and a succ | essiuli examina | lion | | |
| active participat | | | | | |
| active participat Use of the mod | ule | ha final made - | | | |
| active participat Use of the mod Importance of t | ule he grade for t | h e final grade g | raded, but does | not contribute to th | ne weighted |
| active participat Use of the mod Importance of t average final gra | ule : he grade for t ade | • • | | | ne weighted |
| active participat Use of the mod Importance of t | ule he grade for t ade nator/full-time | • • | | | ne weighted |

| Biophysics | | | C | 0.1 | |
|--|---|---|--|--|--|
| Modul 4b | Credits 15-25 CP | Workload 450-750 h | Semester 12. Sem. | Cycle Winter & Summer Term | Duration 2 Semesters |
| Courses e) Lecture f) Exercises g) Seminar (at least 2 CP) h) Advanced Laboratory Courses (at least 5 CP) A complete overview of the courses can be found in the current course catalogue. The CP of the individual courses result from the semester hours per week (1 hour per | | | Contact Hours Each at least. e) 44 h f) 44 h g) 22 h h) 35 h | Self Study mind. 309 h | Group Size Students e) unlimited f) 30 g) 30 h) 2 |
| semester week Requirements | - | | | | |
| re fam investig have a Univers are ab commute can ind | omes Illy completing iliar with the gation and car deeper insig sity Bochum le to work c unicate them c lependently fin | n use these to des tht into current out scientific cor confidently orally nd and use inforn | ogical processes scribe equilibria a research topics ntents, theories and in writing nation in the rele | in molecular bioph and methods inde | ysics at the Ruhr- |
| Force fields, m spectroscopy a Format of Teac Format of Exar Requirements | olecular dyna pplied to curre ching Lecture, nination oral o for the Attribu | mics simulation, ent problems, bio Exercises, Semina examination of 45 ution of Credit Po | QM/MM simulation of the simulatics. Ar, Laboratory W minutes Dints Passing the | oral examination. | an scattering, |
| Including the fi after the final r | nal oral modu nodule examii | le examination (2 nation no longer (| CP), 15-25 CP ca count towards th | y courses (5 CP), a an be achieved. Achio ne module. | |
| | | mpulsory-Electiv | | | |
| - | | | - | g to Credit Points | |
| | | Gerwert, Prof. Dr | | | |
| | | | | sig, PD Dr. Kötting | e module |
| | | ce and coordinat <u>urse list</u> below. | ion of the course | es, please contact th | |
| Supervisor. Plea | ase see the <u>co</u> | uise list below. | | | |
| Winter Semest | er | | | | |
| | | | | | |
| | | | | | |

160821 Laboratory Biophysics: Molecular Biology of Proteins for Physics Students

Seite 36

| | Gerwert, Klaus; Hofma | nn, Eckhard | Laboratory |
|---|--------------------------------|-------------------|----------------|
| 160823 Laboratory Biophysics: Selecte | d Topics of Molecular B | iophysics for Phy | ysics Students |
| | Gerwert, Klaus; Hofma | nn, Eckhard | Laboratory |
| 160830 Biophotonics (Literature Semir | nar Gerwert, Klaus; Köt | ting, Carsten | Seminar |
| 160835 Basics and Current Topics of Pr | otein Crystallography (| Literature Semin | ar) |
| | Hofmann, Eckhard | | Lecture |
| 160250 Advanced Laboratory Course fe | or Physics Students | Krebs, Herman | n; Reicherz, |
| Gerhard | | Labora | tory |
| | | | |
| Summer Semester: | | | |
| | | | |
| 160801 Biophysics II (Lecture) | Gerwert, Klaus; Hofma | nn, Eckhard | Lecture |
| 160802 Biophysics II (Exercises) | Gerwert, Klaus; Hofma | nn, Eckhard | Exercises |
| 160820 Biophysics (Seminar) | Gerwert, Klaus; Hofma | nn, Eckhard | Seminar |
| 160852 Computer Simulation of Protei | ns Gerwert, Klaus; Ho | fmann, Eckhard | Seminar |
| 160855 Proteincrystallography | Hofmann, Eckhard | | Seminar |
| 160856 Literature Seminar: Basics and | Current Topics of Prote | eincrystallograph | у |
| Hofmann, Eckhard | | | |
| Seminar | | | |
| 160858 FTIR in Biophysics (Seminar) | Weis, Kerstin | | Seminar |
| 160859 Research Laboratory: Selected | Topics of molecular Bio | ophysics | |
| Gerwert, Klaus; Hofmann, Eckh | ard | | Laboratory |
| 160250 Fortgeschrittenen-Praktikum f | ür Physikerinnen und P | hysiker / Advanc | ed Laboratory |
| Course for Physics Students Reicherz, Gerha | ard; Krebs, Hermann | Laboratory | |

| | Credits 15-25 CP | Workload 450-750 h | Semester 12. Sem. | Cycle Winter & Summer | Duration 2 Semesters |
|--|--|--|--|--|---|
| Courses i) Lecture j) Exercises k) Seminar (at l l) Advanced La CP) A complete ove found in the cur of the individua semester hours | boratory Cou rview of the c rent course c I courses resu | ourses can be atalogue. The CP It from the | Contact Hours Each at least. i) 44 h j) 44 h k) 22 h l) 35 h | Term Self Study mind. 309 h | Group Size Students i) unlimited j) 30 k) 30 l) 2 |
| semester week Requirements f | = 1 CP). | | | | |
| have a electric are aw theoret know th are fam re able | ly completing basic underst al, magnetic, f are of the pa ical and expen ical and expen iliar with basi to recognise of | mechanical and c ossibilities within imental solid sta opts of the theore c experimental p correlations betw | operties of the sopprical properties optical properties the different te physics etical description rocedures for m veen the microso | solid state, its atomis s research areas and of the solid state easuring solid state p copic structure of the echnological usability | specialisations of properties e solid body and its |
| | | | | | |
| superconductin places the main of special lectu Semiconductor Physics, Physic | g properties. areas of solid res are offere Physics and s of Thin Fi | Theoretical solid state physics on a ed for in-depth s Semiconductor | l state physics de a solid quantum study: Surface P Devices, Phase uring and Spint | ysics, especially opt eals with the many- mechanical basis. In a hysics, Magnetism, 1 Transitions, Metal F tronics, and other | body problem and addition, a number Superconductivity, Physics, Scattering |
| Deepening of k superconductin places the main of special lectu Semiconductor Physics, Physic experimental ar Format of Teac | g properties. areas of solid res are offere Physics and s of Thin Fi nd theoretical hing Lecture, | Theoretical solid state physics on ed for in-depth s Semiconductor ms, Nanostruct solid state physi Exercises, Semin | state physics de a solid quantum study: Surface P Devices, Phase uring and Spint cs. ar, Laboratory W | eals with the many- mechanical basis. In a hysics, Magnetism, 1 Transitions, Metal F tronics, and other | body problem and addition, a number Superconductivity, Physics, Scattering |
| Deepening of k superconductin places the main of special lectu Semiconductor Physics, Physic experimental ar Format of Teac | g properties. areas of solid res are offere Physics and s of Thin Fi nd theoretical hing Lecture, | Theoretical solid state physics on a ed for in-depth s Semiconductor ms, Nanostruct solid state physi | state physics de a solid quantum study: Surface P Devices, Phase uring and Spint cs. ar, Laboratory W | eals with the many- mechanical basis. In a hysics, Magnetism, 1 Transitions, Metal F tronics, and other | body problem and addition, a number Superconductivity, Physics, Scattering |

Utilisation of the Module Compulsory-Elective Module

Importance of the Mark for the Final Mark Weighed according to Credit Points

| | | | |
|---|----------------------------------|--------------------------------------|--------|
| Module Supervisor Prof. Dr. Hägele | | | |
| Examiners Prof. Dr. Böhmer, Prof. Dr. Drautz, Prof. Dr | . Eremin, Prof. Dr. | Hägele, Prof. Scherer, I | Prof. |
| Sulpizi, Prof. Dr. Wieck | | | |
| Further Information For advice and coordination of th | ne courses, please o | contact the module | |
| supervisor. Please see the <u>course list</u> below. | | | |
| | | | |
| Winter Semester | | | |
| 160301 Scientific Methods of Semiconductor Physics | Wieck, Andreas | Lecture | |
| 160302 Scientific Methods of Semiconductor Physics (| Exercises) | Vieck, Andreas | |
| | | Exercises | |
| 160303 Semiconductor Physics I | Ludwig, Arne | Lecture | |
| 160304 Semiconductor Physics I (Exercises) | Ludwig, Arne | Exercises | |
| 160311 Physics of Quantum Cascade Lasers | Jukam, Nathan | Lecture | |
| 160312 Physics of Quantum Cascade Lasers (D | iscussion) Jukam | , Nathan S <i>emina</i> | r/ |
| Exercises | | | |
| 160322 Selected Topics of Applied Solid State Physics | Wieck, Andreas; | Ludwig, Arne | |
| | | Seminar | |
| 160324 Journal Club: Applied Solid State Physics | Ludwig, Arne | Seminar / Textl | ektüre |
| 160323 Spintronics and Ultrafast Spectroscopy Hägele | e, Daniel | Seminar | |
| 160350 Quantum Materials | Böhmer, Anna | Seminar | |
| 160325 Solid State Physics Theory | Eremin, Ilya | Seminar | |
| 160327 Selected Topics of Solid State Physics Theory | Scherer, Michael | Seminar | |
| 160305 Compact Course: Practical Exercises in Semico | nductor Technolog | gy Ludwig, Arne | |
| | (| Compact Laboratory | |
| 160351 Semiconductor Band Structures | Ludwig, Arne | Seminar / Lectu | re |
| 160250 Advanced Laboratory Course for Physics Stude | e nts Krebs, He | ermann; Reicherz, Gerh | nard |
| | | Laboratory | |
| | | | |
| Summer Semester | | | |
| 160303 Introduction to Solid State Physics II | Böhmer, Anna | Lecture | |
| 160304 Introduction to Solid State Physics II (Exercises | s) Böhmer, | Anna; Kreyßig, Andrea | S |
| | | Exercises | |
| 160306 Scientific Methods of Semiconductor Physics | | | |
| 160307 Scientific Methods of Semiconductor Physics (| Exercises) | Vieck, Andreas | |
| | | Exercises | |
| 160309 Semiconductor Physics II: Experiments with Se | emiconductor Qua | | , Arne |
| | | Lecture | |
| 160310 Semiconductor Physics II (Exercises) | Ludwig, Arne | Exercises | |
| 160311 Advanced Solid State Theory | Eremin, Ilya | Lecture | |
| 160312 Advanced Solid State Theory (Exercises) | Eremin, Ilya | Exercises | |
| 160319 Physics of Complex Phase Transitions in Solids | | ; Grünebohm, Anna | |
| | Lecture | | |
| 160320 Physics of Complex Phase Transitions in Solids | | cherer, Michael; Grün | ebohm, |
| Anna | | Exercises | |
| 160315 Introduction to X-ray and Neutron Scattering | Holland-Moritz, [| | |
| 160510 Surface Physics and Chemistry | Linsmeier, Christi | | |
| 160613 Introduction to Statistics for Astronom | ners and Physicists | Wright, Angus | |
| | | Lecture | |
| | technica Marth | 1 | |
| 160328 Quantum Optics | Jukam, Nathan | Lecture | |
| 160329 Quantum Optics (Exercises) | Jukam, Nathan | Exercises | |
| | | <i>Exercises</i> Ludwig, Arne | |
| 160329 Quantum Optics (Exercises) 160322 Journal Club: Applied solid state physics | Jukam, Nathan Wieck, Andreas; | Exercises Ludwig, Arne Seminar | |
| 160329 Quantum Optics (Exercises) | Jukam, Nathan | Exercises Ludwig, Arne Seminar | |

| 160358 Spintronics and Ultrafast Spectroscopy (Semin | ar) Hägele | , Daniel <i>Seminar</i> |
|---|-----------------------|------------------------------|
| 160326 Seminar on Quantum Materials (Seminar) | Böhmer, Anna | Seminar |
| 160353 Selected Topics of Applied Solid State Physics | (Seminar) | Wieck, Andreas; Ludwig, Arne |
| | | Seminar |
| 160354 Selected Topics of Solid State Theory (Seminar |) Eremin, Ilya | Seminar |
| 160321 Semiconductor Band Structures | Ludwig, Arne | Seminar |
| 160250 Fortgeschrittenen-Laboratory für Physikerinne | en und Physiker , | Advanced Laboratory Course |
| for Physics Students Reicherz, Gerhard; Krebs, Herm | nann | Laboratory |

| | Credits | Workload | Semester | Turnus | DURATION |
|--|---|--------------------|--------------------|---------------------------------------|---------------------|
| | 4 CP | 120 h | 5./6. Sem. | WiSe / SoSe | 1 week (plus |
| | | | | | preparation and |
| | | | | | a presentation of |
| | | | | | the results |
| Courses | | | Contact | Self Study | Group size |
| c) Labco | urses: Practic | al Exercises in | Hours | c) 80 h | Students |
| Semic | onductor Tec | hnology | c) 40 h | | c) 3-5 |
| Participation re | equirements | | | | |
| Formal: prepar | | ent | | | |
| Content: will b | • | | | | |
| - | - | | | pplied Solid State F | Physics" is |
| | | n of the content | will be checked i | n advance. | |
| Learning outco | | | | | |
| After successfu | • | | | | |
| | | - | | nductor devices are | made from |
| | | s. And how these | | | |
| | | of the capabilitie | es of photo-litho | graphy, device test | ing setups, focused |
| ion imp | plantation. | | | | |
| studen | ts know the b | pasic concepts of | semiconductor | devices | |
| are fan | niliar with ph | oto lithography | | | |
| Content | | | | | |
| • | | • | • • | nple field-effect tra | |
| techniques of s learned. | emiconducto | or processing, suc | h as photolitho៖ | graphy and wet che | mical etching, are |
| Furthermore, s | tudents will ι | use focused ion in | mplantation to n | nodify the electrica | l properties of |
| semiconductor | heterostruct | ures. | | · | |
| The electrical c | haracterizatio | on of the fabricat | ted devices is an | other focus of the l | ab. Here, modern, |
| electrical meas | urement tecł | nniques are used | for device chara | acterization. Each p | ractical day is |
| introduced wit | h a lecture of | about 45 minute | es, in which the l | basics for the work | of the day are |
| explained. | | | | | |
| Teaching form | | | | | |
| | | | • | w to measure the c | levice (mid term |
| during the wee | | ion after the pra | | | |
| - | for the awar | d of credit points | 5 | | |
| Requirements | | - | | | |
| Requirements Successful oral | exam and pr | | | | |
| Requirements Successful oral Use of the mod | exam and pr Jule Advance | d lab course bloo | | | |
| Requirements Successful oral Use of the moo Importance of | exam and pr Jule Advance the grade fo | d lab course bloo | | Physics Major es not contribute to | the weighted |
| Requirements Successful oral Use of the mod | exam and pr Jule Advance the grade fo | d lab course bloo | | | the weighted |

| | Credits | Workload | Semester | Turnus | DURATION |
|-----------------------------|------------------|--------------------------|--------------------|------------------------|----------------------|
| | 1 CP | 30 h | 410. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| d) Semin | ar | | d) 11 h | d) 19 h | Students |
| | | | | | d) Unlimite |
| | | | | | d |
| Participation re | equirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| • | | nd Participation | in module "Specia | al Problems in Appli | ed Solid State |
| Physics" is reco | | | | | |
| Learning outco | | | | | |
| After successfu | • | | | | |
| | | | | ind understand a sc | ientific article, |
| | | • | a compact and co | • | |
| | | • | es to access journ | al articles behind a | paywall from the |
| | ity bibliograp | • | | | |
| | | pasic concepts of | scientific presen | tation of content, a | sk basic and |
| | ic questions | | | | |
| are fan | hiliar with lite | rature research | methods | | |
| Content | | | | | |
| • | - | • | | nt research publishe | |
| • | • | • | • | | at the whole group |
| | | | | | uss different aspect |
| | - | | | vriting style, and bri | ing a healthy |
| | | aise) to the resul | ts. | | |
| Teaching form | | | | | |
| Forms of exam | | | | | |
| • | | d of credit point | | | |
| | | sentation of a pa | | | |
| | | in Physics Major | | | |
| • | - | r the final grade | graded, but does | not contribute to t | he weighted |
| average final g | | | | | |
| Module coordi | nator/full_tir | ne lecturer Dr. A | rne Ludwig | | |
| Other informat | | | | | |

| | Credits | scade Lasers | Semester | Turnus | DURATION |
|---|--|---|--|------------------------|------------------------------------|
| | 3 CP | 90 h | 1. / 2. Sem. | WiSe / SoSe | 1 Semester |
| <u>Courses</u> | 5 CP | 9011 | - | Selbststudium | |
| Courses | | | Kontaktzeit | | Group size |
| | e "Physics of Q | luantum | e) 22 h | e) 57 h | Students |
| | de Lasers" | (A | 0 441 | | e) Unlimite |
| | sion "Physics o | of Quantum | f) 11 h | | d |
| Casca | de Lasers" | | | | |
| · · · | - | of quantum me | echanics is high | ly recommended | |
| Learning outco | | f the meadule | | | |
| After successfu | l completion o | | - f + h h : | | |
| | | understanding o | | necessary for lasing | |
| Studen | | - | | | |
| StudenStuden | ts are aware of | f the capabilities | | | |
| StudenStudenStuden | ts are aware of ts know the ba | f the capabilities isic concepts of s | solid-state phy | sics, optical and lase | |
| Studen Studen Studen necess | ts are aware of ts know the ba ary for the desi | f the capabilities sic concepts of s ign of quantum o | solid-state phy cascade lasers | sics, optical and lase | |
| Studen Studen Studen necess Studen | ts are aware of ts know the ba ary for the desi | f the capabilities isic concepts of s | solid-state phy cascade lasers | sics, optical and lase | |
| Studen Studen Studen necess | ts are aware of ts know the ba ary for the desi | f the capabilities sic concepts of s ign of quantum o | solid-state phy cascade lasers | sics, optical and lase | |
| Studen Studen Studen necess Studen | ts are aware of ts know the ba ary for the desi ts are familiar y | f the capabilities isic concepts of s ign of quantum o with different qu | solid-state phy cascade lasers uantum cascad | sics, optical and lase | r physics that are |
| Studen Studen Studen necess Studen Studen This course will | ts are aware of ts know the ba ary for the desi ts are familiar cover the phys | f the capabilities sic concepts of s ign of quantum o with different qu sics necessary to | solid-state phy cascade lasers uantum cascad | sics, optical and lase | r physics that are ers. Quantum |

They emit radiation at mid-infrared and far-infrared wavelengths. This contrasts with conventional diode semiconductor lasers which are based on interband transitions and emit radiation at visible and near-infrared wavelengths. The active region of a quantum cascade laser consists of repeating series (cascades) of quantum wells and barriers that are grown in Molecular Beam Epitaxy (MBE) or Metal Organic Vapor Deposition (MOCVD) machines. To achieve lasing, wavefunctions and levels should be designed to maximize/(minimize) the lifetime of the upper/(lower) laser level, reduce parasitic scattering, maximize injection into the upper laser level, and minimize losses. This requires a thorough understanding of the optical properties of two-dimensional semiconductors, and electron transport and scattering in semiconductor heterostructures. In addition to these topics, the course will review basic laser theory and survey different types of waveguides.

Outline

Basic Laser theory: spontaneous emission, stimulated emission, absorption, Einstein A and B coefficients, Rate equations, 3 and 4 level laser systems, laser threshold, gain clamping / saturation, homogeneous and inhomogeneous broadening, multi-mode and single mode lasers, spatial hole burning, longitudinal and transverse modes, spontaneous emission noise and laser line width, frequency pulling, Q-switching, mode-locking line width, different types of lasers.

Wave functions and effective mass: Review of tight binding model, nearly free-electron model, and the formation of bands. Bloch's theorem, envelope approximation, effective mass approximation, hetero-structure effective mass theory - modifications of the continuity conditions and the kinetic operator in the envelope approximation

Idealized potentials parabolic well, infinite square well, finite square well, finite hetero-structure square well, superlattices and minibands, Bloch oscillations, coupled quantum wells, Stark effect **Refinements of effective mass theory:** k dot p method, Kane 2 and 3 band models, non-parabolicity **Optical properties of quantum wells**: Interband and intraband transitions, absorption in quantum wells, selection rules, oscillator strength – sum rules, depolarization shift, gain and loss, modification of sum rules and transition dipole moments from non-parabolicity

QCL design strategies: two-dimensional rate equations, slope efficiency, importance of lifetimes, parasitic scattering, Bragg confinement, resonant tunneling (qualitative treatment), backfilling and

self-heating, bound-to-continuum designs, LO-phonon designs, chirped supper-lattice and phase space designs

Resonant tunneling injection and extraction: coupled quantum wells, resonant tunneling diodes, density matrix - two and three-level models, coherent and incoherent transport regimes, scattering assisted injection, electric field domains

Carrier scattering: phonon scattering, electron-electron scattering, impurity scattering, interface roughness, elevated electron temperatures

Waveguides/mode confinement: TE and TM modes, dielectric slab waveguides, surface plasmon waveguides, photonic crystals, distributed brag reflectors, mode coupling,

orthogonality/completeness of modes, mode overlap factor

Teaching forms Lecture and exercise/discussion session

Forms of examination Weekly exercises will be assigned. Students are expected to write notes on the lecture material. The grade for the course will be based on a final examination.

Requirements for the award of credit points

Active participation during the weekly lecture and exercise session is required. Students are required to submit weekly exercises and handwritten lecture notes to Module. The final examination will be written and take approximately 90 minutes to complete. A single grade will be given for both the lecture and exercises.

Use of the module Elective

Importance of the final examination for the grade The grade will be determined by the final examination.

Module coordinator/full-time lecturer Dr. Nathan Jukam (email: Nathan.Jukam@rub.de)

Other information

| | Credits | Workload | Semester | Turnus | DURATION |
|---------------------------------------|----------------|----------------------------|-------------------|------------------------|-----------------------|
| | 3 CP | 90 h | 3 6. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| g) Lecture | e " Scientific | Methods of | g) 22 h | f) 57 h | Students |
| Semico | onductor Phy | vsics (Lecture)" | | | f) Unlimite |
| h) Exercis | e "Scientific | Methods of | h) 11 h | | d |
| Semico | onductor Phy | vsics (Exercices)" | | | g) 30 |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: no | one | | | | |
| Learning outco | mes | | | | |
| After successful | completion | of the module | | | |
| student | s have a bas | ic understanding o | of preparation, w | work principles and | analytics of |
| semicor | nductor devi | ces | | | |
| Student | s are aware | of the capabilities | of semiconduct | tors in transport an | d optics |
| student | s know the b | pasic concepts of t | hermodynamics | s concerning evapor | ration rates, electri |
| charge | carrier densi | ties and excitatior | ns in solids | | |
| are fam | iliar with ele | ctron and hole dy | namics in semic | onductors | |
| student | s are able to | recognize connec | ctions between t | he materials and b | andgaps, doping, |
| mobility | and electric | cal conductivity ar | nd apply this kno | wledge to all semic | conductors |
| Content | | | | | |
| • | | | • | ble, bandgaps, pn-j | • |
| • | | • | • | -transistor, field-eff | |
| - | | | | e of the electric car | |
| | | | | e feedback, operat | |
| | | | | spectrum analyzer, | - |
| | | | | r applications in lab | |
| - | | | •• | electronics, electro | |
| - | | | nned obsolescer | nce including strate | gies how to react, |
| repair strategies | | | | | |
| Teaching forms | 0 | 8 8 11 | | | |
| | | - | | student performs a | |
| | - | • | | ontents in front of t | |
| | • | • | | nistrative reasons | (e.g. not enough |
| | | ual oral examinati | ion of 45 min. w | all be performed. | |
| • | | d of credit points | | | |
| Successful talk / | | | | | |
| | | in Physics Major | | | |
| • | - | r the final grade g | raded, but does | not contribute to t | he weighted |
| average final gr | | | | | |
| • • • • • • • • • • • • • • • • • • • | | a a la atuman Duaf I | S. A | .1 | |
| Other informat | - | ne lecturer Prof. [| Dr. Andreas wie | СК | |

| Semiconduc | tor Band S | tructures | | | |
|-----------------------------|-----------------|--------------------------|-------------------|-----------------------|-----------------------|
| | Credits | Workload | Semester | Turnus | DURATION |
| | 1 CP | 30 h | 1. / 2. Sem. | WiSe / SoSe | 1 Semester |
| Courses | 1 | | Kontaktzeit | Selbststudium | Group size |
| i) Seminar | "Semicondu | uctor Band | i) 11 h | g) 19 h | Students |
| Structures" | | | | | h) Unlimited |
| Participation red | quirements | | | | |
| Formal: none | - | | | | |
| Content: none | | | | | |
| Preparation: Pa | rticipation in | module "Special | Problems in App | plied Solid State Phy | ysics" is |
| recommended. | | | | | |
| Learning outcon | nes | | | | |
| After successful | completion of | of the module | | | |
| student | s have a basio | c understanding o | of semiconducto | or band structure ca | lculations |
| Student | s are aware | of the capabilit | ies of software | packages to perfo | orm complex device |
| simulati | ons | | | | |
| student | s know the ba | asic concepts of h | neterostructure | devices | |
| are fam | iliar with crea | iting device conc | epts based on b | and structure and f | unctionalities |
| Content | | | | | |
| • | | | • | pining different con | |
| • | | • • | - | s is a huge technolo | |
| | | | | electronic devices l | |
| | | • | • | e control of the arra | - |
| | | | | ucture, the spatial a | _ |
| - | | | | | ve will calculate the |
| | | | | ike quantum wells, | - |
| | | | | oped in practical ex | |
| | | • | experiments wi | th e.g. qubit, single | photon source, and |
| single electron s | | | | | |
| Teaching forms | | | d procontation of | f an own simulatio | n project |
| | | of credit points | u presentation (| of an own simulatio | |
| active participat | | • | | | |
| Use of the mod | | | | | |
| | | | raded but does | not contribute to t | he weighted |
| average final gra | - | and man grade g | | | ne weighted |
| | | e lecturer Dr. Ar | ne Ludwig | | |
| Other informati | | | | | |
| | | | | | |

| | Credits | Workload | Semester | Turnus | DURATION |
|-----------------------------|----------------|---------------------------|-------------------|-----------------------|--------------------|
| | 4 CP | 120 h | 59. Sem. | WiSe / SoSe | 1 Semester |
| Courses | • | · | Kontaktzeit | Selbststudium | Group size |
| j) Lectur | e "Semicond | uctor Physics I | j) 33 h | h) 76 h | Students |
| (Lectu | re)" | | | | i) Unlimite |
| k) Exercis | se "Semicond | luctor Physics I | k) 11h | | d |
| (Exerci | , | | | | j) 30 |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: no | | | | | |
| Learning outco | | | | | |
| After successfu | | | | | |
| | | • | | ng, electronic transp | port, band |
| | • | s in semiconduct | | | |
| | | of the capabilitie | s of different mo | dels applied to des | cribe semiconducto |
| physics | | | | | |
| | | oasic concepts of | selected semicor | nductor devices | |
| are fam | iliar with sen | niconductors | | | |
| Content | | | | | |
| • | | | • • | tics in semiconduct | |
| | | • | • | escribe and method | • |
| | | ced. The physics | and operation p | rinciples of selected | lsemiconductor |
| devices are pres | | | | | |
| Teaching forms | | | | | |
| | | examination at th | | ture | |
| • | | d of credit points | | | |
| | | aining class and p | bass the oral exa | m | |
| | | in Physics Major | | | |
| • | - | the final grade g | graded, but does | not contribute to t | ne weighted |
| average final gr | | | | | |
| ivioquie coordi | nator/tuii-tir | ne lecturer Dr. Ar | me Ludwig | | |
| Other informat | - | | | | |

| Solid State | Physics The | eorv | | | |
|------------------|----------------|---------------------|-------------------|------------------------|--|
| | Credits | Workload | Semester | Turnus | DURATION |
| | 8 CP | 240 h | 1. / 2. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | 1 | Kontaktzeit | Selbststudium | Group size |
| | urse: Advand | ed Solid State | I) 44 | i) 152 h | k) Unlimited |
| Theory | | | m) 22 | | I) 25 |
| m) Exercise for | Advanced Sol | id State Theory | n) 22 h | | m) 25 |
| n) Seminar "So | lid State Phys | ics Theory" | | | |
| | | | | | |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: Basic | knowledge of | solid state theor | y, statistical me | chanics and quantu | m mechanics is |
| desirable | | | | | |
| Preparation: no | one | | | | |
| Learning outco | | | | | |
| After successfu | | | | | |
| | | - | | | neoretical solid state |
| | • • | | • | many-body theory | stata quatance sector |
| | | | | - | state systems using |
| | | - | | | dynamic observables the thermodynamic |
| | | solid state system | | | the thermodynamic |
| • | | | | and finite temperat | ures and can use this |
| | | s model systems | | | |
| | | | e numerical alg | orithms to obtain | the thermodynamic |
| | | | - | Monte-Carlo or sim | |
| | | | | | |
| Content | | | | | |
| Brief descriptio | • | | | | |
| | | | | | any particle Green's |
| | - | | - | • | omentum space, the |
| | | e functions, the R | - | - | inctions, Generating |
| | • | | | cation of the Matsu | |
| | | | | | ransport Theory, The |
| | ormula, | | | | |
| | | id broken symme | etry, Ginzburg La | andau theory, Therr | mal Fluctuations and |
| criticali | | , | ,, 0 | | |
| - Cohere | nt states and | path integrals, Eff | fective action ar | nd Hubbard Stratono | wich transformation, |
| - Superc | onductivity ar | nd BCS theory, Lo | cal Moments ar | nd the Kondo effect. | |
| Teaching forms | s Lecture, Exc | ersize, Seminar | | | |
| Forms of exam | ination Z At t | he beginning of t | he course, the le | ecturer determines | the form of the |
| - | | | | r an exercise certific | |
| | • | • | - | ecture. The seminar | |
| | | | opic, related to | the modern researc | ch. |
| • | | l of credit points | | | |
| | | orm of examinati | | | |
| - | | | - | % of the possible po | • |
| | | • • | | • | form of examination |
| will be determi | ned at the be | ginning of the co | urse. In addition | n, the F practical cou | irse must be |

completed successfully. Both grades go into the module grade with the CP weighted

Use of the module Courses in Physics Major

Importance of the grade for the final grade graded, but does not contribute to the weighted average final grade

Module coordinator/full-time lecturer Prof. Dr. Ilya Eremin

Other information

| | Credits | Workload | Semester | Turnus | DURATION |
|--|---|--|--|---|---|
| | 2 CP | 60 h | 5 10. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| - | iar "Spintroni roscopy" | cs and Ultrafast | o) 22 h | j) 38 h | Students n) Unlimite d |
| Participation re Formal: Lectur | • | | | | |
| Content: none | • | - | | | |
| Preparation: P | | | | | |
| linear | ontics higher | order coherence | in stochastic me | asurement outcom | as and spintropic |
| device: • Content | S. | | | easurement outcom | |
| devices • Content Time-resolved noise spectroso | pump-probe copy. Second | spectroscopy wit order frequency | h 100 fs – tempo resolved spectra | oral resolution. Non I. Higher order polys | -linear optics. Spin |
| devices • Content Time-resolved noise spectroso measurement. | s. pump-probe copy. Second Quantum Po | spectroscopy wit order frequency lyspectra. Optica | h 100 fs – tempo resolved spectra I spin injection. S | oral resolution. Non I. Higher order polys | -linear optics. Spin |
| devices • Content Time-resolved noise spectroso measurement. Teaching form | s. pump-probe copy. Second Quantum Po s Seminar tall | spectroscopy wit order frequency lyspectra. Optica ks by students an | h 100 fs – tempo resolved spectra I spin injection. S d instructors | oral resolution. Non I. Higher order polys ipin-transport. | -linear optics. Spin spectra and their |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s | spectroscopy wit order frequency lyspectra. Optica ks by students an student prepares | h 100 fs – tempo resolved spectra I spin injection. S d instructors | oral resolution. Non I. Higher order polys | -linear optics. Spin spectra and their |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen | spectroscopy wit order frequency lyspectra. Optica ks by students an student prepares t discussion. | h 100 fs – tempo resolved spectra l spin injection. S d instructors and delivers a ta | oral resolution. Non I. Higher order polys ipin-transport. | -linear optics. Spin spectra and their |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for Requirements | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen for the awar | spectroscopy wit order frequency lyspectra. Optical ks by students an student prepares t discussion. d of credit points | h 100 fs – tempo resolved spectra I spin injection. S d instructors and delivers a ta | oral resolution. Non I. Higher order polys Spin-transport. Ilk at the seminar (3 | -linear optics. Spin spectra and their 5-45 Minutes) and |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for Requirements Successful exar | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen for the awar mination. Atto | spectroscopy wit order frequency lyspectra. Optical ks by students an student prepares t discussion. d of credit points endance of the se | h 100 fs – tempo resolved spectra I spin injection. S d instructors and delivers a ta eminar and oral o | oral resolution. Non I. Higher order polys ipin-transport. | -linear optics. Spin spectra and their 5-45 Minutes) and |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for Requirements Successful exar Use of the mod | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen for the aware mination. Atte dule Courses | spectroscopy wit order frequency lyspectra. Optical ks by students an student prepares t discussion. d of credit points endance of the se s in Physics Major | h 100 fs – tempo resolved spectra l spin injection. S d instructors and delivers a ta eminar and oral o | oral resolution. Non I. Higher order polys Spin-transport. Ilk at the seminar (3 | -linear optics. Spin spectra and their 5-45 Minutes) and cussions. |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for Requirements Successful exar Use of the moo Importance of | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen for the awar mination. Atto dule Courses the grade for | spectroscopy wit order frequency lyspectra. Optical ks by students an student prepares t discussion. d of credit points endance of the se s in Physics Major | h 100 fs – tempo resolved spectra l spin injection. S d instructors and delivers a ta eminar and oral o | oral resolution. Non . Higher order polys pin-transport. Ik at the seminar (3 contributions to disc | -linear optics. Spin spectra and their 5-45 Minutes) and cussions. |
| devices • Content Time-resolved noise spectroso measurement. Teaching forms Forms of exam is prepared for Requirements Successful exar Use of the mod Importance of average final g | s. pump-probe copy. Second Quantum Po s Seminar tall ination The s a subsequen for the awar mination. Attr dule Courses the grade for rade | spectroscopy wit order frequency lyspectra. Optical ks by students an student prepares t discussion. d of credit points endance of the se s in Physics Major | h 100 fs – tempo resolved spectra I spin injection. S d instructors and delivers a ta eminar and oral o graded, but does | oral resolution. Non I. Higher order polys ipin-transport. Ilk at the seminar (3 contributions to disc s not contribute to t | -linear optics. Spin spectra and their 5-45 Minutes) and cussions. |

| Solid State P | | | | | - 1 |
|-------------------|-----------------|--------------------|---------------------|------------------------|---------------------|
| | Credits | Workload | Semester | Turnus | DURATION |
| | 2 CP | 60 h | 1. Sem. | WiSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| p) Semina | nr "Solid Stat | e Physics | p) 22 h | k) 38 h | o) 25 |
| Theory | " | | | | |
| | | | | | |
| Participation re | quirements | | | | |
| Formal: none | | | | | |
| Content: Basic k | nowledge o | f solid state theo | ory, statistical me | chanics and quantu | m mechanics is |
| desirable | | | | | |
| Preparation: no | | | | | |
| Learning outcor | | | | | |
| After successful | | | | | |
| | s have devel | oped a basic und | derstanding of th | e modern topics of | the solid state |
| theory | | | | | |
| | | | • | odern literature on t | |
| | | | | presentations on a g | |
| | | • | | ry and can use them | to understand and |
| to comp | prehend new | scientific article | 2S | | |
| | | | | | |
| Content | 6 .1 1.1 | | | | |
| Brief description | - | | | | 1 |
| | | | | vel quantum materi | als |
| | • | | nd qubits realiza | tion | |
| | | ransitions and br | oken symmetry | | |
| | | path integrals, | | | |
| - Superco | inductivity a | nd BCS theory, | | | |
| Teaching forms | | | | | |
| | | | ned via a present | ation by the studen | t on the selected |
| topic, related to | | | _ | | |
| • | | d of credit points | | | |
| | | orm of examinat | | 0/ of the peechle pe | into in the mealdu |
| - | | | - | % of the possible po | |
| | | | | • | form of examination |
| | | | | n, the F practical cou | |
| completed succ | essiully. BOth | n grades go mto | the module grad | e with the CP weigh | ited |
| Use of the mod | ula Courses | in Physics Major | | | |
| | | | | not contribute to t | he weighted |
| • | ne graue ior | the man grade | graueu, but uoes | s not contribute to t | ne weignteu |
| average final ar | aha | | | | 0 |
| average final gra | | ne lecturer Prof. | | | |

| | Credits | Workload | Semester | Turnus | DURATION |
|--------------------------------|---------------|--------------------------|----------------------|-----------------------|---------------------|
| | 2 CP | 60 h | 3 10. Sem. | WiSe / SoSe | 1 Semester |
| Courses | | | Kontaktzeit | Selbststudium | Group size |
| q) Semin | ar "Selected | Topics of | q) 22 h | l) 38 h ? | Students |
| Applie | d Solid State | Physics" | ? | | p) Unlimite |
| | | | | | d |
| | | | | | |
| Participation re | equirements | | | | |
| Formal: none | | | | | |
| Content: none | | | | | |
| Preparation: N | one or "Parti | cipation in solid | state physics mod | dule is recommende | ed." |
| Learning outco | mes | | | | |
| After successfu | • | | | | |
| | | - | s of applied solid s | | |
| | | • | | tors in transport and | • |
| | | pasic concepts of | molecular beam | epitaxy and focuse | d ion beam |
| techno | | | | | |
| | | | • | emiconductor resea | |
| | | recognize conne | ections between s | semiconductor mat | erials and their |
| applica | tions | | | | |
| Content | | | | | |
| | | | | search. In particula | |
| | | | | ration of semicond | |
| • | | | | portant issue is the | |
| - | | | • | quently discussed s | • |
| systems in gene | - | photon sources, | quantum uots ar | nd low-dimensional | |
| | | lks, discussions | | | |
| - | | | ns a talk of 45 mir | n. plus discussion w | vithin the research |
| group | | • | | · | |
| Requirements | for the awar | d of credit point | s: Successful talk | with valid discussion | on |
| Use of the mod | lule Courses | in Physics Major | | | |
| | the grade for | r the final grade | graded, but does | not contribute to t | he weighted |
| | the grade for | | | | |
| | - | _ | | | |
| Importance of average final gr | ade | ne lecturer Dr. A | rne Ludwig, Prof. | Dr. Andreas Wieck | _ |

| Modul 4d | Credits | Workload | Semester | Cycle | Duration |
|--|---|--|--|--|---|
| | 15-25 CP | 450-750 h | 12. Sem. | Winter & Summer | 2 Semesters |
| | | | | Term | |
| Courses | | | Contact Hours | • | Group Size |
| n) Lecture | | | Each at least. | mind. 309 h | Students |
| n) Exercises | | | m) 44 h | | m) unlimited |
| o) Seminar (at | t least 2 CP) | | n) 44 h | | n) 30 |
| - | Laboratory Cou | rses (at least 5 | o) 22 h | | o) 30 |
| CP) | | | p) 35 h | | p) 2 |
| • | verview of the o | | | | |
| | | atalogue. The CP | | | |
| | ial courses resu | | | | |
| | rs per week (1 | nour per | | | |
| semester wee | , | | | | |
| Requirements Formal: none | s for Participat | on | | | |
| | . Knowlodge fr | om "Introduction | to Nuclear and | Particle Physics" will | he expected |
| Preparation: r | - | | to nuclear and | raiticle rilysics Will | be expected |
| .earning Outo | | | | | |
| | | | | weak and strong inte | |
| are ab posses partic | ole to make the ss a knowledge le physics | can interpret No connection betw of open questior | veen symmetries and current re | ments in nuclear and and experimental o esearch topics in the t and the development | bservations field of nuclear an |
| are ab posses partic can ex Contents Dirac equations strangeness, go resonances, co parton model states, Higgs of theories, solit | ole to make the ss a knowledge le physics kplain the conn group theory ar olours in QCD, , deep inelasti mechanism of ons. In additio | can interpret No connection betw of open question ection between p articles, conserva nd symmetry, Cle charm, confiner c scattering and mass production n, special events | veen symmetries as and current re particle physics a ation laws, Fey bsch-Gordon con nent, Global and scale behaviour , physics beyon are offered in | and experimental o esearch topics in the f | bservations field of nuclear and of the universe of the universe kawa interaction, nets, Breit-Wigner hadron structure, weak WW, mixing lel, quantum field and seminars on |

Format of Examination or al examination of 45 minutes

Requirements for the Attribution of Credit Points Passing the oral examination.

The specialisation module must include: advanced laboratory courses (5 CP), a seminar (2 CP). Including the final oral module examination (2 CP), 15-25 CP can be achieved. Achievements made after the final module examination no longer count towards the module.

| Module Supervisor Prof. Dr. Wiedner, Prof. Dr. Epelb | aum | |
|---|---------------------------|---|
| Examiner Prof. Dr. Epelbaum Prof. Dr. Fritsch, Prof. D | r. Heinsius, Prof. Dr. Tj | us, Prof. Dr. Wiedner, PD |
| Dr. Krebs, | | |
| Further Information For advice and coordination of the | he courses, please cont | tact the module |
| supervisor. Please see the <u>course list</u> below. | | |
| Winter Semester | | |
| 60406 Symbolic Computation in Mathematica | Krebs, Hermann | Lecture |
| 60412 Detectors and Algorithms for Charged Track R | Reconstruction Ritm | ian, James |
| | | Lecture with |
| ntegrated Exercises | | |
| 60616 Theoretical Neutrino Astrophysics | Tjus, Julia | Lecture |
| 60617 Theoretical Neutrino Astrophysics (Exercises) | Tjus, Julia; Merten, L | |
| | | Exercises |
| 60420 Experimental Methods in Nuclear and Particle | e Physics Wiedner, Ulri | |
| | | Seminar |
| 60421 Detectors for Particle Physics | Wiedner, Ulrich; Hei | |
| | | Seminar |
| 60418 Seminar on Hadron Physics | Fritsch, Miriam | Seminar |
| 60422 Selected Topics of Hadron Physics I | Epelbaum, Evgeny; K | rebs, Hermann Seminar |
| 60429 Current Topics in the Standard Model and bey | yond Epelbaum, E | vgeny |
| | | Seminar |
| 60250 Advanced Laboratory Course for Physics Stud | ents Krebs, Herm | ann; Reicherz, Gerhard <i>Laboratory</i> |
| Summer Semester | | |
| 60401 Introduction to Nuclear and Particle Physics II | I Wiedner, Ulrich | Lecture |
| .60402 Introduction to Nuclear and Particle Physics II | I (Exercices) Wied | dner, Ulrich |
| | | Exercises |
| 60412 Particle Detectors for Hadron Physics Experim | | |
| 60413 Particle Detectors for Hadron Physics Experim | nents (Excercises) Ritm | |
| | | Exercises |
| 60403 Quantum Field Theory I | Krebs, Hermann | Lecture |
| 60404 Quantum Field Theory I (Exercises) | Krebs, Hermann | Exercises |
| 60411 Symbolic Computation in Mathematica | Krebs, Hermann | Lecture |
| 60613 Introduction to Statistics for Astronomers and | d Physicists Wrig | sht, Angus |
| | | Lecture |
| 60420 Experimental Methods in Nuclear and Particle | e Physics (Seminar) | Wiedner, Ulrich <i>Seminar</i> |
| 60421 Particle Physics Detectors (Seminar) | Wiedner, Ulrich; Hei | nsius, Fritz-Herbert |
| 60426 Selected Tenics of Ledrer Division II (Constraint) |) Englhaum Eurore K | Seminar |
| 60426 Selected Topics of Hadron Physics II (Seminar) | j Eperbaum, Evgeny; K | |
| | | Seminar |
| | | (rebs, Hermann; Körber, |
| | Eperbaum, Evgeny; K | |
| .60429 Effective Field Theories (Seminar) Christopher .60250 Fortgeschrittenen-Laboratory für Physikerinn | | Seminar |

| | Credits | Standard Mo | Semester | Cycle | Duration |
|-----------------------------|----------------------------|---------------------------|--------------------|-----------------------|------------------------|
| | 2 CP | 60 h | 1. Sem. | Winter Term | 1 Semester |
| Courses | | | Contact | Self-Study | Group Size |
| r) Semina | ar "Current To | opics in the | Hours | m) 38 h | Students |
| Standa | Standard Model and Beyond" | | r) 22 h | | q) 30 |
| Requirements f | or Participat | ion: | | • | |
| Formal: none | | | | | |
| Content-Wise: S | Successful pa | rticipation in the | course Advance | d Quantum Mech | anics and Quantum |
| Field Theory I ar | nd/or Introdu | uction to Theoret | ical Hadron Phys | ics will be advanta | ageous. |
| Preparation: no | one | | | | |
| Learning Outco | | | | | |
| | | g the module, the | | | |
| are fam | iliar with the | basics of the Sta | ndard Model of | particle physics, it | s successes and |
| shortco | mings as wel | l as current resea | irch topics in par | ticle physics | |
| Student | s have a dee | per understandin | g of the scientifi | c issues in the cho | osen focus area. |
| student | s have exper | ience in preparin | g and giving a sc | ientific presentation | on. |
| Contents | | | | | |
| | | | | | cs such as quantum |
| • | • | | | | ods, precision tests o |
| | - | | • | ndard Model, etc. | |
| | | | • | | seminar, different |
| • | • | • | • | ssed. Within the se | eminar series, |
| | | ed and presente | d. | | |
| Format of Teac | | | | | |
| Format of Exam | ination Pres | entation | | | |
| • | | ution of Credit P | | | |
| Active participa | tion in the se | ssions, presentat | ion | | |
| Utilisation of th | e Module El | ective Course | | | |
| Importance of t | he Mark for | the Final Mark g | raded, contribut | ion to the final ma | ark weighed for CP |
| Module Superv | isor and Inst | ructor Prof. Dr. E | vgeny Epelbaun | n, Priv Doz. Dr. Hei | rmann Krebs |
| Fuuthau lufauna | | | • | | |

Further Information

| | Credits | Workload | Semester | Cycle | Duration |
|---|---|---|--|--|---|
| | 2 CP | 60 h | 1. Sem. | Winter/Summer | 1 Semester |
| | | | | Term | |
| Courses | 1 | | Contact | Self-Study | Group Size |
| s) Semina | ar "Detector | s for Particle | Hours | n) 38 h | Students |
| Physics | s" | | s) 22 h | | r) 30 |
| Requirements | for Participa | tion | | | |
| Formal: none | | | | | |
| Content-Wise: | none | | | | |
| Preparation: no | one | | | | |
| Learning Outco | mes | | | | |
| Students will | | | | | |
| Study in | ndividual sub | detectors for sul | patomic particles | | |
| Learn h | ow complete | e detector systen | ns are composed | from subdetectors | |
| Unders | tand the limi | tations of detect | ors | | |
| Get acc | uainted with | n modern electro | nics and data acc | uisition systems | |
| Unders | tand the inte | erplay between p | hysics goals and t | tailored experiments | S. |
| | | | | | |
| Contents | | | | | |
| | | outral particles | with their advants | ages and drawbacks | The relevance of |
| | - | • | | - | |
| | - | • | | or systems. The inte | |
| electronics and | data acquisi | tion systems for | composed detect | - | erplay between the |
| electronics and source of subat | data acquisi omic particle | tion systems for es and the design | composed detect | or systems. The inte | erplay between the red to very specific |
| electronics and source of subat physics goals. N | data acquisi omic particle Iultipurpose | tion systems for es and the design | composed detect of a complete de s at accelerators | or systems. The interest of systems. The interest of system tailor | erplay between the red to very specific |
| electronics and source of subat physics goals. M Format of Teac | data acquisi omic particle Iultipurpose hing Semina | tion systems for es and the design detector system r talks by the stu | composed detect of a complete de <u>s at accelerators</u> dents. | or systems. The interest of systems. The interest of system tailor | erplay between the red to very specific ents. |
| source of subat physics goals. M Format of Teac Format of Exan group. | data acquisi omic particle <u>1ultipurpose</u> hing Semina hination Pre | tion systems for es and the design detector system r talks by the stu paration and sub | composed detect of a complete de s at accelerators dents. sequent presenta | cor systems. The inte etector system tailor and their achieveme | erplay between the red to very specific ents. |
| electronics and source of subat physics goals. M Format of Teac Format of Exan group. | data acquisi omic particle <u>1ultipurpose</u> hing Semina hination Pre | tion systems for es and the design detector system r talks by the stu | composed detect of a complete de s at accelerators dents. sequent presenta | cor systems. The inte etector system tailor and their achieveme | erplay between the red to very specific ents. |
| electronics and source of subat physics goals. M Format of Teac Format of Exan group. Requirements f Independent pr | data acquisi omic particle <u>Aultipurpose</u> hing Semina hination Prep for the Attrik | tion systems for es and the design detector system r talks by the stu paration and sub oution of Credit I a seminar talk a | composed detect of a complete de <u>s at accelerators</u> dents. sequent presenta Points bout particle dete | ectors and their physical sectors and their achievements and their achievements and their physical sectors and the physical sectors are physical sectors and the physical sectors are physical sectors and the physical sectors are physi | erplay between the red to very specific ents. Ik to the whole |
| electronics and source of subat physics goals. N Format of Teac Format of Exan group. Requirements f Independent pr comprehensive | data acquisi omic particle <u>Aultipurpose</u> hing Semina hination Prep for the Attrik reparation of presentation | tion systems for es and the design detector system r talks by the stu paration and sub oution of Credit I a seminar talk a n of the material | composed detect of a complete de s at accelerators dents. sequent presenta Points | ectors and their physical sectors and their achievements and their achievements and their physical sectors and the physical sectors are physical sectors and the physical sectors are physical sectors and the physical sectors are physi | erplay between the red to very specific ents. Ik to the whole |
| electronics and source of subat physics goals. N Format of Teac Format of Exan group. Requirements f Independent pr comprehensive | data acquisi omic particle <u>Aultipurpose</u> hing Semina hination Prep for the Attrik reparation of presentation | tion systems for es and the design detector system r talks by the stu paration and sub oution of Credit I a seminar talk a n of the material | composed detect of a complete de <u>s at accelerators</u> dents. sequent presenta Points bout particle dete | ectors and their physical sectors and their achievements and their achievements and their physical sectors and the physical sectors are physical sectors and the physical sectors are physical sectors and the physical sectors are physi | erplay between the red to very specific ents. Ik to the whole |
| electronics and source of subat physics goals. M Format of Teac Format of Exan group. Requirements f Independent pr comprehensive Utilisation of th | data acquisi omic particle <u>Aultipurpose</u> hing Semina nination Prep for the Attrik reparation of presentation ne Module E | tion systems for es and the design detector system r talks by the stu paration and sub oution of Credit I a seminar talk a n of the material lective Course | composed detect of a complete de <u>s at accelerators</u> dents. sequent presenta Points bout particle dete to the seminar p | ectors and their physical sectors and their achievements and their achievements and their physical sectors and the physical sectors are physical sectors and the physical sectors are physical sectors and the physical sectors are physi | erplay between the red to very specific ents. Ik to the whole sics goals. Clear and |
| electronics and source of subat physics goals. M Format of Teac Format of Exan group. Requirements f Independent pr comprehensive Utilisation of th Importance of f | data acquisi omic particle Aultipurpose hing Semina nination Prep for the Attrik reparation of presentation ne Module E the Mark for visor and Inst | tion systems for es and the design detector system r talks by the stu paration and sub oution of Credit I a seminar talk a n of the material lective Course the Final Mark | composed detect of a complete de <u>s at accelerators</u> dents. sequent presenta Points bout particle dete to the seminar p | ectors and their physical sectors and their achievement of a seminar taken the sectors and their physical sectors and the sectors are sectors as a sector sector sector sectors and the sectors are sectors as a sector sector sector sector sectors as a sector sector sector sector sector sectors as a sector sec | erplay between the red to very specific ents. Ik to the whole sics goals. Clear and s weighed for CP |

| | Credits | Workload | Semester | Cycle | Duration |
|---|---|--|--|--|------------------------|
| | 2 CP | 60 h | 2. Sem. | Summer Term | 1 Semester |
| Courses | | | Contact | Self-Study | Group Size |
| t) Sem | inar "Effective I | Field Theories" | Hours | o) 38 h | Students |
| | | | t) 22 h | | s) 30 |
| Requirement | s for Participat | ion: | | | |
| Formal: none | | | | | |
| | • | • | | | inics; participation i |
| | | Theory I and/or Ir | ntroduction to T | heoretical Hadron | Physics will be |
| advantageous | | | | | |
| Preparation: | | | | | |
| Learning Out | | | | | |
| | , , , | g the module, the | | | |
| | | basics of effectiv | e field theories | and their application | ons in nuclear and |
| - | cle physics. | | | | |
| | | | - | fic issues in the cho | |
| stude | ents have exper | ience in preparin | g and giving a so | cientific presentatio | on. |
| Contents | | | | | |
| | | | | ogy of effective field | |
| | ••• | | | pics include the inte | • |
| | • | | | ion and renormalisa | |
| equation, EFI | for the treatm | ent of halo nucle | i, EFT for BSIM p | hysics, EFT of gravit | ty, etc. |
| The cominer i | a designed to u | vark an a spacific | tania Atthe | ainning of the comi | har different tonio |
| | - | • | • | | nar, different topics |
| are handed a | ut by the super | visors and prienv | uiscusseu. witi | init the seminar sem | es, muividual topics |
| are handed o | d and procente | • | | | |
| are develope | d and presented | d. | | | |
| are developed Format of Te | aching Seminar | d. | | | |
| are developed Format of Tea Format of Exa | aching Seminar amination Pres | d. entation | | | |
| are developed Format of Tea Format of Exa Requirement | aching Seminar amination Pres s for the Attrib | d. entation ution of Credit P | oints | | |
| are developed Format of Tex Format of Exa Requirement Active partici | aching Seminar amination Pres s for the Attrib pation in the se | d. entation ution of Credit P essions, presentat | oints | | |
| are developed Format of Tex Format of Exa Requirement Active partici Utilisation of | aching Seminar amination Pres s for the Attrib pation in the se the Module Ele | d. entation ution of Credit P essions, presentat ective Course | oints ion | tion to the final ma | |
| are developed Format of Tex Format of Exa Requirement Active partici Utilisation of Importance of | aching Seminar amination Pres s for the Attrib pation in the se the Module Ele of the Mark for | d. entation ution of Credit P essions, presentat ective Course the Final Mark g | oints ion raded, contribu | tion to the final ma | - |
| are developed Format of Tex Format of Exa Requirement Active partici Utilisation of Importance of | aching Seminar amination Pres s for the Attrib pation in the se the Module Ele of the Mark for rivisor and Inst | d. entation ution of Credit P essions, presentat ective Course the Final Mark g | oints ion raded, contribu | tion to the final ma n, Priv Doz. Dr. Her | - |

| Experimenta | l Method | s in Nuclear a | nd Particle F | Physics | |
|------------------------------|---------------------------|--------------------------|-------------------|-----------------------|-----------------------|
| | Credits | Workload | Semester | Cycle | Duration |
| | 2 CP | 60 h | 1. Sem. | Winter/Summer | 1 Semester |
| | | | | Term | |
| Courses | | | Contact | Self-Study | Group Size |
| | | tal Methods in | Hours | p) 38 h | Students |
| Nuclear | r and Particle | Physics" | u) 22 h | | t) 30 |
| Requirements for | or Participati | on | | | |
| Formal: none | | | | | |
| Content-Wise: r | | | | | |
| Preparation: no | | | | | |
| Learning Outcor | nes | | | | |
| Students will | | | | | |
| • | | | • | and particle physics | |
| Present | the underlyir | ng theoretical co | ncepts | | |
| Learn th | e interpretat | ion of experimer | ntal data | | |
| Have a b | basic knowled | lge of nuclear an | d particle physic | CS | |
| Be awar | e of the prec | ision of measure | ments and the c | uestion of statistics | |
| Contents | | | | | |
| Strong and weal | <pre>c interactions</pre> | . Heavy ion and | neutrino physics | . Quantum field the | ory as underlying |
| theoretical conc | ept. Statistica | al interpretation | of data. | | |
| Format of Teach | ning Seminar | talks by the stud | ents. | | |
| Format of Exam | ination Prepa | aration and subs | equent presenta | ation of a seminar ta | lk to the whole |
| group. | | | | | |
| Requirements for | or the Attrib | ution of Credit P | oints | | |
| Independent pre | eparation of a | a seminar talk ab | out particle dete | ectors and their phy | sics goals. Clear and |
| comprehensive | presentation | of the material t | o the seminar p | articipants. | |
| Utilisation of th | e Module Ele | ective Course | | | |
| Importance of t | he Mark for t | t he Final Mark g | raded, contribut | ion to the final mark | weighed for CP |
| Module Supervi | sor and Instr | uctor Prof. Dr. L | Jlrich Wiedner | | |
| Further Informa | tion | | | | |

| | Credits | Workload | Semester | Cycle | Duration |
|--|---|--|---|---|---|
| | 4 CP | 120 h | 7. Sem. | Summer Term | 1 Semester |
| Courses | | | Contact | Self-Study | Group Size |
| v) Lecture | e "Introductio | on to Nuclear | Hours | q) 38 h | Students |
| and Pa | rticle Physics | 5 II" | v) 22 h | r) 38 h | u) Unlimite |
| w) Exercis | es "Introduc | tion to Nuclear | w) 22 h | | d |
| and Pa | rticle Physics | ill (Exercises)" | | | v) 30 |
| Requirements f | or Participat | ion | | | |
| Formal: none | | | | | |
| Content-Wise: | Basic knowle | dge of nuclear ph | iysics. | | |
| Preparation: no | | | | | |
| Learning Outco | | | | | |
| | • | n of the module | | | |
| | | over the Standard | | • | |
| | | be the most impo | • | | |
| | • | • | | ods and techniques | |
| Have st | udents know | ledge of the basic | c principles of de | etectors for subator | nic particles. |
| Is the co | onnection be | tween theory and | d experiment cle | ear. | |
| modern particle numbers. Detail observation in a | e physics. The s of the strou historical co | e course will explang and weak inten ontext discussed. | ain the connection raction will be p Important expension | mental tools that la on between symme resented and their e rimental discoveries e course including in | tries and quantum experimental and their |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc | e physics. The ls of the stron historical co or the develo ike the disco | e course will explain ng and weak inter ontext discussed. opment of the fiel very of the Higgs | ain the connection raction will be p Important expend d are part of the boson or the ob | on between symme resented and their e | tries and quantum experimental and their nportant no oscillations. Also |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. | e physics. The ls of the stron historical co or the develo ike the disco ok into the fu | e course will expla ng and weak inter ontext discussed. opment of the fiel very of the Higgs ture to address o | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a | on between symme resented and their or rimental discoveries e course including ir pservation of neutrin nd the planned exp | tries and quantum experimental and their nportant no oscillations. Also |
| modern particle numbers. Detail observation in a consequences fo breakthroughs I included is a loc goals. Format of Teacl | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures | e course will explain ng and weak inter ontext discussed. opment of the fiel very of the Higgs ture to address o | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a nort presentation | on between symme resented and their or rimental discoveries e course including ir pservation of neutrin nd the planned exp | tries and quantum experimental and their nportant no oscillations. Also eriments and their |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teacl Format of Exam | e physics. The ls of the stroi historical co or the develo ike the disco k into the fu hing Lectures hination Succ | e course will explain ng and weak inter ontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl cessful and regula | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in | on between symme resented and their e rimental discoveries e course including ir oservation of neutrin nd the planned exp ons of the students in the exercise classe | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor |
| modern particle numbers. Detail observation in a consequences fo breakthroughs I included is a loc goals. Format of Teacl Format of Exam section at least | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures hination Succ 50% of all po | e course will explain on and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o <u>s, exercises and sl</u> cessful and regula | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a mort presentation r participation in dents are asked | on between symme resented and their of rimental discoveries e course including in oservation of neutrin nd the planned exp ns of the students n the exercise classe to present solution | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a |
| modern particle numbers. Detail observation in a consequences fo breakthroughs I included is a loc goals. Format of Teacl Format of Exam section at least least twice durin | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures hination Succ 50% of all po ng the semes | e course will explain on and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o <u>s, exercises and sl</u> cessful and regula | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a mort presentation r participation in dents are asked | on between symme resented and their e rimental discoveries e course including ir oservation of neutrin nd the planned exp ons of the students in the exercise classe | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teacl Format of Exam section at least least twice durin previous lecture | e physics. The ls of the stron historical co or the develo ike the disco k into the fu hing Lectures hination Succ 50% of all po ng the semes e twice. | e course will explain ng and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o <u>s, exercises and sl</u> essful and regula ssible points. Stu | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to | on between symme resented and their of rimental discoveries e course including in oservation of neutrin nd the planned exp ns of the students n the exercise classe to present solution | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a |
| modern particle numbers. Detail observation in a consequences fo breakthroughs I included is a loc goals. Format of Teacl Format of Exam section at least least twice durin previous lecture Requirements f | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures hing Lectures 50% of all po ng the semes twice. | e course will explain ng and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl cessful and regula sible points. Stu ster to the group a oution of Credit P | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to | on between symme resented and their of rimental discoveries e course including in oservation of neutrin nd the planned exp ns of the students n the exercise classe to present solution | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a |
| modern particle numbers. Detail observation in a consequences fo breakthroughs I included is a loc goals. Format of Teacl Format of Teacl Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures hing Lectures to all po ng the semes twice. for the Attrib gter Prüfung | e course will explain on and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl cessful and regula ssible points. Stu ster to the group a oution of Credit Pars | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to oints | on between symme resented and their of rimental discoveries e course including in oservation of neutrin nd the planned exp <u>ons of the students</u> n the exercise classe to present solution o present a short sur | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teacl Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele The students ne | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures hing Lectures of all po ng the semes twice. for the Attrib gter Prüfung eed to obtain | e course will explang and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o <u>s</u> , exercises and sl essful and regula ossible points. Stu ster to the group a sution of Credit P sform: at least 50% of th | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a nort presentation r participation in dents are asked and are asked to oints | on between symme resented and their of rimental discoveries e course including in oservation of neutrin nd the planned exp ons of the students to present solution o present a short sup ts in the weekly pra | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ctice assignments |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teacl Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele The students ne and participate | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures hination Succ 50% of all po ng the semes twice. for the Attrib gter Prüfung eed to obtain actively in th | e course will explain ng and weak inter- ontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl essful and regula ossible points. Stu ster to the group a oution of Credit Par sform: at least 50% of the rediscussion of the | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to oints ne possible poin ne exercises. Also | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp <u>ins of the students</u> n the exercise classe to present a short sum ts in the weekly pra o, twice a short sum | tries and quantum experimental and their mportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ctice assignments mary of the |
| modern particle numbers. Detail observation in a consequences for breakthroughs I included is a loc goals. Format of Teacl Format of Teacl Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele The students ne and participate previous lecture | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures hing Lectures thing Lectures to the semes twice. For the Attrib gter Prüfung eed to obtain actively in the | e course will explang and weak inter- pontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl cessful and regula ssible points. Stu- cetter to the group a ster to the g | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to oints ne possible poin he exercises. Also addition, the ad | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp <u>ons of the students</u> n the exercise classe to present solution o present a short sum ts in the weekly pra o, twice a short sum vanced practical ex | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ctice assignments mary of the ercises (F- |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teach Format of Teach Format of Exam section at least least twice durin previous lecture The students ne and participate previous lecture Praktikum) are n | e physics. The s of the stron historical co or the develo ike the disco k into the fu hing Lectures hing Lectures to a fall po og the semes twice. For the Attrib geter Prüfung eed to obtain actively in the will be pres required. The | e course will explang and weak inter- pontext discussed. opment of the fiel very of the Higgs ture to address o s, exercises and sl cessful and regula ssible points. Stu- cetter to the group a ster to the g | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to oints ne possible poin he exercises. Also addition, the ad | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp <u>ins of the students</u> n the exercise classe to present a short sum ts in the weekly pra o, twice a short sum | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ctice assignments mary of the ercises (F- |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teacl Format of Teacl Format of Exam section at least least twice durin previous lecture The students ne and participate previous lecture Praktikum) are n grade of the mo | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures hination Succ 50% of all po ng the semes twice. For the Attrib gter Prüfung eed to obtain actively in the ewill be pres required. The odule. | e course will explang and weak inter- pontext discussed. opment of the fiel very of the Higgs ture to address o <u>s</u> , exercises and sl essful and regula sisble points. Stu ster to the group a sution of Credit Pa (sform: at least 50% of the ediscussion of the ented in class. In e grades from the | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a <u>nort presentation</u> r participation in dents are asked and are asked to oints ne possible poin he exercises. Also addition, the ad | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp <u>ons of the students</u> n the exercise classe to present solution o present a short sum ts in the weekly pra o, twice a short sum vanced practical ex | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ctice assignments mary of the ercises (F- |
| modern particle numbers. Detail observation in a consequences for breakthroughs I included is a loc goals. Format of Teach Format of Teach Format of Teach Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele The students ne and participate previous lecture Praktikum) are r grade of the mo Utilisation of th | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures ination Succ 50% of all po ng the semes twice. for the Attrib gter Prüfung ed to obtain actively in the will be pres required. The odule. | e course will explang and weak inter- pontext discussed. opment of the fiel- very of the Higgs ture to address o s, exercises and sl essful and regula ssible points. Stu- ster to the group a ster to the group a ster to the group a ster to the group a ster to the group a stat least 50% of the ediscussion of the ented in class. In a grades from the ective Course | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a nort presentation r participation in dents are asked and are asked to oints ne possible poin ne exercises. Also addition, the ad lectures/exercises | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp ms of the students n the exercise classe to present solution present a short sum ts in the weekly pra- o, twice a short sum vanced practical ex- ses and the lab cour | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ercises (F- rse enter both the |
| modern particle numbers. Detail observation in a consequences fo breakthroughs l included is a loc goals. Format of Teach Format of Teach Format of Teach Format of Exam section at least least twice durin previous lecture Requirements f Je nach festgele The students ne and participate previous lecture Praktikum) are n grade of the mo Utilisation of th | e physics. The s of the stron historical co or the develo ike the disco ok into the fu hing Lectures hing Lectures ination Succ 50% of all po ng the semes twice. for the Attrib gter Prüfung ed to obtain actively in the will be pres required. The dule. he Module Eli- | e course will explang and weak inter- pontext discussed. opment of the fiel- very of the Higgs ture to address o s, exercises and sl essful and regula ssible points. Stu- ster to the group a ster to the group a ster to the group a ster to the group a ster to the group a stat least 50% of the ediscussion of the ented in class. In a grades from the ective Course | ain the connection raction will be p Important expend d are part of the boson or the ob pen questions a nort presentation r participation in dents are asked and are asked to oints ne possible poin ne exercises. Also addition, the ad lectures/exercises | on between symme resented and their of rimental discoveries e course including in pservation of neutrin nd the planned exp <u>ons of the students</u> n the exercise classe to present solution o present a short sum ts in the weekly pra o, twice a short sum vanced practical ex | tries and quantum experimental and their nportant no oscillations. Also eriments and their es. In the homewor s to the problems a mmary of the ercises (F- rse enter both the |

| | Credits | Workload | Semester | Cycle | Duration |
|---------------------------------------|--------------------|--------------------|--------------------------------|---|------------------------|
| | 2 CP | 60 h | 1. Sem. | Winter and | 1 Semester |
| | | | | Summer Term | |
| Courses | | | Contact | Self-Study | Group Size |
| x) Semina | ar "Selected | Topics of | Hours | s) 38 h | Students |
| Hadror | n Physics" | - | x) 22 h | | w) 30 |
| Requirements | or Participa | tion: | | | · |
| Formal: none | | | | | |
| Content-Wise: | The seminar | is aimed at Mas | ter students and | PhD students who | are already familiar |
| with the basics | of quantum | field theory, effe | ective field theor | ies and hadron phys | sics. |
| Preparation: no | one | | | | |
| Learning Outco | mes | | | | |
| After successful | ly completin | ng the module, th | ne students | | |
| have an | overview o | f the current res | earch directions | and questions in the | e field of theoretical |
| hadron | physics. | | | | |
| have ex | perience in | preparing and gi | ving a scientific _l | presentation. | |
| Contents | | | | | |
| The event deals | with curren | t developments | in hadron physic | cs. External experts a | are increasingly |
| invited to provi | de the broad | lest possible ove | rview of the res | earch topics. Lecture | es are accompanied |
| by intensive tec | hnical discu | ssions and offer | the opportunity | to exchange ideas w | ith the speakers. |
| Scientific staff f | rom the Dep | partment of Theo | oretical Hadron F | Physics also take par | t in the event. |
| The participatin | g students a | nd doctoral can | didates have the | opportunity to pres | ent their latest |
| results and rece | eive feedbac | k. | | | |
| Format of Teac | hing Semina | r | | | |
| Format of Exam | nination Pres | sentation | | | |
| Requirements | or the Attri | bution of Credit | Points | | |
| | tion in the s | essions, presenta | ation | | |
| Active participa | | lactive Course | | | |
| Active participa Utilisation of th | ie Module E | lective course | | | |
| Utilisation of th | | | graded, contribu | ution to the final ma | rk weighed for CP |
| Utilisation of th Importance of t | the Mark for | the Final Mark | | ution to the final ma m, Priv. Doz. Dr. He | |

| Seminar on Ha | dron Ph | vsics | | | |
|--|--|--|---|---|-------------------------|
| | redits | Workload | Semester | Cycle | Duration |
| 2 | СР | 60 h | 1. Sem. | Winter Term | 1 Semester |
| Courses | | | Contact | Self-Study | Group Size |
| y) Seminar "S | Seminar o | n Hadron | Hours | t) 38 h | Students |
| Physics" | | | y) 22 h | | x) 30 |
| Requirements for I | Participati | on | | | |
| Formal: none | | | | | |
| Content-Wise: non | е | | | | |
| Preparation: none | | | | | |
| Learning Outcome | S | | | | |
| know the bknow the bleaned abo | asic conce pasic conce out differen ght in a sel he field of tector Cor | epts of different epts of detector nt concepts of p ection of histor Hadron Physics trol System, An | erforming data a ical important ex : Detector Techn | logies s and data process nalysis periments and finc iques, Detector Co | lings mponents, Data |
| Format of Teaching | g Seminar | · | | | |
| Format of Examina | i tion none | | | | |
| Requirements for t | the Attrib | ution of Credit I | Points | | |
| Regular attendance | e, at least | 75% of the cont | act hours necess | ary, preparation ar | nd giving of one |
| presentation. Only | | - | d. | | |
| Utilisation of the N | | | | | |
| | | | | ion to the final ma | rk weighed with CP |
| Module Supervisor | | uctor Prof. Dr. | Miriam Fritsch | | |
| Further Informatio | n | | | | |

| Plasma Phy | | | 1 | | [|
|--------------------|------------------------|------------------------------|----------------------|---|-------------------------|
| Modul 4e | Credits 15-25 CP | Workload 450-750 h | Semester 12. Sem. | Cycle Winter & Summer Term | Duration 2 Semesters |
| Courses | | | Contact Hours | • | Group Size |
| q) Lecture | | | Each at least. | mind. 309 h | Students |
| r) Exercises | | | q) 44 h | | q) unlimited |
| s) Seminar (at | | | r) 44 h | | r) 30 |
| - | aboratory Cou | rses (at least 5 | s) 22 h | | s) 30 |
| CP) | | | t) 35 h | | t) 2 |
| A complete ov | | | | | |
| | | atalogue. The CF | | | |
| of the individu | | | | | |
| semester hour | • • | nour per | | | |
| semester weel | | ion | | | |
| Formal: none | | | | | |
| | · Basic knowled | lge of plasma ph | ysics will be expe | octed | |
| Preparation: r | | | ysies will be expe | | |
| Learning Outc | | | | | |
| - | | g the module, the | students | | |
| | | | | s of plasma generati | on and the heating |
| | anisms of plasn | - | | s or plasma generati | |
| | • | | c methods of pla | sma | |
| | | | | oncepts to describe | nlasma in differen |
| | of time and sp | - | | | |
| | • | of measurement | of plasma | | |
| | | | • | eraction with biolog | ical systems or wit |
| | es of fusion ex | | 1 , | | ····· |
| | | | e Einsatzfelder vo | n Plasmen wie die W | /echselwirkung mit |
| | | | | es Fusionsexperiment | |
| Contents | | | | · | |
| Plasma genera | ition; plasma h | eating; plasma d | iagnostics; physic | cs of the plasma bou | ndary layer; plasma |
| surface interac | ction; plasma c | hemistry, plasma | a deposition, plas | sma etching; waves i | n plasmas, etc. |
| | | | | | |
| Format of Tea | ching Lecture, | Exercises, Semin | ar, Laboratory W | /ork | |
| Format of Exa | mination oral | examination of 4 | 5 minutes | | |
| Requirements | for the Attrib | ution of Credit P | oints Passing the | oral examination. | |
| The specialisation | tion module n | nust include: adv | anced laborator | y courses (5 CP), a | seminar (2 CP). |
| Including the f | inal oral modu | le examination (2 | 2 CP), 15-25 CP ca | an be achieved. Achi | evements made |
| after the final | module exami | nation no longer | count towards th | ne module. | |
| Utilisation of t | t he Module Co | mpulsory-Electiv | ve Module | | |
| Importance of | the Mark for | the Final Mark V | Veighed accordin | g to Credit Points | |
| Module Super | visor Prof. Dr. | von Keudell | | | |
| Examiner Prof | . Dr. Czarnetzk | i, Jun-Prof. Dr. G | olda, Prof. Dr. Gr | auer, Jun-Prof. Dr. Ir | nocenti, Prof. Dr. |
| von Keudell, P | rof. Dr. Tjus, Pl | D Dr. Fichtner | | | |
| Further Inforn | nation For adv | ice and coordinat | tion of the course | es, please contact th | e module |
| supervisor. Ple | ase see the <u>co</u> | <u>urse list</u> below. | | | |
| | | | | | |
| Minton Como | tor | | | | |
| Winter Semes | lei | | | | |

| 160502 Introduction to Plasma Physics II (Exercises) | von Keudell, Achim | Exercises | | | | | | |
|--|---|----------------------|--|--|--|--|--|--|
| 160515 Modeling of Atomic Populations in the Spectro | ••••••• | • • | | | | | | |
| Plasmas | Marchuk, Oleks | andr <i>Lecture</i> | | | | | | |
| 160516 Modeling of Atomic Populations in the Spectro | scopy of Laboratory and | d Astrophysical | | | | | | |
| Plasmas (Exercises) | Marchuk, Oleksandr | Exercises | | | | | | |
| 160618 Introduction to Space Physics | Fichtner, Horst | Lecture | | | | | | |
| 160619 Introduction to Space Physics (Exercises) | Fichtner, Horst | Exercises | | | | | | |
| 160511 Confinement Concepts and Advanced Materials for Extreme Environments Linsmeier, | | | | | | | | |
| Christian; Unterberg, Bernhard; Coenen, Jan | | Lecture | | | | | | |
| 160521 Problems of Modern Plasma Physics | Czarnetzki, Uwe; Lugge | nhölscher, Dirk | | | | | | |
| | | Seminar | | | | | | |
| 160522 Applied Plasma Physics | von Keudell, Achim; Bö | ke, Marc; Schulz-von | | | | | | |
| der Gathen, Volker; Golda, Judith | | Seminar | | | | | | |
| 160517 Selected Topics of Plasma Theory Grauer, | , Rainer; Dreher, Jürgen | Seminar | | | | | | |
| 160523 Compact Course: "Low Temperature Plasma Pl | nysics: Basis and Applica | tions" and Master | | | | | | |
| Class "Low Temperature Plasma Physics" von Kei | udell, Achim; Böke, Marc | ; Schulz-von der | | | | | | |
| Gathen, Volker | | Compact Seminar | | | | | | |
| 160510 Turbulence and Transport in Fusion Plasmas | Püschel, M.J. | Lecture | | | | | | |
| 160526 Plasma Kinetics for Experimentalists Tsanko | v, Tsanko | Compact Seminar | | | | | | |
| 160250 Advanced Laboratory Course for Physics Stude | nts Krebs, Hermani | n; Reicherz, Gerhard | | | | | | |
| | | Laboratory | | | | | | |
| | | - | | | | | | |
| Summer Semester | | | | | | | | |
| 160505 Plasma Diagnostics Schulz-von der | Gathen, Volker | Lecture | | | | | | |
| 160506 Plasma Diagnostics (Exercises) Schulz-von der | | Exercises | | | | | | |
| 160510 Surface Physics and Chemistry Linsmeier, Chris | | Lecture | | | | | | |
| 160513 Introduction to Nuclear Fusion - Plasma- Wall- | Interactions and Plasma | a Edge Physics | | | | | | |
| Unterberg, Ber | | Lecture | | | | | | |
| 160511 Modeling of Atomic Populations in the Spectro | scopy of Laboratory and | d Astrophysical | | | | | | |
| Plasmas II March | uk, Oleksandr | Lecture | | | | | | |
| 160512 Modeling of Atomic Populations in the Spectro | scopy of Laboratory and | d Astrophysical | | | | | | |
| Plasmas II (Exercises) Marchuk, Oleks | sandr | Exercises | | | | | | |
| 160529 Introduction to Hydrodynamics Fichtne | r, Horst | Lecture | | | | | | |
| 160530 Introduction to Hydrodynamics (Exercises) | Fichtner, Horst | Exercises | | | | | | |
| 160664 Magnetohydrodynamic Turbulence and Recon | nection Scherer, Klaus | Lecture | | | | | | |
| 160522 Problems of Modern Plasma Physics (Seminar) | | | | | | | | |
| , , , , | , | Seminar | | | | | | |
| 160523 Applied Plasma Physics (Seminar) von Kei | udell, Achim; Golda, Judi | | | | | | | |
| Gathen, Volker; Böke, Marc | , , , , | Seminar | | | | | | |
| 160558 Seminar on Space Plasma Physics (Seminar) | Innocenti, Maria Elena; | | | | | | | |
| Dargent, Jérémy | ,, | Seminar | | | | | | |
| 160250 Advanced Laboratory Course for Physics Stude | nts Krebs, Hermanı | n; Reicherz, Gerhard | | | | | | |
| , | , - | Laboratory | | | | | | |
| L | | | | | | | | |

| | Credits | Workload | Semester | Cycle | Duration |
|----------|--|---------------------|------------------|-----------------------|------------------------|
| | 5 CP | 120 h | 1. Sem. | Winter Term | 1 Semester |
| Courses | | - | Contact | Self-Study | Group Size |
| z) Lectu | are "introduction to | Plasma Physics | Hours | , 76 h | Students |
| II" (4 | | | z) 22 h | | y) unlimited |
| - | Exercises "Introduc ics II (Exercises)" (1 C | | aa) 22 h | | z) 30 |
| • | ments for Participati | on | | | |
| Formal: | | | | | |
| | -Wise: none | a in the field of a | | | |
| - | Physics I" desirable b | | | e.g. through the led | cture "Introduction to |
| | | | y. | | |
| | g Outcomes: uccessful completior | of the module | | | |
| | students have a basi | | of the essential | characteristics of a | low-temperature |
| | plasma | | | | low temperature |
| | students know the h | eating methods a | nd ignition phe | enomena of a plasm | а |
| | students can assess | - | | | |
| | | | | | |
| Content | S | | | | |
| | Introduction: Overvi models, electrotechi | | ure plasmas, p | lasmas and their s | urface layers, plasma |
| | | | | ments, ignition of | a plasma volume vs |
| | surface mechanisms | | - | aating Mayo Hoati | ng Clobal Madal fa |
| | describing Plasmas, I | | - | eating, wave neati | ng, Global Model fo |
| | Low pressure Plasma | - | | MS | |
| | Atmospheric pressur | | - | | |
| Format | of Teaching Lecture, | Exercise | | | |
| Format | of Examination At th | ne beginning of th | e course, the l | ecturer determines | the form of |
| | · | | , | cipation in the exerc | ises) for the lecture. |
| • | ments for the Attrib | | | | |
| • | ing on the specified i | | | | |
| - | | - | | | he weekly exercises. |
| | on, in this case, active letermined at the be | | | s manualory. The to | in or examination |
| | on of the Module El | | ui 30. | | |
| | ince of the Mark for | | raded, contribu | ution to the final ma | rk weighed for CP |
| - | Supervisor and Inst | - | | | - |
| | Information | | | | |

Modelling of Atomic Populations in the Spectroscopy of Laboratory and Astrophysical Plasmas II

| Astrophysica | al Plasmas | II | | | | |
|--|--|--------------------|-------------------|-----------------------|-----------------------|--|
| | Credits | Workload | Semester | Cycle | Duration | |
| | 4 CP | 120 h | 2. Sem. | Summer Term | 1 Semester | |
| Courses | | | Contact | Self-Study | Group Size | |
| bb) Lecture "Modelling of Atomic | | Hours | 76 h | Students | | |
| Populations in the Spectroscopy of | | bb) 22 h | | aa) unlimited | | |
| Laboratory a | Laboratory and Astrophysical Plasmas II" | | cc) 22 h | | bb) 30 | |
| cc)Exercises | "Modelling | of Atomic | _ | | | |
| Populations in the Spectroscopy of | | | | | | |
| Laboratory and Astrophysical Plasmas II | | | | | | |
| (Exercises)" | | | | | | |
| Requirements f | or Participatio | on | | | | |
| Formal: none | | | | | | |
| Content-Wise: r | none | | | | | |
| Preparation: no | ne | | | | | |
| Learning Outco | mes | | | | | |
| After successful | ly completing | the module, the | students | | | |
| have a | basic understa | anding of atomi | c processes rele | evant to spectroscop | pic investigations in | |
| laborato | ory and astrop | hysical plasmas. | | | | |
| are awa | ire of the pos | sibilities of appl | ying numerical i | methods in other a | reas of astrophysics | |
| and plas | sma physics. | | | | | |
| are fam | iliar with the b | asic concepts of | f the Stroß radia | tion models and des | cribe the important | |
| interrela | ationships of p | lasma spectroso | сору. | | | |
| • are familiar with modern methods of plasma spectroscopy as well as on-line tools like FLYCHK | | | | | | |
| (https:// | /nlte.nist.gov/ | FLY/) or | atomic | and spectroso | copic database | |
| (https://physics.nist.gov/PhysRefData/ASD/lines_form.html) | | | | | | |
| can reco | ognise connec | tions between a | atomic and plase | ma physics and app | ly them to different | |
| spectroscopic observations | | | | | | |
| Contents | | | | | | |
| | | | • | asma spectroscopy. | | |
| topics of atomic physics are explained, which are necessary for the understanding of the most important atomic processes. Previous knowledge from quantum mechanics is deepened. The most | | | | | | |
| • | • | | • | | • | |
| | | - | | dation of plasma sp | | |
| • | | | | nd from astrophysic | - | |
| • • • | | | | vailable atomic cod | | |
| | | | | liar with the current | status of atomic | |
| models and can | · · · · | | roblems in resea | arch if required. | | |
| Format of Teach Format of Exam | • | | F minutos | | | |
| | | | | | | |
| Requirements for Depending on the | | | | | | |
| | • | | | possible points in th | a waaklu avaraica | |
| - | | - | | ompulsory. The form | | |
| determined at t | - | | | | | |
| | | | | | | |
| | Utilisation of the Module Elective Course Importance of the Mark for the Final Mark graded, contribution to the final mark weighed for CP | | | | | |
| | Module Supervisor and Instructor Priv. Doz. Dr. Oleksanr Marchuk | | | | | |
| | | ILLOI FILV. DUZ. | | ICIUN | | |

Further Information

| | Credits | Workload | Semester | Cycle | Duration |
|--|---|--|---|---|--|
| | 4 CP | 120 h | 2. Sem. | Summer Term | 1 Semester |
| Courses | | | Contact | Self-Study | Group Size |
| dd) Lectur | e "Plasma Dia | gnostics" | Hours | u) 38 h | Students |
| ee) Exercis | ses "Plasma D | iagnostics" | dd) 22 h | v) 38 h | cc) 30 |
| | | | ee) 22 h | | |
| Requirements | for Participat | tion | | | |
| Formal: none | | | | | |
| Content-Wise: | none | | | | |
| Preparation: n | one | | | | |
| Learning Outco | omes | | | | |
| After successfu | Illy passing th | e module, the st | udents | | |
| • Know | the most impo | ortant diagnostic | al methods | | |
| • Know | to make the | appropriate cho | pice of a diagn | ostical method for t | he measurement o |
| define | d parameters | of a plasma | _ | | |
| Verste | hen Studiere | nde die richtige | e Auswahl eine | r Diagnostikmethod | e zu treffen für die |
| Bestim | imung von de | finierten Kenngr | ößen eines Plas | mas | |
| | | | | | |
| | | | | | |
| | | | | | |
| The lecture int | | | | liagnostics. The esse | - |
| The lecture int atomic physica | l concepts are | e introduced. The | e lecture begins | with the presentation | on of measurement |
| The lecture int atomic physica and analysis of | l concepts are electrical par | e introduced. The rameters e.g., fro | e lecture begins om a probe mea | s with the presentations with the presentation surement. The spect | on of measurement roscopic methods |
| The lecture int atomic physica and analysis of are explained i | l concepts are electrical par n detail, the p | e introduced. The rameters e.g., fro parameters that (| e lecture begins om a probe mea can be directly a | with the presentations with the presentation surement. The spect and indirectly derived | on of measurement roscopic methods d from them, e.g., |
| The lecture int atomic physica and analysis of are explained i electron densit | l concepts are electrical par n detail, the p ty and temper | e introduced. The rameters e.g., fro parameters that rature, are discus | e lecture begins om a probe mea can be directly a ssed, and the re | with the presentation surement. The spect and indirectly derived spective area of app | on of measurement croscopic methods d from them, e.g., lication as well as |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th | I concepts are electrical par n detail, the p ty and temper e methods ar | e introduced. The rameters e.g., fro parameters that e rature, are discus e shown. Particu | e lecture begins om a probe mea can be directly a ssed, and the re llar emphasis is | with the presentation surement. The spect and indirectly derived spective area of app also placed on teach | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta |
| atomic physica and analysis of are explained i electron densit the limits of th methodology, | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode | e introduced. The rameters e.g., fro parameters that rature, are discus e shown. Particu e of operation an | e lecture begins om a probe mea can be directly a ssed, and the re llar emphasis is d use of optical | with the presentation is with the presentation is uncertained indirectly derived is prective area of app also placed on teach components and de | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode coptical meth | e introduced. The rameters e.g., fro parameters that rature, are discus e shown. Particu e of operation an ods, energy-resc | e lecture begins om a probe mea can be directly a ssed, and the re llar emphasis is d use of optical | with the presentation surement. The spect and indirectly derived spective area of app also placed on teach | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de | e introduced. The rameters e.g., fro parameters that e rature, are discus e shown. Particu e of operation an ods, energy-resc ealt with. | e lecture begins om a probe mea can be directly a ssed, and the re llar emphasis is d use of optical | with the presentation is with the presentation is uncertained indirectly derived is prective area of app also placed on teach components and de | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Tea | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de ching Lecture | e introduced. The rameters e.g., fro parameters that o rature, are discus e shown. Particu e of operation an ods, energy-reso ealt with. , Exercises | e lecture begins om a probe mea can be directly a ssed, and the re lar emphasis is d use of optical plved mass spec | with the presentation is with the presentation is with the presentation is prective area of app also placed on teach components and de troscopy for the deter | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Tear | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de ching Lecture mination Deli | e introduced. The rameters e.g., fro parameters that of rature, are discuss e shown. Particu e of operation an lods, energy-resc ealt with. , Exercises very of a coursev | e lecture begins om a probe mea can be directly a ssed, and the re lar emphasis is d use of optical plved mass spec | with the presentation is with the presentation is uncertained indirectly derived is prective area of app also placed on teach components and de | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Teau or an interview | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also do ching Lecture mination Deli v with the lect | e introduced. The rameters e.g., fro parameters that o rature, are discus e shown. Particu e of operation an ods, energy-reso ealt with. , Exercises very of a coursey turer. | e lecture begins om a probe mea can be directly a ssed, and the re ilar emphasis is id use of optical plved mass spec work The course | with the presentation is with the presentation is with the presentation is prective area of app also placed on teach components and de troscopy for the deter | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Tea format of Exa or an interview | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de ching Lecture mination Deli y with the lect for the Attrik | e introduced. The rameters e.g., fro parameters that of rature, are discuss e shown. Particu e of operation an ods, energy-reso ealt with. , Exercises very of a courses turer. | e lecture begins om a probe mea can be directly a ssed, and the re ilar emphasis is id use of optical olved mass spec work The course Points | with the presentation is with the presentation is with the presentation is present the spect and indirectly derived is present of app also placed on teach components and de troscopy for the deter ework can take the for | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Teau or an interview Requirements Passing the exa | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de ching Lecture mination Deli with the lect for the Attrik | e introduced. The rameters e.g., fro parameters that of rature, are discuss e shown. Particu e of operation an ods, energy-resc ealt with. , Exercises very of a course turer. bution of Credit I h at least 50% of | e lecture begins om a probe mea can be directly a ssed, and the re ilar emphasis is id use of optical olved mass spec work The course Points | with the presentation is with the presentation is with the presentation is present the spect and indirectly derived is present of app also placed on teach components and de troscopy for the deter ework can take the for | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Tear Format of Tear or an interview Requirements Passing the exa | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also do ching Lecture mination Deli with the lect for the Attrik amination wit he Module El | e introduced. The rameters e.g., fro parameters that of rature, are discuss e shown. Particuss e of operation an ods, energy-reso ealt with. , Exercises very of a courses turer. pution of Credit I h at least 50% of lective Course | e lecture begins om a probe mea can be directly a ssed, and the re- ilar emphasis is id use of optical olved mass spec work The course Points f the achievable | with the presentation is with the presentation is urement. The spect and indirectly derived is pective area of app also placed on teach components and de troscopy for the deter ework can take the for points. | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |
| The lecture int atomic physica and analysis of are explained i electron densit the limits of th methodology, addition to the molecules and Format of Teau or an interview Requirements Passing the exa Utilisation of t | I concepts are electrical par n detail, the p ty and temper e methods ar i.e., the mode optical meth ions is also de ching Lecture mination Deli with the lect for the Attrik amination wit he Module El the Mark for | e introduced. The rameters e.g., fro parameters that of rature, are discuss e shown. Particuss e of operation an ods, energy-reso ealt with. , Exercises very of a courses turer. pution of Credit I h at least 50% of lective Course | e lecture begins om a probe mea can be directly a ssed, and the re- ilar emphasis is d use of optical olved mass spec work The course Points f the achievable graded, contribu | with the presentation is urement. The spect and indirectly derived ispective area of app also placed on teach components and de troscopy for the dete ework can take the for points. | on of measurement croscopic methods d from them, e.g., lication as well as ing the experimenta vices. Finally, in ection of atoms, |

Modul 5.x Compulsory Elective Modules from the Minor Subject

Modules amounting to 5-18 CP can be brought in from the range of other faculties and their subjects. However, should you plan to **write the Master's thesis in the minor subject**, 15 CP must be taken in the minor subject in which the thesis is written.

| Minor Subject: | Modules | | | |
|-----------------------|---|--|--|--|
| Analytical Chemistry | Methods of Structure Analysis II | | | |
| Anorganic Chemistry: | Anorganical Chemistry II | | | |
| | Block Courses Anorganical Chemistry | | | |
| Biochemistry | Laboratory Biochemical Working Techniques | | | |
| | Introduction to Biochemistry | | | |
| | Biochemistry I | | | |
| Physical Chemistry | Laser Spectroscopy Laboratory | | | |
| | Rasterforce Microscopy Laboratory | | | |
| | Biophysical Chemistry I | | | |
| | Biophysical Chemistry II | | | |
| | Physical-Chemical Laboratory | | | |
| | Physical Chemistry II | | | |
| | Concepts of Spectroscopy and Introduction in Laser Spectroscopy | | | |
| | Concepts of Spectroscopy II | | | |
| Technical Chemistry | Technical Chemistry I | | | |
| | Technical Chemistry II | | | |
| | Chemical-Technical Laboratory for Physicists | | | |
| Theoretical Chemistry | Theoretical Chemistry I | | | |
| | Theoretical Chemistry II | | | |
| | Theoretical Chemistry III | | | |
| | Theoretical-Chemical Laboratory for Physicists | | | |

from the range of courses offered by the Faculty of **Chemistry and Biochemistry**:

From the range of courses from the Faculty of **Geosciences**:

| Minor Subject: | Modules |
|----------------|---|
| Geophysics* | Theoretical Geophysics |
| | Evaluation and Interpretation of Geophysical Data |
| | Dynamics of the Earth |
| | Exploration Goephysics |

*we recommend an in-person interview with the student counsellor of geophysics, before taking this minor subject!

From the range of courses from the Faculty of **Electrical Engineering and Information Technology:**

| Minor Subject: | Modules | |
|--------------------------|--|--|
| Plasmatechnology* | Plasmatechnology I | |
| | Fields, Waves and Particles | |
| Nanoelektronics** | Solid State Electronics | |
| | Nanoelektronics | |
| Microelektronics | VLSI-Design | |
| | Integrated Digital Circuits | |
| Technology of Energy | Introduction to Technology of Energy Systems | |
| Systems | | |
| | Technology of Regenerative Electric Energy | |
| Communication Technology | Systems of High Frequency Technology | |
| | Digital Processing of Signals | |
| Medical Technology | Ultrasound in Medicin | |
| | Tomographical Imaging in Medicin | |
| | Image Processing in Medicin | |

*ONLY if the specialisation in physics is NOT in plasma physics

** ONLY if the specialisation in physics is NOT in solid state physics

From the range of courses from the Faculty of **Mechanical Engineering**:

| Minor Subject: | Modules | | | |
|--------------------------|------------------------------------|--|--|--|
| Laser Application | Laser Technology | | | |
| Technology* | | | | |
| | Laser Measurement Technology | | | |
| | Laser Manufacturing Technology | | | |
| | Laser Technology in Medicin | | | |
| Systems and Economics of | | | | |
| Energy | Energy Economics | | | |
| | Energy Conversion Systems | | | |
| | Regenerative Energy | | | |
| | Technology of Nuclear Power Plants | | | |
| | Technology of Nuclear Reactors | | | |
| | Water Power Plants | | | |
| Material Sciences | Basic Materials | | | |
| | Material Sciences I | | | |
| | Material Sciences II | | | |
| | Polymere Materials | | | |
| | Light Metals and Composites | | | |
| | Electron and X-Ray Diffraction | | | |

*All examinations are oral Examinations. A personal registration is required

From the range of courses from the Faculty of Mathematics:

| Minor Subject: | Modules | | | |
|------------------------|--|--|--|--|
| Algebra | Algebra I | | | |
| | Algebra II (Commutative Algebra and Algebraic Geometry) | | | |
| | Numbers Theory | | | |
| | Theory of Representation of Lie-Groups | | | |
| Geometry/Topology | Curves and Areas | | | |
| | Differential Geometry I | | | |
| | Differential Geometry II | | | |
| | Differential Topology | | | |
| | Topology I | | | |
| | Algebraic Topology | | | |
| Analysis | Functional Analysis | | | |
| | Function Theory I | | | |
| | Function Theory II | | | |
| | Common Differential Equations | | | |
| | Partial Differential Equations I | | | |
| | Curves and Areas | | | |
| | Differential Geometry I | | | |
| | Differential Geometry II | | | |
| | Differential Topology | | | |
| Numerical Mathematics | Numerics I (Numerical Treament of Differential Equations I) | | | |
| | Numerics II (Numerical Treatment of Differential Equations II) | | | |
| | Optimisation | | | |
| Probability Theory and | | | | |
| Statistics | Probability Theory I | | | |
| | Probability Theory II (Stochastical Models) | | | |
| | Statistics I | | | |
| | Statistics II | | | |
| | Mathematical Physics | | | |
| | Financial Mathematics | | | |
| | Number Series | | | |
| Computer | Theoretical Computer Science | | | |
| Science/Cryptography | | | | |
| | Complexity Theory | | | |
| | Cryptography | | | |
| | Approximation Theory | | | |
| | Data Structures | | | |
| | Databank Systems | | | |
| | Discrete Mathematics I | | | |
| | Quantum Algorithms | | | |
| | Efficient Algorithms | | | |
| | Cryptanalysis | | | |
| | Theory of Machine Learning | | | |
| | Algorithmic Geometry | | | |
| | Cryptographic Protocols | | | |

From the range of courses from the Faculty of **Neuroinformatics**:

| Minor Subject: | Modules |
|------------------|--|
| Neuroinformatics | Computational Neuroscience: Neural Dynamics |
| | Computational Neuroscience: Vision and Memory |
| | Autonomous Robotics (lab course) |
| | Autonomous Robotics: Action, Perception and Cognition |
| | Machine Learning: Unsupervised Methods |
| | Machine Learning: Supervised Methods |
| | Machine Learning: Evolutionary Algorithms |
| | Introduction to Deep Learning for Computer Vision (lab course) |
| | Introduction to Perception |
| | The Neural Basis of Vision (seminar) |
| | Computational Cognitive Modeling (seminar) |
| | Deep Learning Computer Vision |

From the range of courses from the **ICAMS**:

| Minor Subject: | Modules |
|-------------------|--|
| Material Sciences | Elements of Microstructure |
| | Assessment and Description of Materials Properties |
| | Materials Processing |
| | Atomistic Simulation Methods |
| | Advanced Atomistic Simulation Methods |
| | Interfaces and Surfaces |
| | Application and Implementation of Electronic Structure Methods |
| | Phase Field Theory and Application |
| | Phase Field Theory II |
| | Programming Concepts in Materials Science |
| | Quantum Mechanics in Materials Science |
| | Microstructure and Mechanical Properties |
| | Continuum Methods in Materials Science |
| | The Calphad Method |
| | Multiscale Modeling in Materials Science |
| | Numerical Simulation of Fracture of Materials |
| | Lattice Boltzmann Modelling: From Simple Flows to Interface Driven |
| | Phenomena |
| | Modelling of Metal Plasticity in Finite Element Analysis |
| | Solidification Processing |
| | Stochastische Prozesse |

| Computatio | nal Physic | s I | | | |
|--|-----------------------|-------------------------|------------------------|-----------------------|-------------------------|
| Module 6a | Credits | Workload | Semester | Cycle | Duration |
| | 4 CP | 120 h | from 5. Sem. | Winter Term | 1 Semester |
| Courses | | · | Contact Hours | Self Study | Group size |
| a) Lecture Com | putational P | hysics I | a) 22 h | 76 h | Students |
| b) Exercises Computational Physics Ib) 22 ha) unlimitedb) 30 | | | | | |
| Requirements f Formal: none | for Participat | ion | | | |
| Content-Wise: | none | | | | |
| Preparation: no | one | | | | |
| Learning Outco | mes | | | | |
| After successful | lly completin | g the module, th | ne students | | |
| | | - | | methods and pro | cedures for dealing |
| | ysical proble | - | | • | 0 |
| • | • • | | crete implementat | tion and verification | on |
| | - | | , hysical model pro | | |
| | | | | | |
| Contents | | | | | |
| | | - | | - | ations, linear systems |
| of equations, FI | T, Monte Ca | rlo methods, pra | actical exercises w | ith Matlab, Pytho | n or Julia. |
| Format of Teac | hing Lecture, | , Exercises | | | |
| Format of Exam | nination At th | e beginning of tl | ne course, the lect | urer determines t | he form of examination |
| (written examin | nation of 90 | min, oral exam | ination of 45 mir | n or an exercise o | certificate with weekly |
| homework and | active partic | ipation in the ex | ercises) for the lea | cture. | |
| Requirements | fort he attrib | ution of Credit I | Points Depending | on the specified f | orm of examination: |
| Passing the wri | tten/oral exa | amination or ob | taining at least 5 | 0% of the possibl | e points in the weekly |
| exercises. In thi | s case, active | e participation in | the exercise is al | so compulsory. Th | ne form of examination |
| is determined a | t the beginni | ing of the course | | | |
| Utilisation of th | ne Module Ke | ey Competences | | | |
| Importance of | the Mark for | the Final Mark | Weighed accordin | g to Credit Points | |
| Module Superv | visor and Inst | ructor Jun-Prof. | Dr. Innocenti | | |
| Further Inform | ation | | | | |

| Module 6b | Credits | Workload | Semester | Cycle | Duration |
|-----------------------------------|--|---------------------------|----------------------|---------------------|--|
| | 4 CP | 120 h | From 5. Sem. | Summer Term | 1 Semester |
| Courses | | | Contact Hours | • | Group size |
| c) Lecture Con | • | • | c) 22 h | 76 h | Students |
| a) Exercises Co | omputational F | Physics II | a) 22 h | | c) unlimited a) 30 |
| Requirements | for Participati | ion | | | |
| Formal: none | knowladge fr | om Computatio | nal Dhysics Lwill h | approxiated | |
| Preparation: n | - | om computatio | nal Physics I will b | e appreciated | |
| | | | | | |
| Learning Outco | | g the module, th | o students | | |
| | | | | thods and applica | tions in physics |
| | | - | | • • | |
| | • | | | e of numerical me | |
| | Carlo method | • | of multiscale met | nods, stochastic d | ifferential equations, |
| | | possibilities of p | aarallolication | | |
| | illar with the | possibilities of t | Jaranensation | | |
| | | | | | |
| Cell met - Stocha - Paralle | hods (Boris-Pustic differentia stic differentia | ush). al equations, Mo | onte Carlo methoo | • | e Method, Particle in prithm, Ising model |
| Format of Tead | ching Lecture, | Exercises | | | |
| Format of Exam | nination At the | e beginning of th | ne course, the lect | urer determines th | e form of examination |
| (written exami | nation of 90 | min, oral exam | ination of 45 mir | n or an exercise c | ertificate with weekly |
| homework and | active partici | pation in the ex | ercises) for the lea | cture. | |
| Requirements | fort he attribu | ution of Credit F | Points Depending | on the specified fo | orm of examination: |
| Passing the wr | itten/oral exa | mination or ob | taining at least 50 | 0% of the possible | e points in the weekly |
| exercises. In th | is case, active | participation in | the exercise is als | so compulsory. Th | e form of examinatior |
| is determined a | at the beginnir | ng of the course | | | |
| Litilisation of t | he Module Ke | y Competences | | | |
| ounsation of t | the Mark for f | the Final Mark | Weighed accordin | g to Credit Points | |
| | | | | | |
| Importance of | | uctor Jun-Prof. | - | | |

| Module 6c | Credits | Workload | Semester | Cycle | Duration | | | |
|--|--|--|---|---|--|--|--|--|
| | 5 CP | 120 h | ab 4. Sem. | WiSe & SoSe | 1 Semester | | | |
| Courses | | | Contact Hours | | Group Size | | | |
| a) Seminar En | | | a) 22 h | 98 h | Students | | | |
| | omy and Othe | r Subjects | | | a) 30 | | | |
| (from Level | | | | | b) unlimited | | | |
| b) Online-Exer | | | | | | | | |
| Requirements | • | | | f faile | 1 | | | |
| | | otitude through a | an entrance test (| cf. www.zfa.rub.c | ie) | | | |
| Content-Wise: | | | | | | | | |
| Preparation: n | | | | | | | | |
| Learning Outco | | the medule th | a studanta | | | | | |
| | | g the module, th | | | | | | |
| • | | | | | omprehensible way | | | |
| | • | | • | | eading techniques. | | | |
| | | | and evidence to d | | | | | |
| | | | d form of differe | nt types of texts | and apply this | | | |
| - | | in self-produced | | Constant Productions | | | | |
| | | | | - | nd reading texts and | | | |
| | | • | • | • | - | | | |
| are able to | о таке а тори | communicate this clearly, precisely, and concisely to others, both orally and in writing are able to make a topic of interest accessible to non-experts (laypersons) in a lecture and to | | | | | | |
| answer questions on it | | | | | | | | |
| | | | | | | | | |
| • re able to | express and as | sk for personal p | oints of view and | - | ate arguments and | | | |
| • re able to counter-ar | express and as guments and | sk for personal p point out advant | oints of view and | - | ate arguments and sion on specialised | | | |
| • re able to counter-ar | express and as guments and | sk for personal p | oints of view and | - | - | | | |
| • re able to counter-ar | express and as guments and | sk for personal p point out advant | oints of view and | - | - | | | |
| • re able to counter-ar | express and as guments and | sk for personal p point out advant | oints of view and | - | - | | | |
| re able to counter-ar topics and | express and as guments and | sk for personal p point out advant | oints of view and | - | - | | | |
| re able to counter-ar topics and Contents | express and as guments and topics of their | sk for personal p point out advant r own interest | oints of view and tages and disadva | ntages in a discus | sion on specialised | | | |
| re able to counter-artopics and Contents The course is d | express and as guments and topics of their livided into a f | sk for personal p point out advant r own interest face-to-face phas | oints of view and tages and disadva | ntages in a discus | sion on specialised | | | |
| re able to counter-artopics and Contents The course is d times). The foc | express and as guments and topics of their livided into a f cus of the face | sk for personal p point out advant r own interest ace-to-face phas -to-face course i | oints of view and tages and disadva se (2 hours) and a s on the commun | ntages in a discus n online phase (fr icative use of lang | sion on specialised reely divisible practice guage in reception, | | | |
| re able to counter-ar topics and Contents The course is d times). The foc production, int | express and as guments and topics of their livided into a f cus of the face ceraction and i | sk for personal p point out advant r own interest ace-to-face phas -to-face course i mediation, both | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo | ntages in a discus n online phase (fr icative use of lang oken form. Variou | eely divisible practice guage in reception, is reading strategies | | | |
| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud | ntages in a discus n online phase (fr icative use of lang oken form. Variou io and visual text | reely divisible practice guage in reception, us reading strategies s on Moodle. | | | |
| re able to counter-artopics and Contents The course is datimes). The foc production, intare taught and Furthermore, taught and | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s | sk for personal p point out advant r own interest ace-to-face phas -to-face course i mediation, both students work w cabulary in the f | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and | ntages in a discus n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended | | | |
| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and Furthermore, t Learning: The course | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s the specific voi course is accor | sk for personal p point out advant r own interest ace-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spo | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and | ntages in a discus n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra | reely divisible practice guage in reception, us reading strategies s on Moodle. | | | |
| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and Furthermore, t Learning: The c course. It there | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s the specific voi course is accor efore consists | sk for personal p point out advant r own interest ace-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spo | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and | ntages in a discus n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended | | | |
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| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and Furthermore, t Learning: The course. It there face-to-face moodle course | express and as guments and topics of their livided into a f cus of the face eraction and r applied, and s the specific voi course is accor efore consists course. rse in blended | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spo of two parts: learning format | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th | ntages in a discus n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i ne help of the ma | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided | | | |
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| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and Furthermore, t Learning: The c course. It there face-to-face moodle cours 4-5 different ty | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s che specific vor course is accor efore consists course. rse in blended vpes of texts a ching: Semina | sk for personal p point out advant r own interest ace-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spo of two parts: learning format re written and re | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th evised on the basi | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the mar s of individual fee | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. | | | |
| re able to counter-artopics and Contents The course is divided times). The fociproduction, interproduction, interproductin, interproducti | express and as guments and topics of their livided into a f cus of the face eraction and r applied, and s the specific voi course is accor efore consists course. rse in blended pes of texts a ching: Semina mination: Pres | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spe of two parts: learning format re written and re r, practical exerce sentation, writte | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th evised on the basi cises in portfolio, Listen | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the ma s of individual fee | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. | | | |
| re able to counter-ar topics and Contents The course is d times). The foc production, int are taught and Furthermore, t Learning: The course. It there face-to-face moodle cours 4-5 different ty Format of Tear Format of Example | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s the specific vor course is accor efore consists course. rse in blended upes of texts a ching: Semina mination: Press | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spe of two parts: learning format re written and re r, practical exerce sentation, writte | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th evised on the basi cises in portfolio, Listen | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the ma s of individual fee | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. | | | |
| re able to counter-artopics and Contents The course is datimes). The foctor production, intrate taught and Furthermore, the course. It there are taught and Furthermore, the course. It there are the course to the course the examination of the course the examination of the examin | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s the specific vor course is accor efore consists course. rse in blended ypes of texts a ching: Semina mination: Press for the Attrib on | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spe of two parts: learning format re written and re r, practical exerce sentation, writte | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th evised on the basi cises in portfolio, Listen | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the ma s of individual fee | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. | | | |
| re able to counter-artopics and Contents The course is detimes). The foctor production, intare taught and Furthermore, the course. It there are taught and Furthermore, the course. It there are the course. It there are and the course are the course are the course are the examination of the course are the examination of the course. | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s che specific vor course is accor efore consists course. rse in blended ypes of texts a ching: Semina mination: Press for the Attrib on he Module Ke | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spe of two parts: learning format re written and re r, practical exerce sentation, writte ution of Credit F | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with th evised on the basi cises in portfolio, Listen | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the mar s of individual fee hing-discussion te cipation in the se | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. st of c. 30 min minars (>75%), passir | | | |
| re able to counter-artopics and Contents The course is datimes). The foc production, intare taught and Furthermore, the course. It there are taught and Furthermore, the course. It there are taught and furthermore, the course. It there are taught and the course. It there are taught and the course are taught and the course. It there are are taught and the course are taught and the course. It there are taught and the course are taught and the course. It there are taught are taught and the course. It there are are taught are taught are taught are taught are taught are taught and the course. It there are taught are tau | express and as guments and topics of their livided into a f cus of the face ceraction and r applied, and s che specific vor course is accor efore consists course. rse in blended vpes of texts a ching: Semina mination: Press for the Attrib on he Module Ke the Mark for | sk for personal p point out advant r own interest face-to-face phas -to-face course i mediation, both students work w cabulary in the f mpanied by a spe of two parts: learning format re written and re r, practical exerce sentation, writte ution of Credit F | oints of view and tages and disadva se (2 hours) and a s on the commun in written and spo ith authentic aud ield of physics and ecific e-learning o , in which, with the vised on the basi cises on portfolio, Listen Points active parti | n online phase (fr icative use of lang oken form. Variou io and visual text d astronomy is tra ffer, which is an i he help of the mar s of individual fee hing-discussion te cipation in the se | reely divisible practice guage in reception, us reading strategies s on Moodle. ained. Blended ntegral part of the terials provided edback. st of c. 30 min minars (>75%), passir | | | |
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List of Additional Key Competences

In <u>justified exceptional cases</u>, modules that are not in this module handbook may also be recognised. For this purpose, a justified request must be submitted to the study advisor (Dr. Ivonne Möller).

Note on Programming Languages:

All modules that deepen a programming language (C, C++, Phython, Java, PHP or Modula) can be chosen from the RUB's offer (e.g. the module "Computer Science I (from winter semester 21/22: "Programming for ITS") on the programming language TScript). However, modules that only represent a basic introduction to the understanding of programming techniques cannot be credited in the M.Sc. in Physics.

From the catalogue of **RUBION**:

| Module: | Workload/ Credits | Semester: | Frequency of Offering: | Duration: |
|--|----------------------|-----------|---------------------------|--------------|
| Foundational Course in Radiation Protection S4.1 | 150 h/5 CP | | s. RUBION | Block Course |

From the catalogue of the Academic Writing Centre:

| Module: | Workload/ Credits | Semester: | Frequency of Offering: | Duration: |
|---|----------------------|-----------|---------------------------|------------|
| Intensive Module Theses in Science and Engineering A or B | 5 CP | | s. SCHREIBZENTRUM | 1 Semester |

From the catalogue of the faculty of **Economic Sciences**:

Modules (key competences) from economic sciences

Corporate Finance I: Finanzierung & Investition Corporate Finance II: Finanzielles Risikomanagement Corporate Finance III: Kapitalmarkttheorie Start -Up I: Grundlagen der Existenzgründung Start-Up II: Coaching-Workshop für Existenzgründer Start-Up III: Grundlagen der Businessplanerstellung

| N/adula 7 | Cuadita | Workload | Competer | Cuele | Duration |
|---|--|--|---|--|--|
| Module 7 | Credits 5 CP | 150 h | Semester ab 1. Sem. | Cycle Summer Term | Duration 1 Semester |
| | 5 CP | 150 ft | | | |
| Courses | | | Contact Hours | • | Group Size |
| | oject Manager | | a) 50 h | 50 h | Students |
| b) Practical ex | ercises Projec | t Management | b) 50 h | | a) 30 b) 30 |
| Requirements | for Participat | ion | | | 67 50 |
| Formal: none | | | | | |
| Content-Wise | : none | | | | |
| Preparation: r | none | | | | |
| Learning Outo | omes | | | | |
| | | g the module, th | | | |
| | | basics of project | U U | | |
| | | anding of leading | - | | |
| - | | | e its implementat | ion | |
| can ac | here to time a | and formal frame | eworks | | |
| | agement. On t | the other hand, | results from the | practical exercises | skills for project and s are discussed and ck from the module |
| problems a supervisor. b) In the prac to a group From the p | agement. On t inalysed. The f Leadership pr tical exercises, of Bachelor st preparation of | the other hand, focus is on the e otocols and prog the participants tudents and to g | results from the xchange of inforr gress reports are p have the opport guide them in the the final poster | practical exercises nation and feedba prepared. unity to apply the a mplementation of | s are discussed and ck from the module acquired knowledge of a SOWAS project. participants of this |
| problems a supervisor. b) In the prac to a group From the p module sup Format of Tea Format of Exa | agement. On t inalysed. The f Leadership pr tical exercises, of Bachelor st preparation of oport the SOW | the other hand, focus is on the e otocols and prog the participants tudents and to g the exposés to AS students both r, practical exerci entation, active | results from the xchange of inforr gress reports are p s have the opport guide them in the the final poster h professionally a ses participation | practical exercises mation and feedba prepared. unity to apply the a implementation of presentation, the nd interdisciplinari | s are discussed and ck from the module acquired knowledge of a SOWAS project. participants of this ly. |
| problems a supervisor. b) In the prac to a group From the p module sup Format of Tea Format of Exa Requirements | agement. On t inalysed. The f Leadership pr tical exercises, of Bachelor st oreparation of oport the SOW iching Seminar mination Pres of the Attrib | the other hand, focus is on the e otocols and prog the participants tudents and to g the exposés to 'AS students both 'AS students both ', practical exerci entation, active | results from the xchange of inforr gress reports are p s have the opport guide them in the the final poster h professionally a ses participation | practical exercises mation and feedba prepared. unity to apply the a implementation of presentation, the nd interdisciplinari | s are discussed and ck from the module acquired knowledge of a SOWAS project. participants of this |
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| problems a supervisor. b) In the prac to a group From the p module sup Format of Tea Format of Tea Format of Exa Requirements participation i Utilisation oft Importance of Module Super Further Inform project proces | agement. On t inalysed. The f Leadership pr tical exercises, of Bachelor st oreparation of oport the SOW ching Seminar mination Pres for the Attrib n the exercises the Module M f the Mark for rvisor and Inst mation Alterna ssing and self-o | the other hand, focus is on the e otocols and prog the participants tudents and to g the exposés to AS students both (AS | results from the xchange of inforr gress reports are p s have the opport guide them in the the final poster h professionally a ses participation Points active parti e Weighed accordin oft he faculty ule can be replace | practical exercises mation and feedba prepared. unity to apply the a implementation of presentation, the nd interdisciplinari cipation in the sem g to Credit Points ed by the module ' | s are discussed and ck from the module acquired knowledge of a SOWAS project. participants of this ly. |
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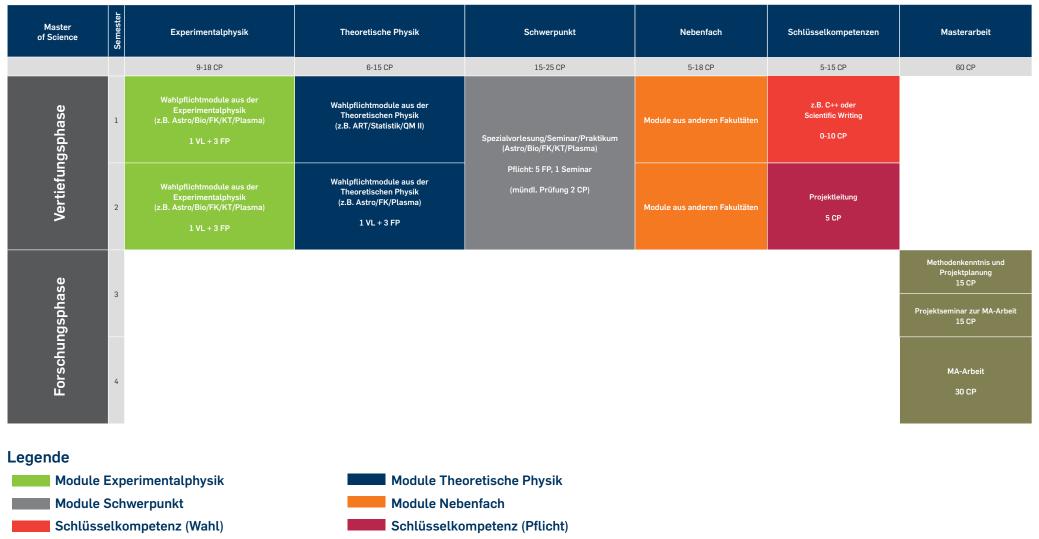
| Мос | dule 8 | Credits | Workload | Semester | Cycle | Duration |
|---|--|--|---|--|---|---|
| | | 15 CP | 450 h | 3. Sem. | WiSe & SoSe | 1 Semester |
| Cou | | | | Contact Hours | • | Group Size |
| | ractical ex | ercises | | a) 320 h | 100 h | Students |
| b) S | eminar | | | b) 30 h | | a) 30 b) 30 |
| Req | uirements | for Participat | tion | | | |
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| | | | | -25 CP) and the co | | |
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| | | | subject must be | proven. | | |
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| | ning Outc | | | | | |
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| | | from their sub | • | | | |
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| | are fai | miliar with the | | | | |
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| | | | • | • | - | a project work |
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| Con | can pla tents | an the upcomi | ing Master's the | sis in terms of tim | e and content | |
| | can pla tents In the pra | an the upcomi | ing Master's the | sis in terms of tim | e and content | oup are learned. Afte |
| Con | can pla tents In the pra an intens | an the upcomi ctical exercise ive familiarisa | ing Master's the es, the required c ation phase, the | sis in terms of time concrete working r e students have | e and content nethods of the gr the opportunity | oup are learned. Afte to participate in the |
| Con | can pla tents In the pra an intens concretisa | an the upcomi ctical exercise live familiarisa | ing Master's the es, the required c ation phase, the r topic for the | sis in terms of time concrete working r e students have | e and content nethods of the gr the opportunity s. In addition, | oup are learned. After to participate in the a timetable for the |
| Cont a) | can pla tents In the pra an intens concretisa implement | an the upcomi ctical exercise live familiarisa ation of thei ntation of the l | ing Master's the es, the required c ation phase, the r topic for the Master's thesis i | sis in terms of time concrete working r e students have e Master's thesi s drawn up and its | e and content nethods of the gr the opportunity s. In addition, feasibility is chec | oup are learned. Afte to participate in the a timetable for the cked. |
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| Module 9 | Credits | Workload | Semester | Cycle | Duration |
|--|--|---|---|--|---|
| | 15 CP | 450 h | 3. & 4. Sem. | WiSe & SoSe | 2 Semesters |
| Courses | | | Contact Hours | Self Study | Group Size |
| a) Seminar A | | | a) 100 h | 320 h | Students |
| b) Seminar B | | | b) 30 h | | a) 30 |
| | | | | | b) 30 |
| Requirements Formal: proof Project" Content-Wise Preparation: | of completion | | "Knowledge of Me | ethods and Plannin | ng a |
| Learning Outo | | | | | |
| | | g the module, th | | | |
| | | urrent status of | their project "Ma | ster's thesis" (on a | a weekly and monthly |
| scale) | | | | | |
| can ar step | halyse success | es, problems and | a difficulties and w | ork out suggestio | ns for the next project |
| • | a basic unders | tanding of how t | o communicate si | ibject content an | propriately (orally and |
| in wri | | | o communicate st | | |
| Contents | | | | | |
| should be t by graphs o the aim of b) In seminar presentatio end as a | the starting po or a presentat designing the B, the proje on can be given "final report | int for further pl ion. The group d next work steps ct "Master's the n either in the m ". The individu | anning. The expla iscusses the feasil as effectively as p esis" is presented iddle of the Maste | nations or argume bility in terms of t ossible. I in the respectiv er's thesis as an "ir as as well as th | result of this analysis ents can be supported ime and content with re working group. The nterim report" or at the le time planning an ontent. |
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| Format of Tea | aching Semina | r | | | |
| Format of Tea | | | | | |
| Format of Tea Format of Exa | mination Pres | sentation | Points active parti | cipation in the ex | ercises, individual |
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| Module 10 | Credits | Workload | Semester | Cycle | Duration |
|----------------|-----------------|---------------------|----------------------|---------------------|-------------------------|
| | 30 CP | 900 h | 3. & 4. Sem. | WiSe & SoSe | 2 Semester |
| Courses | | | Contact Hours | Self Study | Group Size |
| Thesis | | | 720 h | 180 h | 1 |
| Requirements | for Participa | tion | | | |
| • | of completion | of the module ' | 'Knowledge of Me | thods and Planni | ng a |
| Project" | | | | | |
| Content-Wise | | | | | |
| Preparation: | | | | | |
| Learning Outo | | | | | |
| | | g the module, th | | | |
| | • | - | ntific ways of thin | | |
| | • | | ons and solve den | ned problems us | ing scientific methods |
| | a given perio | | an annronriate w | ritten nresentati | on of demanding and |
| | scientific resu | | | niten presentatio | |
| | | | t concepts of inde | nendent work org | anisation |
| | | - | | | the principles of good |
| | ific practice | equate interature | | | the principles of 600d |
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| Contents | | | | | |
| Independent | construction | of an experime | nt or a theoretic | al model, indep | endent planning and |
| execution of t | he experimen | ts or calculation | s/simulations, ana | lysis of the result | ts, optimisation of the |
| processes, do | cumentation o | of the process ste | eps. | | |
| • | | ormulated in suc | h a way that they | can be completed | d within 9 months with |
| a workload of | | | | | |
| Format of Tea | | | | | |
| | | ting a scientific p | | | |
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| Astronomy. U | pon applicatio | n, other examine | ers may be admitt | ed if necessary. | |
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| - | | as completed. In | addition, it is poss | ible to write the t | hesis in a minor subjec |
| upon applicati | on | | | | |

Studienplan Master of Science Physics





Abschlussarbeit und vorbereitende Module