Fachgebundenes Wahlpflichtmodul - physik450

Modul-Nr.	**physik450**
Kategorie	Wahlpflicht
Leistungspunkte	6
vorgesehenes Semester	4.-6.

Modul: Fachgebundenes Wahlpflichtmodul

Modulbestandteile:

Nr	Lehrveranstaltung	LV-Nr.	LP	LV-Art	SWS	Semester
1	Projektpraktikum Physik	physik458	6	Praktikum	6	WS/SS
2	Betriebspraktikum	physik459	6	Praktikum	n.a.	WS/SS
3	Particle Physics	physics611	6	Lect. + ex.	3+1	WT
4	Accelerator Physics	physics612	6	Lect. + ex.	3+1	WT
5	Condensed Matter Physics	physics613	6	Lect. + ex.	3+1	WT
6	Theoretical Particle Physics	physics615	7	Lect. + ex.	3+2	WT
7	Theoretical Hadron Physics	physics616	7	Lect. + ex.	3+2	WT
8	Theoretical Condensed Matter Physics	physics617	7	Lect. + ex.	3+2	WT
9	Physics of Particle Detectors	physics618	6	Lect. + ex.	3+1	WT
10	Advanced Atomic, Molecular, and Optical Physics	physics620	6	Lect. + ex.	3+1	WT
11	Physics of Hadrons	physics632	6	Lect. + ex.	3+1	ST
12	High Energy Collider Physics	physics633	6	Lect. + ex.	3+1	ST
13	Magnetism/Superconductivity	physics634	6	Lect. + ex.	3+1	ST
14	Advanced Quantum Theory	physics606	7	Lect. + ex.	3+2	WT
15	Group Theory (T)	physics751	7	Lect. + ex.	3+2	WT
16	General Relativity and Cosmology (T)	physics754	7	Lect. + ex.	3+2	ST
17	Quantum Field Theory (T)	physics755	7	Lect. + ex.	3+2	ST
18	Stars and Stellar Evolution or specific: Stellar Structure and Evolution	astro811	6	Lect. + ex.	3+1	WT
19	Cosmology	astro812	6	Lect. + ex.	3+1	WT
20	Astrophysics of Galaxies	astro821	6	Lect. + ex.	3+1	ST
21	Physics of the Interstellar Medium	astro822	6	Lect. + ex.	3+1	ST

Teilnahmevoraussetzungen: keine

Prüfungsform: Klausur bzw. schriftliche Ausarbeitung

Inhalt:

Eine weiterführende/vertiefende Vorlesung aus den Masterstudiengängen Physik und Astrophysik

oder: Betriebspraktikum im Umfang von 180 Arbeitsstunden

Qualifikationsziel: Mit den Wahlpflichtvorlesungen wird die Möglichkeit eröffnet, den Stoff des Pflichtkanons mit einer ausgewählten, fortgeschrittenen Lehrveranstaltung der Physik oder Astrophysik zu ergänzen; zum Teil dienen sie der Vorbereitung auf das Masterstudium. Alternativ kann im Betriebspraktikum Erfahrung mit der Arbeit in der Industrie oder in einer anderen Institution, in der physikalische Kenntnisse erforderlich sind, gesammelt werden. Forschungseinrichtungen (z. B. DLR, FhG, MPI) sind davon ausgenommen.

Studienleistung/Kriterien zur Vergabe von LP: Erfolgreiche Bearbeitung der Übungsaufgaben, des Projektes, bzw. Bescheinigung über ein Betriebspraktikum

Dauer: 1 Semester

Max. Teilnehmerzahl: ca. 200

Gewichtung: 6/163

Anmerkung:

- Wird für B.Sc. als 6 LP angerechnet

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Projektpraktikum Physik - physik458

Lehrveranstaltung	**Projektpraktikum Physik**
LV-Nr.	physik458

Kategorie	LV-Art	Sprache	SWS	LP	Semester
Wahlpflicht	Praktikum	deutsch	6	6	WS/SS

Teilnahmevoraussetzungen: Erfolgreiche Teilnahme an physik260 und physik360

Empfohlene Vorkenntnisse: physik110, physik210, physik310

Studien- und Prüfungsmodalitäten: Führen eines Laborbuches, erfolgreiche Bearbeitung des Projekts, Posterpräsentation und Diskussion

Dauer der Lehrveranstaltung: 1 Semester (während Vorlesungszeit und evtl. vorlesungsfreier Zeit)

Lernziele der LV: Einüben des experimentell-wissenschaftlichen Prozesses anhand ausgewählter (kleiner) Projekte. Dies beinhaltet u. a. eine "Forschungsfrage" zu formulieren, entsprechende Fachliteratur zu finden und zu verstehen, ein adäquates Versuchsdesign zu entwickeln, den entwickelten Versuch durchzuführen, Daten zu nehmen und auszuwerten, Ergebnisse zu dokumentieren und zu diskutieren. Grundlegend dafür sind entsprechende Fachkenntnisse.

Inhalte der LV: Die Studenten identifizieren experimentelle Themen, die sie bearbeiten möchten und entwickeln einen Projektplan in Abstimmung mit der Praktikumsleitung, um die abgesprochenen Versuche zu entwickeln und durchzuführen. Die Themen sollen einen Bezug zu physikalischen Fragestellungen der experimentellen Vorlesungen des Bachelorstudiengangs (Physik 1 – Physik 5) haben. Physikalische Versuche werden entwickelt und durchgeführt. Die Ergebnisse werden in einer Posterpräsentation dem gesamten Kurs vorgestellt und diskutiert.

Literaturhinweise:

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Betriebspraktikum - physik459

Lehrveranstaltung	**Betriebspraktikum**
LV-Nr.	physik459

Kategorie	LV-Art	Sprache	SWS	LP	Semester
Wahlpflicht	Praktikum	deutsch	n.a.	6	WS/SS

Teilnahmevoraussetzungen:

Empfohlene Vorkenntnisse: Lehrveranstaltungen des 1.-3. Semesters

Studien- und Prüfungsmodalitäten: Zulassungsvoraussetzung zur Modulprüfung (schriftlicher Bericht): erfolgreiche Teilnahme am Praktikum

Dauer der Lehrveranstaltung: 1 Semester

Lernziele der LV: Der Studierende soll in einem Praktikum in einem Industriebetrieb oder in einer Institution, in der physikalische Kenntnisse erforderlich sind, erste praktische Erfahrungen sammeln

Inhalte der LV:

Sammeln erster berufsnaher Erfahrungen in einem Betrieb der öffentlichen Hand oder der Wirtschaft.

Verfassen eines Erfahrungsberichtes

Literaturhinweise:

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Particle Physics - physics611

Course	**Particle Physics**
Course No.	physics611

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation: Introductory particle physics and quantum mechanics courses

Form of Testing and Examination:

Requirements for the examination (written or oral): successful work with the

exercises

Length of Course: 1 semester

Aims of the Course: Understanding of the fundamentals of particle physics: properties of quarks and leptons and their interactions (electromagnetic, weak, strong), experiments that have led to this understanding, the Standard Model of particle physics and measurements that test this model, the structure of hadrons

Contents of the Course:

Basics: leptons and quarks, antiparticles, hadrons, forces / interactions, Feynman graphs,

relativistic kinematics, two-body decay, Mandelstam variables, cross-section, lifetime

Symmetries and Conservation Laws. Positronium, Quarkonium. Accelerators and Detectors

Electromagnetic interactions: (g-2) experiments, lepton-nucleon scattering

Strong interactions: colour, gauge principle, experimental tests of QCD. Electroweak interactions and the Standard Model of particle physics: spontaneous symmetry breaking, Higgs mechanism, experimental tests of the Standard Model. Neutrino physics, neutrino oscillations; CP violation

Recommended Literature:

F Halzen, A. Martin; Quarks and Leptons (J. Wiley, Weinheim 1. Aufl. 1984)

C. Berger; Elementarteilchenphysik (Springer, Heidelberg 2. überarb. Aufl. 2006)

Perkins; Introduction to High Energy Physics (Cambridge University Press 4. Aufl. 2000)

D. Griffith; Introduction to Elementary Particle Physics (J. Wiley, Weinheim 1. Aufl. 1987)

A. Seiden; Particle Physics : A Comprehensive Introduction (2005)

Martin & Shaw; Particle Physics, Wiley (2nd edition, 1997)

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Accelerator Physics - physics612

Course	**Accelerator Physics**
Course No.	physics612

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation:

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course:

Understanding of the functional principle of different types of particle accelerators

Layout and design of simple magneto-optic systems

Basic knowledge of radio frequency engineering and technology

Knowledge of linear beam dynamics in particle accelerators

Contents of the Course:

Elementary overview of different types of particle accelerators: electrostatic and induction accelerators, RFQ, Alvarez, LINAC, Cyclotron, Synchrotron, Microtron

Subsystems of particle accelerators: particle sources, RF systems, magnets, vacuum systems

Linear beam optics: equations of motion, matrix formalism, particle beams and phase space

Circular accelerators: periodic focusing systems, transverse beam dynamics, longitudinal beam dynamics

Guided tours through the ELSA accelerator of the Physics Institute and excursions to other particle accelerators (COSY, MAMI, HERA, . . .) complementing the lecture

Recommended Literature:

F. Hinterberger; Physik der Teilchenbeschleuniger und Ionenoptik (Springer Heidelberg 1997)

H. Wiedemann; Particle Accelerator Physics (Springer, Heidelberg 2. Aufl. 1999)

K. Wille; Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen (Teubner, Wiesbaden 2. Aufl. 1996)

D. A. Edwards, M.J. Syphers; An Introduction to the Physics of High Energy Accelerators, Wiley & Sons 1993)

Script of the Lecture "Particle Accelerators"

http://www-elsa.physik.uni-bonn.de/~hillert/Beschleunigerphysik/

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Condensed Matter Physics - physics613

Course	**Condensed Matter Physics**
Course No.	physics613

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation:

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Understanding of the concepts of condensed matter physics

Contents of the Course:

Crystallographic structures: Bravais lattices, Millers indices, crystallographic defects, structural analysis; Chemical bonds: van der Waals bond, covalent bond, hybridisation, ionic bond, metallic bond, Hydrogen bridge bond;

Lattice vibrations: acoustic and optical phonons, specific heat, phonon-phonon interaction;

Free electrons in the solid state: free electron gas, Drude model, Fermi distribution, specific heat of the electrons;

Band structure: metals, semiconductors, insulators, effective masses, mobility of charge carrier, pn-transition, basic principles of diodes, bipolar and unipolar transistors;

Superconductivity: basic phenomena, Cooper pairs, BSC-theory and its consequences;

Magnetic properties: diamagnetism, Langevin-theory of paramagnetism, Pauli-paramagnetism, spontaneous magnetic order, molecular field, Heisenberg-exchange;

Nuclear solid state physics: Hyperfine interaction, Mössbauer spectroscopy, perturbed angular correlation, positron annihilation, typical applications.

Recommended Literature:

N. W. Ashcroft , N. D. Mermin , Solid State Physics (Brooks Cole 1976) ISBN-13: 978-0030839931

N. W. Ashcroft , N. D. Mermin, Festkörphysik (Oldenbourg 2001) ISBN-13: 978-3486248340

H. Ibach, H. Lüth, Solid-State Physics (Springer 2003) ISBN-13: 978-3540438700

H. Ibach, H. Lüth, Festkörperphysik (Springer 2002) ISBN-13: 978-3540427384

C. Kittel, Einführung in die Festkörperphysik (Oldenbourg 2006) ISBN-13: 978-3-486-57773-5

W. Demtröder, Experimentalphysik, Bd. 3. Atome, Moleküle und Festkörper (Springer 2005) ISBN-13: 978-3540214731

K. Kopitzki, P. Herzog Einführung in die Festkörperphysik (Vieweg+Teubner 2007) ISBN-13: 978-3835101449

L. Bergmann, C. Schaefer, R. Kassing, Lehrbuch der Experimentalphysik 6.: Festkörper (Gruyter 2005) ISBN-13: 978-3110174854

W. Buckel, R. Kleiner, Supraleitung (Wiley-VCH 2004) ISBN-13: 978-3527403486

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Theoretical Particle Physics - physics615

Course	**Theoretical Particle Physics**
Course No.	physics615

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation:

Advanced quantum theory (physics606)

Quantum field theory (physics755)

Group theory (physics751)

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Introduction to the standard model of elementary particle physics and its extensions (unified theories)

Contents of the Course:

Classical field theory, gauge theories, Higgs mechanism;

Standard model of strong and electroweak interactions;

Supersymmetry and the supersymmetric extension of the standard model;

Grand unified theories (GUTs);

Neutrino physics;

Cosmological aspects of particle physics (dark matter, inflation)

Recommended Literature:

T. P. Cheng, L.F. Li: Gauge theories of elementary particle physics (Clarendon Press, Oxford 1984)

M. E. Peskin, D.V. Schroeder; An introduction to quantum field theory (Addison Wesley, 1995)

J. Wess; J. Bagger; Supersymmetry and supergravity (Princeton University Press 1992)

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Theoretical Hadron Physics - physics616

Course	**Theoretical Hadron Physics**
Course No.	physics616

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation:

Advanced quantum theory (physics606)

Quantum field theory (physics755)

Group theory (physics751)

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Introduction to the theory of strong interaction, hadron structure and dynamics

Contents of the Course:

Meson and Baryon Spectra: Group theoretical Classification, Simple Quark Models

Basics of Quantum Chromodynamics: Results in Perturbation Theory

Effective Field Theory

Bethe-Salpeter Equation

Recommended Literature:

F. E. Close, An Introduction to Quarks and Partons (Academic Press 1980)

F. Donoghue, E. Golowich, B.R. Holstein; Dynamics of the Standard Model (Cambridge University Press 1994)

C. Itzykson, J.-B. Zuber; Quantum Field Theory (Dover Publications 2005)

S. Weinberg; The Quantum Theory of Fields (Cambridge University Press 1995)

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Theoretical Condensed Matter Physics - physics617

Course	**Theoretical Condensed Matter Physics**
Course No.	physics617

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation:

Advanced Quantum Theory (physics606)

Quantum Field Theory (physics755)

Group theory (physics751)

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Introduction to the theoretical standard methods and understanding important phenomena in the Physics of Condensed Matter

Contents of the Course:

Crystalline Solids: Lattice structure, point groups, reciprocal lattice

Elementary excitations of a crystal lattice: phonons

Electrons in a lattice; Bloch theorem, band structure

Fermi liquid theory

Magnetism

Symmetries and collective excitations in solids

Superconductivity

Integer and fractional quantum Hall effects

Recommended Literature:

N. W. Ashcroft, N.D. Mermin, Solid State Physics (Saunders College 1976)

P. M. Chaikin, T.C. Lubensky; Principles of Condensed Matter Physics (Cambridge University Press 1997)

W. Nolting; Grundkurs Theoretische Physik Band 7: Vielteilchentheorie (Springer, Heidelberg 2002)

Ch. Kittel; Quantentheorie der Festkörper (Oldenburg Verlag, München 3. Aufl. 1989)

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Physics of Particle Detectors - physics618

Course	**Physics of Particle Detectors**
Course No.	physics618

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation: Useful: physik510

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Understanding the basics of the physics of particle detectors, their operation and readout

Contents of the Course: Physics of detectors and detection mechanisms, interactions of charged particles and photons with matter, ionization detectors, drift and diffusion, gas filled wire chambers, proportional and drift chambers, semiconductor detectors, microstrip detectors, pixel detectors, radiation damage, cerenkov detectors, transition radiation detectors, scintillation detectors (anorganic crystals and plastic scintillators), electromagnetic calorimeters, hadron calorimeters, readout techniques, VLSI readout and noise

Recommended Literature:

Wermes: Skriptum and web-based Teaching Module

K. Kleinknecht; Detectors for Particle Radiation (Cambridge University Press 2nd edition 1998)

W.R. Leo; Techniques for Nuclear and Particle Detection (Springer, Heidelberg 2nd ed. 1994)

H. Spieler, Semiconductor detector system (Oxford University Press 2005)

L. Rossi, P. Fischer, T. Rohe, N. Wermes, Pixel Detectors: From Fundamentals to Applications (Springer 2006)

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Advanced Atomic, Molecular, and Optical Physics - physics620

Course	**Advanced Atomic, Molecular, and Optical Physics**
Course No.	physics620

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation: Fundamentals of Quantum Mechanics, Atomic Physics

Form of Testing and Examination: Requirements for the examination (written or oral): successful work within the exercises

Length of Course: 1 semester

Aims of the Course: The aim of the course is to give the students a deeper insight to the field of atomic, molecular and optical (AMO) physics. Building on prior knowledge from the Bachelor courses it will cover advanced topics of atomic and molecular physics, as well as the interaction of light and matter.

Contents of the Course:

Atomic physics: Atoms in external fields; QED corrections: Lamb-Shift; Interaction of light and matter: Lorentz oscillator, selection rules; magnetic resonance; Coherent control

Molecular physics: Hydrogen Molecule; Vibrations and rotations of molecules; Hybridization of molecular orbitals; Feshbach Resonances; Photoassociation; Cold Molecules

Bose Condensation; Matterwave Optics

Recommended Literature:

C. J. Foot, Atomic Physics, Oxford University Press 2005

H. Haken, The physics of atoms and quanta, Springer 1996

S. Svanberg, Atomic and molecular spectroscopy basic aspects and practical applications, Springer 2001

W. Demtröder, Molecular Physics, Wiley VCH 2005

T. Buyana, Molecular physics, World Scientific 1997

W. Demtröder, Atoms, Molecules and Photons, Springer 2010

P, Meystre, Atom Optics, Springer 2010

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Physics of Hadrons - physics632

Course	**Physics of Hadrons**
Course No.	physics632

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	ST

Requirements for Participation:

Preparation: Completed B.Sc. in Physics, with experience in electrodynamics, quantum mechanics, atomic- and nuclear physics

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Understanding the many-body structure of hadrons, understanding structural examinations with electromagnetic probes, introduction into experimental phenomenology

Contents of the Course:

Structure Parameters of baryons and mesons; hadronic, electromagnetic and weak probes; size, form factors and structure functions; quarks, asymptotic freedom, confinement, resonances; symmetries and symmetry breaking, hadron masses;

quark models, meson and baryon spectrum; baryon spectroscopy and exclusive reactions; missing resonances, exotic states

Recommended Literature:

B. Povh, K. Rith C. Scholz, F. Zetsche; Teilchen und Kerne (Springer, Heidelberg 6. Aufl. 2004)

Perkins; Introduction to High Energy Physics (Cambridge University Press 4. Aufl. 2000)

K. Gottfried, F. Weisskopf; Concepts of Particle Physics (Oxford University Press 1986)

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High Energy Collider Physics - physics633

Course	**High Energy Collider Physics**
Course No.	physics633

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	ST

Requirements for Participation:

Preparation: physics611 (Particle Physics)

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: In depth treatment of particle physics at high energy colliders with emphasis on LHC

Contents of the Course:

Kinematics of electron-proton and proton-(anti)proton collisions,

Electron-positron, electron-hadron and hadron-hadron reactions, hard scattering processes,

Collider machines (LEP, Tevatron and LHC) and their detectors (calorimetry and tracking),

the Standard Model of particle physics in the nutshell, fundamental questions posed to the LHC, spontaneous symmetry breaking and experiment,

QCD and electroweak physics with high-energy hadron colliders,

Physics of the top quark, top cross section and mass measurements,

Higgs Physics at the LHC (search strategies, mass measurement, couplings),

Supersymmetry and beyond the Standard Model physics at the LHC

Determination of CKM matrix elements, CP violation in K and B systems,

Neutrino oscillations

Recommended Literature:

V. D. Barger, R. Phillips; Collider Physics (Addison-Wesley 1996)

R. K. Ellis, W.J. Stirling, B.R. Webber; QCD and Collider Physics (Cambridge University Press 2003)

D. Green; High PT Physics at Hadron Colliders (Cambridge University Press 2004)

C. Berger; Elementarteilchenphysik (Springer, Heidelberg 2nd revised edition 2006)

A. Seiden; Particle Physics A Comprehensive Introduction (Benjamin Cummings 2004)

T. Morii, C.S. Lim; S.N. Mukherjee Physics of the Standard Model and Beyond (World Scientific 2004)

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Magnetism/Superconductivity - physics634

Course	**Magnetism/Superconductivity**
Course No.	physics634

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+1	6	ST

Requirements for Participation:

Preparation:

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: To give an introduction to the standard theories of both fields as major example of collective phenomena in condensed-matter physics and comparison with experiments

Contents of the Course:

Magnetism:

orbital and spin magnetism without interactions, exchange interactions, phase transitions, magnetic ordering and domains, magnetism in 1-3 dimensions, spin waves (magnons), itinerant magnetism, colossal magnetoresistance

Superconductivity:

macroscopic aspects, type I and type II superconductors, Ginzburg-Landau theory, BCS theory, Josephson effect, superfluidity, high-temperature superconductivity

Recommended Literature:

L. P. Lévy: Magnetism and superconductivity (Springer; Heidelberg 2000)

P. Mohn: Magnetism in the Solid State - An Introduction (Springer, Heidelberg 2005)

J. Crangle: Solid State Magnetism, Van Nostrand Reinhold (Springer, New York 1991)

C. N. R. Rao, B. Raveau: Colossal Magnetoresistance [. . .] of Manganese Oxides (World Scientific 2004)

J. F. Annett: Superconductivity, super fluids and condensates (Oxford University Press 2004)

A. Mourachkine: High-Temperature Superconductivity in Cuprates [. . .] (Springer/Kluwer, Berlin 2002)

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Advanced Quantum Theory - physics606

Course	**Advanced Quantum Theory**
Course No.	physics606

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Required	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation: Theoretical courses at the Bachelor degree level

Form of Testing and Examination: Requirements for the module examination (written examination): successful work with exercises

Length of Course: 1 semester

Aims of the Course: Ability to solve problems in relativistic quantum mechanics, scattering theory and many-particle theory

Contents of the Course:

Born approximation, partial waves, resonances

advanced scattering theory: S-matrix, Lippman-Schwinger equation

relativistic wave equations: Klein-Gordon equation, Dirac equation

representations of the Lorentz group

many body theory

second quantization

basics of quantum field theory

path integral formalism

Greens functions, propagator theory

Recommended Literature:

L. D. Landau, E.M. Lifschitz; Course of Theoretical Physics Vol.3 Quantum Mechanics (Butterworth-Heinemann 1997)

J. J. Sakurai, Modern Quantum Mechanics (Addison-Wesley 1995)

F. Schwabl, Advanced Quantum Mechanics. (Springer, Heidelberg 3rd Ed. 2005)

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Group Theory (T) - physics751

Course	**Group Theory (T)**
Course No.	physics751

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation: physik421 (Quantum Mechanics)

Form of Testing and Examination: Requirements for the examination (written): successful work with the

Length of Course: 1 semester

Aims of the Course: Acquisition of mathematical foundations of group theory with regard to applications in theoretical physics

Contents of the Course:

Mathematical foundations:

Finite groups, Lie groups and Lie algebras, highest weight representations, classification of simple Lie algebras, Dynkin diagrams, tensor products and Young tableaux, spinors, Clifford algebras, Lie super algebras

Recommended Literature:

B. G. Wybourne; Classical Groups for Physicists (J. Wiley & Sons 1974)

H. Georgi; Lie Algebras in Particle Physics (Perseus Books 2. Aufl. 1999)

W. Fulton, J. Harris; Representation Theory (Springer, New York 1991)

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General Relativity and Cosmology (T) - physics754

Course	**General Relativity and Cosmology (T)**
Course No.	physics754

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	3+2	7	ST

Requirements for Participation:

Preparation:

physik221 and physik321 (Theoretical Physics I and II)

Differential geometry

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Understanding the general theory of relativity and its cosmological implications

Contents of the Course:

Relativity principle

Gravitation in relativistic mechanics

Curvilineal coordinates

Curvature and energy-momentum tensor

Einstein-Hilbert action and the equations of the gravitational field

Black holes

Gravitational waves

Time evolution of the universe

Friedmann-Robertson-Walker solutions

Recommended Literature:

S.Weinberg; Gravitation and Cosmology (J. Wiley & Sons 1972)

R. Sexl: Gravitation und Kosmologie, Eine Einführung in die Allgemeine Relativitätstheorie (Spektrum Akadem. Verlag 5. Aufl 2002)

L.D. Landau, E.M. Lifschitz; Course of Theoretical Physics Vol.2: Classical field theory (Butterworth-Heinemann 1995), also available in German from publisher Harry Deutsch

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Quantum Field Theory (T) - physics755

Course	**Quantum Field Theory (T)**
Course No.	physics755

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	3+2	7	ST

Requirements for Participation:

Preparation: Advanced quantum theory (physics606)

Form of Testing and Examination: Requirements for the examination (written): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Understanding quantum field theoretical methods, ability to compute processes in quantum electrodynamics (QED) and many particle systems

Contents of the Course:

Classical field theory

Quantization of free fields

Path integral formalism

Perturbation theory

Methods of regularization: Pauli-Villars, dimensional

Renormalizability

Computation of Feynman diagrams

Transition amplitudes in QED

Applications in many particle systems

Recommended Literature:

N. N. Bogoliubov, D.V. Shirkov; Introduction to the theory of quantized fields (J. Wiley & Sons 1959)

M. Kaku, Quantum Field Theory (Oxford University Press 1993)

M. E. Peskin, D.V. Schroeder; An Introduction to Quantum Field Theory (Harper Collins Publ. 1995)

L. H. Ryder; Quantum Field Theory (Cambridge University Press 1996)

S. Weinberg; The Quantum Theory of Fields (Cambridge University Press 1995)

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Stars and Stellar Evolution or specific: Stellar Structure and Evolution - astro811

Course	**Stars and Stellar Evolution or specific: Stellar Structure and Evolution**
Course No.	astro811

Category	Type	Language	Teaching hours	CP	Semester
Required	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation:

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: Students will acquire sufficient knowledge to understand stars and their evolution. Study of radiation transport, energy production, nucleosynthesis and the various end phases of stellar evolution shall lead to appreciation for the effects these processes have on the structure and evolution of galaxies and of the universe

Contents of the Course: Historical introduction, measuring quantities, the HRD. Continuum and line radiation (emission and absorption) and effects on the stellar spectral energy distribution. Basic equations of stellar structure. Nuclear fusion. Making stellar models. Star formation and protostars. Brown Dwarfs. Evolution from the main-sequence state to the red giant phase. Evolution of lower mass stars: the RG, AGB, HB, OH/IR, pAGB, WD phases. Stellar pulsation. Evolution of higher mass stars: supergiants, mass loss, Wolf-Rayet stars, P-Cyg stars. Degenerate stars: White Dwarfs, Neutron Stars, Black Holes. Supernovae and their mechanisms. Binary stars and their diverse evolution (massive X-ray binaries, low-mass X-ray binaries, Cataclysmic variables, etc.). Luminosity and mass functions, isochrones. Stars and their influence on evolution in the universe

Recommended Literature: Lecture notes on “Stars and Stellar Evolution” (de Boer & Seggewiss)

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Cosmology - astro812

Course	**Cosmology**
Course No.	astro812

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Required	Lecture with exercises	English	3+1	6	WT

Requirements for Participation:

Preparation: Introductory astronomy

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: The student shall acquire deep understanding of the foundation of our world models and of their consequences, with special emphasis on the formation of structures in the universe and its physical and observational consequences. The lecture shall enable the student to read and understand original literature in astrophysical cosmology, but also to see the direct connection between the fundamental problems in cosmology and particle physics, such as the nature of dark matter and dark energy

Contents of the Course: Kinematics and dynamics of cosmic expansion, introduction to General relativity, Friedmann equations and classification of world models, flatness and horizon problem; thermal history of the big bang, decoupling, WIMPS, nucleosynthesis, recombination and the CMB; gravitational light deflection, principles and applications of strong and weak gravitational lensing; structure formation in the Universe, perturbation theory, structure growth and transfer function, power spectrum of cosmic fluctuations, spherical collapse model, Press-Schechter theory and generalizations, cosmological simulations, cosmic velocity fields; principles of inflation; lensing by the large-scale structure, cosmic shear; anisotropies of the CMB, determination of cosmological parameters

Recommended Literature:

J. A. Peacock; Cosmological Physics (Cambridge University Press 1998)

P. J. E. Peebles; Principles of Physical Cosmology (Princeton University Press 1993)

Handout of the Transparencies

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Astrophysics of Galaxies - astro821

Course	**Astrophysics of Galaxies**
Course No.	astro821

Category	Type	Language	Teaching hours	CP	Semester
Required	Lecture with exercises	English	3+1	6	ST

Requirements for Participation:

Preparation: Introductory astronomy as well as a good understanding of stars and their evolution as well as of the interstellar medium

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with exercises

Length of Course: 1 semester

Aims of the Course:

The student shall acquire deep knowledge of the structure of the Milky Way and of other galaxies including their evolution.

This must enable them to understand and evaluate new publications in the field. It should provide the student a quick entry into the research phase of the study programme

Contents of the Course: Review of stars and stellar evolution, review of the interstellar medium. Solar neighbourhood: observables, differential galactic rotation, Hyades, Goulds Belt, Local Bubble. The Galaxy: size, dynamics of objects, rotation curve, disk and z-distribution. Stellar dynamics: Boltzmann, Jeans drift, Schwarzschild ellipsoid, scale length and height, density wave, mass distribution, age of populations, dark matter concept, evolution. Satellites: the Magellanic Clouds, their structure and evolution, Magellanic Stream, Dwarf spheroidals, Local Group galaxies. Star clusters: stellar dynamics, binary and multiple stars, energy exchange, star-cluster birth and death, origin of galactic field population. Active galactic nuclei: observables, jets, accretion, black holes. Structure and shape of spirals and ellipticals, surface brightness, globular cluster systems. Galaxy clusters: distances, statistics, luminosity function, X-ray halos, virial theorem. Galaxy evolution: chemical enrichment, galactic winds, infall, observables. Galaxy collisions: relaxation, mergers, birth of dwarf galaxies

Recommended Literature:

J. Binney; B. Merrifield; Galactic Astronomy (Princeton University Press 1998)

J. Binney, S. Tremaine; Galactic Dynamics (Princeton University Press 1988)

L. S. Sparke; J. S. Gallagher; Galaxies in the Universe (Cambridge University Press, 2000)

Write-up of the class

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Physics of the Interstellar Medium - astro822

Course	**Physics of the Interstellar Medium**
Course No.	astro822

Category	Type	Language	Teaching hours	CP	Semester
Required	Lecture with exercises	English	3+1	6	ST

Requirements for Participation:

Preparation: Introductory astronomy

Form of Testing and Examination: Requirements for the examination (written or oral): successful work with the exercises

Length of Course: 1 semester

Aims of the Course: The student shall acquire a good understanding of the physics and of the phases of the ISM. The importance for star formation and the effects on the structure and evolution of galaxies is discussed.

Contents of the Course: Constitutens of the interstellar medium, physical processes, radiative transfer, recombination, HI 21cm line, absorption lines, Stroemgren spheres, HII regions, interstellar dust, molecular gas and clouds, shocks, photodissociation regions, energy balances, the multi-phase ISM, gravitational stability and star formation.

Recommended Literature:

B. Draine; The Physics of the Interstellar and Intergalactic Medium (Princeton Univ. Press 2010)

J. Lequeux; The Interstellar Medium (Springer 2005)

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