Specialization: Advanced Experimental Physics - physics62a

Module No.	**physics62a**
Category	Elective
Credit Points (CP)	6
Semester	2.

Module: Specialization: Advanced Experimental Physics

Module Elements:

Nr	Course	Course No.	CP	Type	Teaching hours	Semester
1	Physics of Hadrons	physics632	6	Lect. + ex.	3+1	ST
2	High Energy Collider Physics	physics633	6	Lect. + ex.	3+1	ST
3	Advanced Topics in High Energy Particle Physics	physics639	6	Lect. + ex.	3+1	ST
4	Magnetism/Superconductivity	physics634	6	Lect. + ex.	3+1	ST
5	Photonics	physics641	6	Lect. + ex.	3+1	ST
6	Quantum Technology	physics642	6	Lect. + ex.	3+1	ST
7	Molecular Physics II	MolPhys II	6	Lect. + ex.	3+1	ST

Requirements for Participation:

Form of Examination: see with the course

Content: Fundamentals on an advanced level in experimental physics in Bonn or Cologne

Aims/Skills: The students will get acquainted with modern research topics

Course achievement/Criteria for awarding cp's: see with the course

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: Note: The student must achieve at least 24 CP out of all 6 Specialization Modules

PDF version of this page.

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)

PDF version of this page.

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)

PDF version of this page.

Advanced Topics in High Energy Particle Physics - physics639

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 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: 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)

PDF version of this page.

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)

PDF version of this page.

Photonics - physics641

Course	**Photonics**
Course No.	physics641

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:

Examination written or oral (announced at the beginning of the module).

Prerequisite for participation in the exam: successful work within the exercises.

Length of Course: 1 semester

Aims of the Course: The lecture conveys the physical and technological foundations of laser-based photonics, and enables the students to practically apply their knowledge in research and development.

Contents of the Course:

Foundations: Advanced geometric and wave optics, Fourier optics;

Active and passive devices (Acoustooptics, electrooptics, detectors, imaging)

Advanced optics: Waveguides, Fibers; Photonic Crystals; Metamaterials; Resonators

Laser physics: Light-matter-interaction, principles, operation modes and properties

Nonlinear optics: Second- and third order processes, parametric oscillators, phase matching

Recommended Literature:

D. Meschede; Optics, Light and Lasers (Wiley-VCH, 3rd ed. 2017)

A. Yariv; Photonics: Optical Electronics in Modern Communications (Oxford Univ. Press 6th edition 2006)

B. Saleh, M. Teich; Fundamentals of Photonics (John Wiley & Sons, New York, 1991)

C. Yeh; Applied Photonics (Academic Press, 1994)

R. Menzel; Photonics (Springer, Berlin 2001)

PDF version of this page.

Quantum Technology - physics642

Course	**Quantum Technology**
Course No.	physics642

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

Requirements for Participation:

Preparation: Quantum mechanics,

Form of Testing and Examination:

Examination written or oral (announced at the beginning of the module).

Prerequisite for participation in the exam: successful work within the exercises.

Length of Course: 1 semester

Aims of the Course: The aim of the course is to introduce the students to modern applications of quantum physics. Both fundamental concepts of quantum technology as well as platforms for the implementation will be discussed.

Contents of the Course:

Basics of quantum information: Qubits, entanglement, EPR-tests

Quantum communication: Cryptography, teleportation

Quantum computing: circuit computation, paradigms, exotic computation

Quantum simulation

Quantum-enhanced metrology

Selected platforms: Ultracold atoms, single emitters, photonics

Recommended Literature:

S. M Barnett, Quantum information (Oxford University Press 2012)

M.A. Nielsen, I.L. Chuang, Quantum computation and quantum information (Cambridge 2010)

E. Göbel, U. Siegner, Quantum Metrology (Wiley VCH,2015)

W. Nawrocki, Introduction to Quantum Metrology (Springer 2019)

M. Lewenstein, A. Sanpera, V. Ahufinger, Ultracold atoms in optical lattices Simulating quantum many-body systems (Oxford University Press 2012)

PDF version of this page.

Molecular Physics II - MolPhys II

Course	**Molecular Physics II**
Course No.	MolPhys II

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

Requirements for Participation:

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)

PDF version of this page.