Degree: M.Sc. in Physics (PO von 2006)

Module No.: physics630
Credit Points (CP): 12
Category: Elective
Semester: 8.

Fachgruppe
Physik und Astronomie
Universität Bonn

Module: Specialization II

Module Elements:

Nr.	Course Title	Number	CP	Type	Workload	Sem.
Particle Physics						
1.	Physics of Hadrons	physics632	6	Lect. + ex.	180 hrs	ST
2.	High Energy Collider Physics	physics633	6	Lect. + ex.	180 hrs	ST
3.	Advanced Topics in High Energy Particle Physics	physics639	6	Lect. + ex.	180 hrs	ST
Condensed Matter and Photonics						
1.	Magnetism/Superconductivity	physics634	6	Lect. + ex.	180 hrs	ST
2.	Laser Spectroscopy	physics635	6	Lect. + ex.	180 hrs	ST
3.	Molecular Physics II	MolPhys II	6	Lect. + ex.	180 hrs	ST
Theoretical Physics						
1.	Advanced Theoretical Particle Physics	physics636	7	Lect. + ex.	210 hrs	ST
2.	Advanced Theoretical Hadron Physics	physics637	7	Lect. + ex.	210 hrs	ST
3.	Advanced Theoretical Condensed Matter Physics	physics638	7	Lect. + ex.	210 hrs	ST

Requirements:

Preparation:

Content:
In depth knowledge on the basics of the research programme in physics at Bonn University

Aims/Skills:
The students shall learn the basics as well as the present state of current research in the fields

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

Length of Module: 1 semester

Maximum Number of Participants: ca. 100

Registration Procedure:
s. https://basis.uni-bonn.de u. http://bamawww.physik.uni-bonn.de

Note: The student must achieve 12 CP from one or two specialization areas.

Module: Specialization II

Module No.: physics630

Course: universitätbonn Physics of Hadrons

Course No.: physics632

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

Requirements:

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)

Module: Specialization II

Module No.: physics630

Course: universitätbonn High Energy Collider Physics

Course No.: physics633

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

Requirements:

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)

Module: Specialization II

Module No.: physics630

Course: Advanced Topics in High Energy Particle Physics

Course No.: physics639

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

Requirements:

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:
To discuss advanced topics of high energy particle physics which are the subject of current research efforts and to deepen understanding of experimental techniques in particle physics.

Contents of the Course:
Selected topics of current research in experimental particle physics. Topics will be updated according to progress in the field. For example:
- LHC highlights
- CP-violation experiments
- Experimental challenges in particle and astroparticle physics
- Current questions in neutrino physics

Recommended Literature:
A. Seiden; Particle Physics: A Comprehensive Introduction (Cummings 2004)
R.K. Ellis, B.R. Webber, W.J. Stirling; QCD and Collider Physics (Cambridge Monographs on Particle Physics 1996)
C. Burgess, G. Moore; The Standard Model: A Primer (Cambridge University Press 2006)
F. Halzen, A. Martin; Quarks and Leptons (J. Wiley, Weinheim 1998)
C. Berger; Elementarteilchenphysik (Springer, Heidelberg, 2. überarb. Aufl. 2006)

Module: Specialization II

Module No.: physics630

Course: universitätbonn Magnetism/Superconductivity

Course No.: physics634

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

Requirements:

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)

Module: Specialization II

Module No.: physics630

Course: Laser Spectroscopy

universitätbonn

Course No.: physics635

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

Requirements:

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:
Make the students understand the principles of spectroscopy and enable them to practically apply their knowledge in research and development.

Contents of the Course:
Spectroscopy phenomena - time and frequency domain;
high resolution spectroscopy;
pulsed spectroscopy; frequency combs;
coherent spectroscopy; nonlinear spectroscopy: Saturation, Raman spectroscopy, Ramsey spectroscopy.
Single molecule spectroscopy; spectroscopy at interfaces & surfaces
Advanced optical imaging;
spectroscopy of cold atoms;
atomic clocks; atom interferometry

Recommended Literature:
W. Demtröder; Laser spectroscopy (Springer 2002)
S. Svanberg; Atomic and molecular spectroscopy basic aspects and practical applications (Springer 2001)
A. Corney; Atomic and laser spectroscopy (Clarendon Press 1988)
N. B. Colthup, L. H. Daly, S. E. Wiberley; Introduction to infrared and Raman spectroscopy (Academic Press 1990)
P. Hannaford; Femtosecond laser spectroscopy (Springer New York 2005)
C. Rulliere; Femtosecond laser pulses: principles and experiments (Springer Berlin 1998)

Module: Specialization II

Module No.: physics630

Course: Molecular Physics II

Course No.:

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

Requirements:

Preparation:
Atomic Physics, Molecular Physics and Quantum Mechanics at the level of the bachelor courses in physics, Molecular Physics I

Form of Testing and Examination:
Oral Examination

Length of Course:
1 semester

Aims of the Course:
In the second part of the core courses more complex issues of molecular spectra are introduced. The students will be enabled to analyze spectra of complex molecules which are subject to couplings between electronic, vibrational and rotational motions.
In the special courses basic and advanced molecular physics are applied to atmospherical and astronomical environments.
This module prepares for topics of current research in molecular physics and provides the basis for the preparation of the master thesis.

Contents of the Course:
- Vibrational modes of polyatomic molecules
- Fundamentals of point group symmetry
- Vibrational dipole moment and selection rules
- Characteristic ro-vibrational spectra of selected molecules
- Breakdown of Born-Oppenheimer Approximation
- Coupling of rotation and vibration
- Coupling of angular momenta in molecular physics

Recommended Literature:
Bernath, "Spectra of Atoms and Molecules", Oxford University Press)
Townes Schawlow, "Microwave Spectroscopy" (Dover Publications)
Gordy & Cook, Microwave Spectra" (Wiley)
Engelke, "Aufbau der Moleküle" (Teubner)
P. R. Bunker and Per Jensen: "Molecular Symmetry and Spectroscopy, 2nd Edition", (NRC Research Press, Ottawa)

Module: Specialization II

Module No.: physics630

Course: Advanced Theoretical Particle Physics

Course No.: physics636

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

Requirements:

Preparation:
Theoretical Particle Physics (physics615)

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

Length of Course:
1 semester

Aims of the Course:
Survey of methods of theoretical high energy physics beyond the standard model, in particular supersymmetry and extra dimensions in regard to current research

Contents of the Course:
Introduction to supersymmetry and supergravity,
Supersymmetric extension of the electroweak standard model,
Supersymmetric grand unification,
Theories of higher dimensional space-time,
Unification in extra dimensions

Recommended Literature:
J. Wess; J. Bagger; Supersymmetry and supergravity (Princeton University Press 1992)
H. P. Nilles, Supersymmetry, Supergravity and Particle Physics, Physics Reports 110 C (1984) 1
D. Bailin; A. Love; Supersymmetric Gauge Field Theory and String Theory (IOP Publishing Ltd. 1994)
M. F. Sohnius; Introducing supersymmtry, (Phys.Res. 128 C (1985) 39)
P. Freund; Introduction to Supersymmetry (Cambridge University Press 1995)

Module: Specialization II

Module No.: physics630

Course: Advanced Theoretical Hadron Physics

Course No.: physics637

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

Requirements:

Preparation:
physics616 (Theoretical Hadron 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:
Survey of methods of theoretical hadron physics in regard to current research

Contents of the Course:
Quantum Chromodynamics: Nonperturbative Results, Confinement
Lattice Gauge Theory
Chiral Perturbation Theory
Effective Field Theory for Heavy Quarks

Recommended Literature:
F. E. Close; An Introduction 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 2006)
A. V. Manohar, M. B. Wise; Heavy Quark Physics (Cambridge University Press 2000)
S. Weinberg; The Quantum Theory of Fields (Cambridge University Press 1995)

Module: Specialization II

Module No.: physics630

Course: Advanced Theoretical Condensed Matter Physics

Course No.: physics638

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

Requirements:

Preparation:
physics617 (Theoretical Condensed Matter 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:
Survey of methods of theoretical condensed matter physics and their application to prominent examples in regard to current research

Contents of the Course:
Bosonic systems:
Bose-Einstein condensation
Photonics

Quantum dynamics of many-electrons systems:
Feynman diagram technique for many-particle systems at finite temperature
Quantum magnetism, Kondo effect, Renormalization group techniques
Disordered systems: Electrons in a random potential
Superconductivity

Recommended Literature:
A. A. Abrikosov, L.P. Gorkov; Methods of Quantum Field Theory in Statistical Physics (Dover, New York 1977)
W. Nolting; Grundkurs Theoretische Physik Band 7: Vielteilchentheorie (Springer, Heidelberg 2002)
A. C. Hewson, The Kondo Problem to Heavy Fermions (Cambridge University Press, 1997)
C. Itzykson, J.-M. Drouffe; Statistical Field Theory (Cambridge University Press 1991)
J. R. Schrieffer; Theory of Superconductivity (Benjamin/Cummings, Reading/Mass, 1983)