Elective Advanced Lectures: Applied Physics - physics70b

Module No.	**physics70b**
Category	Elective
Credit Points (CP)	3-6
Semester	1.-2.

Module: Elective Advanced Lectures: Applied Physics

Module Elements:

Nr	Course	Course No.	CP	Type	Teaching hours	Semester
1	Advanced Electronics and Signal Processing (E/A)	physics712	6	Lect. + ex.	3+1	ST
2	Particle Detectors and Instrumentation (E/A)	physics713	6	Lect. + lab.	3+1	ST
3	Advanced Accelerator Physics (E/A)	physics714	6	Lect. + ex.	3+1	ST/WT
4	Programming in Physics and Astronomy with C++ or Python (E/A)	physics718	4	Lect. + ex.	2+1	ST
5	Hands-on Seminar: Detector Construction (E/A)	physics723	3		2	WT/ST
6	Low Temperature Physics (E/A)	physics731	6	Lect. + ex.	3+1	WT/ST
7	Optics Lab (E/A)	physics732	4	Laboratory		WT/ST
8	Holography (E/A)	physics734	3	Lecture	2	ST
9	Crystal Optics (E/A)	physics736	6	Lect. + ex.	3+1	WT
10	Lecture on Advanced Topics in Photonics (E/A)	physics739	4		2+1	WT/ST
11	Hands-on Seminar: Experimental Optics and Atomic Physics (E/A)	physics740	3		2	WT/ST
12	Modern Spectroscopy (E/A)	physics741	4		2+1	WT/ST
13	Environmental Physics & Energy Physics (A)	physics771	3	Lecture	2	WT
14	Physics in Medicine: Fundamentals of Analyzing Biomedical Signals (A)	physics772	6	Lect. + ex.	3+1	WT
15	Physics in Medicine: Fundamentals of Medical Imaging (A)	physics773	6	Lect. + ex.	3+1	ST
16	Electronics for Physicists (E/A)	physics774	6	Lect. + ex.	3+1	ST
17	Nuclear Reactor Physics (A)	physics775	3	Lecture	2	ST
18	Physics in Medicine: Physics of Magnetic Resonance Imaging (A)	physics776	6	Lect. + ex.	3+1	WT
19	Internships in the Research Groups	physics799	4	internship		WT/ST

Requirements for Participation: none

Form of Examination: see with the course

Content: Advanced lectures in applied physics

Aims/Skills: Preparation for Master's Thesis work; broadening of scientific knowledge

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

Length of Module: 1 or 2 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 18 CP out of all 4 Elective Advanced Modules

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Advanced Electronics and Signal Processing (E/A) - physics712

Course	**Advanced Electronics and Signal Processing (E/A)**
Course No.	physics712

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

Requirements for Participation:

Preparation:

Electronics laboratory of the B.Sc. in physics programme

Recommended: module nuclear and particle physics of the B.Sc. programme

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

Length of Course: 1 semester

Aims of the Course: Comprehension of the basics of electronics circuits for the processing of (detector) signals, mediation of the basics of experimental techniques regarding electronics and micro electronics as well as signal processing

Contents of the Course: The physics of electronic devices, junctions, transistors (BJT and FET), standard analog and digital circuits, amplifiers, elements of CMOS technologies, signal processing, ADC, DAC, noise sources and noise filtering, coupling of electronics to sensors/detectors, elements of chip design, VLSI electronics, readout techniques for detectors

Recommended Literature:

P. Horowitz, W. Hill; The Art of Electronics (Cambridge University Press 2. Aufl. 1989)

S. Sze; The Physics of Semiconductor Devices (Wiley & Sons 1981)

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

J. Krenz; Electronics Concepts (Cambridge University Press 2000)

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Particle Detectors and Instrumentation (E/A) - physics713

Course	**Particle Detectors and Instrumentation (E/A)**
Course No.	physics713

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

Requirements for Participation:

Preparation: Completed B.Sc. in Physics, with experience in 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: Designing an experiment in photoproduction on pi-0, selection and building of appropriate detectors, set-up and implementation of an experiment at ELSA

Contents of the Course: Quark structure of mesons and baryons, nucleon excitation; electromagnetic probes, electron accelerators, photon beams, relativistic kinematics interaction of radiation with matter, detectors for photons, leptons and hadrons; laboratory course: setup of detectors and experiment at ELSA

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)

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

K. Kleinknecht; Detektoren für Teilchenstrahlung (Teubner, Wiesbaden 4. überarb. Aufl. 2005)

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Advanced Accelerator Physics (E/A) - physics714

Course	**Advanced Accelerator Physics (E/A)**
Course No.	physics714

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

Requirements for Participation:

Preparation: Accelerator Physics (physics612)

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 physics of synchrotron radiation and its influence on beam parameters

Basic knowledge of collective phenomena in particle accelerators

General knowledge of applications of particle accelerators (research, medicine, energy management)

Contents of the Course:

Synchrotron radiation:

radiation power, spatial distribution, spectrum, damping, equilibrium beam emittance, beam lifetime

Space-charge effects:

self-field and wall effects, beam-beam effects, space charge dominated beam transport, neutralization of beams by ionization of the residual gas

Collective phenomena:

wake fields, wake functions and coupling impedances, spectra of a stationary and oscillating bunches, bunch interaction with an impedance, Robinson instability

Applications of particle accelerators:

medical accelerators, neutrino facilities, free electron lasers, nuclear waste transmutation, etc.

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)

A. Chao; Physics of Collective Beam Instabilities in High Energy Accelerators (Wiley & Sons 1993)

Script of the Lecture Particle Accelerators (physics612)

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

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Programming in Physics and Astronomy with C++ or Python (E/A) - physics718

Course	**Programming in Physics and Astronomy with C++ or Python (E/A)**
Course No.	physics718

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	2+1	4	ST

Requirements for Participation:

Preparation: Basic knowledge of programming and knowledge of simple C/C++ or Python constructs.

Form of Testing and Examination:

C/C++ part: Requirements for the examination (written or oral): successful work with the exercises.

Python part: Requirements for examination: successful implementation of the scientific projects in Python during the semester.

Length of Course: 1 semester

Aims of the Course:

C++ part: In-depth understanding of C++ and its applications in particle physics. Discussion of advanced features of C++ using examples from High Energy Physics. The course is intended for students with some background in C++ or for advanced students who wish to apply C++ in their graduate research.

Python part: Effective and flexible program solving with the easy-to-learn, high level programming language Python. The course addresses master and PhD students with prior Python-programming knowledge as taught in the bachelor course physics131.

Contents of the Course:

C++ part: - Basic ingredients of C++, - Object orientation: classes, inheritance, polymorphism, - How to solve physics problems with C++, - Standard Template Library, - C++ in data analysis, example: the ROOT library, - C++ and large scale calculations, - How to write and maintain complex programs, - Parallel computing and the Grid, - Debugging and profiling

Python part: - In-depth introduction to Python based on prior programming experience, - Introduction to numpy arrays (primary Python data structure for scientific computing), - Introduction to scientific-Python modules (scipy, astropy), - Interactive work / development with Python (ipython), - Web interaction with Python (jupyter notebooks, web and database queries), - Plotting with Python (the matplotlib module)

Recommended Literature:

Eckel: Thinking in C++, Prentice Hall 2000.

Lippman, Lajoie, Moo: C++ Primer, Addison-Wesley 2000.

Deitel and Deitel, C++ how to program, Prentice Hall 2007.

Stroustrup, The C++ Programming Language, Addison-Wesley 2000.

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Hands-on Seminar: Detector Construction (E/A) - physics723

Course	**Hands-on Seminar: Detector Construction (E/A)**
Course No.	physics723

Category	Type	Language	Teaching hours	CP	Semester
Elective	Laboratory	English	2	3	WT/ST

Requirements for Participation: Basic knowledge of particle physics

Preparation: physics618 is helpful but not mandatory

Form of Testing and Examination: Credit points can be obtained after successful construction and operation of the detector and preparing a written and/or oral report on a specific task

Length of Course: 1 semester

Aims of the Course: Students will design, construct, assemble and operate a particle detector.

Contents of the Course:

Students will construct, assemble and commission a particle detector. They will gain hands-on experience on detector construction. The students organize and execute the tasks of the project in personal responsibility. This includes many tasks common to more complex research or industrial projects. Topics include:

- order the needed detector components
- prepare CAD drawings
- prepare PCB layout
- develop electronic circuits
- produce and assemble detector parts
- vacuum technology
- cooling technology
- organize the work effort in personal responsibility
- communicate with team members and technical staff

Recommended Literature:

H. Kolanoski, N. Wermes, Teilchendetektoren, (Springer, Heidelberg, 2016)

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

K. Kleinknecht; Detektoren für Teilchenstrahlung (Teubner, Wiesbaden 4. überarb. Aufl. 2005)

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Low Temperature Physics (E/A) - physics731

Course	**Low Temperature Physics (E/A)**
Course No.	physics731

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

Requirements for Participation:

Preparation: Elementary thermodynamics; principles of quantum mechanics; introductory lecture on solid state 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: Experimental methods at low (down to micro Kelvin) temperatures; methods of refrigeration; thermometry; solid state physics at low temperatures

Contents of the Course: Thermodynamics of different refrigeration processes, liquefaction of gases; methods to reach low (< 1 Kelvin) temperatures: evaporation cooling, He-3-He-4 dilution cooling, Pomeranchuk effect, adiabatic demagnetisation of atoms and nuclei; thermometry at low temperatures (e.g. helium, magnetic thermometry, noise thermometry, thermometry using radioactive nuclei); principles for the construction of cryostats for low temperatures

Recommended Literature:

O.V. Lounasmaa; Experimental Principles and Methods Below 1K (Academic Press, London 1974)

R.C. Richardson, E.N. Smith; Experimental Techniques in Condensed Matter Physics at Low Temperatures (Addison-Wesley 1988)

F. Pobell, Matter and Methods at Low Temperatures (Springer-Verlag, Heidelberg 2. Aufl. 1996)

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Optics Lab (E/A) - physics732

Course	**Optics Lab (E/A)**
Course No.	physics732

Category	Type	Language	Teaching hours	CP	Semester
Elective	Laboratory	English		4	WT/ST

Requirements for Participation:

Preparation:

Form of Testing and Examination: Credit points can be obtained after completion of a written report.

Length of Course: 4-6 weeks

Aims of the Course:

The student learns to handle his/her own research project within one of the optics groups

Available projects and contact information can be found at: http://www.iap.uni-bonn.de/opticslab/

Contents of the Course:

Practical training/internship in a research group, which can have several aspects:

- setting up a small experiment
- testing and understanding the limits of experimental components
- simulating experimental situations

Recommended Literature: Will be given by the supervisor

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Holography (E/A) - physics734

Course	**Holography (E/A)**
Course No.	physics734

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture	English	2	3	ST

Requirements for Participation:

Preparation:

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: The goal of the course is to provide in-depth knowledge and to provide practical abilities in the field of holography as an actual topic of applied optics

Contents of the Course: The course will cover the basic principle of holography, holographic recording materials, and applications of holography. In the first part the idea behind holography will be explained and different hologram types will be discussed (transmission and reflection holograms; thin and thick holograms; amplitude and phase holograms; white-light holograms; computer-generated holograms; printed holograms). A key issue is the holographic recording material, and several material classes will be introduced in the course (photographic emulsions; photochromic materials; photo-polymerization; photo-addressable polymers; photorefractive crystals; photosensitive inorganic glasses). In the third section several fascinating applications of holography will be discussed (art; security-features on credit cards, banknotes, and passports; laser technology; data storage; image processing; filters and switches for optical telecommunication networks; novelty filters; phase conjugation ["time machine"]; femtosecond holography; space-time conversion). Interested students can also participate in practical training. An experimental setup to fabricate own holograms is available

Recommended Literature:

Lecture notes;

P. Hariharan; Optical Holography - Principles, Techniques, and Applications (Cambridge University Press, 2nd Edition, 1996)

P. Hariharan; Basics of Holography (Cambridge University Press 2002)

J. W. Goodman; Introduction to Fourier Optics (McGraw-Hill Education - Europe 2nd Ed. 2000)

A. Yariv; Photonics (Oxford University Press 6th Ed. 2006)

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Crystal Optics (E/A) - physics736

Course	**Crystal Optics (E/A)**
Course No.	physics736

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: Because of their aesthetic nature crystals are termed "flowers of mineral kingdom". The aesthetic aspect is closely related to the symmetry of the crystals which in turn determines their optical properties. It is the purpose of this course to stimulate the understanding of these relations. The mathematical and tools for describing symmetry and an introduction to polarization optics will be given before the optical properties following from crystal symmetry are discussed. Particular emphasis will be put on the magneto-optical properties of crystals in magnetic internal or external fields. Advanced topics such as the determination of magnetic structures and interactions by nonlinear magneto-optics will conclude the course

Contents of the Course: Crystal classes and their symmetry; basic group theory; polarized light; optical properties in the absence of fields; electro-optical properties; magneto-optical properties: Faraday effect, Kerr effect, magneto-optical materials and devices, semiconductor magneto-optics, time-resolved magneto-optics, nonlinear magneto-optics

Recommended Literature:

R. R. Birss, Symmetry and Magnetism, North-Holland (1966)

R. E. Newnham: Properties of Materials: Anisotropy, Symmetry, Structure, Oxford University (2005)

A. K. Zvezdin, V. A. Kotov: Modern Magnetooptics & Magnetooptical Materials, Taylor/Francis (1997)

Y. R. Shen: The Principles of Nonlinear Optics, Wiley (2002)

K. H. Bennemann: Nonlinear Optics in Metals, Oxford University (1999)

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Lecture on Advanced Topics in Photonics (E/A) - physics739

Course	**Lecture on Advanced Topics in Photonics (E/A)**
Course No.	physics739

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	2+1	4	WT/ST

Requirements for Participation:

Preparation: Optics

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 goal of the course is to introduce the students to a special field of research in photonics. New research results will be presented and their relevance is discussed.

Contents of the Course: Will be given in the bulletin of lectures. The main theme will vary from term to term

Recommended Literature: Will be given in the lecture

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Hands-on Seminar: Experimental Optics and Atomic Physics (E/A) - physics740

Course	**Hands-on Seminar: Experimental Optics and Atomic Physics (E/A)**
Course No.	physics740

Category	Type	Language	Teaching hours	CP	Semester
Elective	Laboratory	English	2	3	WT/ST

Requirements for Participation:

Preparation: Fundamentals of optics and quantum mechanics

Form of Testing and Examination: Credit points can be obtained after successful carrying out the experiments and preparing a written report on selected experiments

Length of Course: 1 semester

Aims of the Course: The students learn to handle optical setups and carry out optical experiments. This will prepare participants both for the successful completion of research projects in experimental quantum optics/photonics and tasks in the optics industry.

Contents of the Course:

Practical training in the field of optics, where the students start their experiment basically from scratch (i.e. an empty optical table). The training involves the following topics:

- diode lasers
- optical resonators
- acousto-optic modulators
- spectroscopy
- radiofrequency techniques

Recommended Literature: Will be given by the supervisor

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Modern Spectroscopy (E/A) - physics741

Course	**Modern Spectroscopy (E/A)**
Course No.	physics741

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	2+1	4	WT/ST

Requirements for Participation:

Preparation: Fundamentals of Optics, Fundamentals of Quantum Mechanics

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

Length of Course: 1 semester

Aims of the Course: The aim of the course is to introduce the students to both fundamental and advanced concepts of spectroscopy and enable them to practically apply their knowledge.

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.

Applications of spectroscopic methods (e.g. Single molecule spectroscopy; spectroscopy at interfaces & surfaces, 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)

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Environmental Physics & Energy Physics (A) - physics771

Course	**Environmental Physics & Energy Physics (A)**
Course No.	physics771

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture	English	2	3	WT

Requirements for Participation:

Preparation: Physik I-V (physik110-physik510)

Form of Testing and Examination: Active contributions during term and written examination

Length of Course: 1 semester

Aims of the Course: A deeper understanding of energy & environmental facts and problems from physics (and, if needed, nature or agricultural science) point of view

Contents of the Course: After introduction into related laws of nature and after a review of supply and use of various resources like energy a detailed description on each field of use, use-improvement strategies and constraints and consequences for environment and/or human health & welfare are given.

Recommended Literature:

Diekmann, B., Heinloth, K.: Physikalische Grundlagen der Energieerzeugung, Teubner 1997

Hensing, I., Pfaffenberger, W., Ströbele, W.: Energiewirtschaft, Oldenbourg1998

Fricke, J., Borst, W., Energie, Oldenbourg 1986

Bobin, J. L.,Huffer,E., Nifenecker,H., L'Energie de Demain ,EDP Sciences 2005

Thorndyke, W., Energy and Environment, Addison Wesley 1976

Schönwiese, C. D., Diekmann, B., Der Treibhauseffekt , DVA 1986

Boeker, E., von Grondelle, R., Physik und Umwelt, Vieweg, 1997

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Physics in Medicine: Fundamentals of Analyzing Biomedical Signals (A) - physics772

Course	**Physics in Medicine: Fundamentals of Analyzing Biomedical Signals (A)**
Course No.	physics772

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

Requirements for Participation:

Preparation: Elementary thermodynamics; principles of quantum mechanics, principles of condensed matter

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 principles of physics and the analysis of complex systems

Contents of the Course:

Introduction to the theory of nonlinear dynamical systems; selected phenomena (e.g. noise-induced transition, stochastic resonance, self-organized criticality); Nonlinear time series analysis: state-space reconstruction, dimensions, Lyapunov exponents, entropies, determinism, synchronization, interdependencies, surrogate concepts, measuring non-stationarity.

Applications: nonlinear analysis of biomedical time series (EEG, MEG, EKG)

Recommended Literature:

Lehnertz: Skriptum zur Vorlesung

E. Ott; Chaos in dynamical systems (Cambridge University Press 2. Aufl. 2002)

H. Kantz, T. Schreiber ; Nonlinear time series analysis. (Cambridge University Press 2:Aufl. 2004).

A. Pikovsky, M. Rosenblum, J. Kurths; Synchronization: a universal concept in nonlinear sciences

(Cambridge University Press 2003)

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Physics in Medicine: Fundamentals of Medical Imaging (A) - physics773

Course	**Physics in Medicine: Fundamentals of Medical Imaging (A)**
Course No.	physics773

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

Requirements for Participation:

Preparation: Lectures Experimental Physics I-III (physik111-physik311) respectively

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 principles of physics of modern imaging techniques in medicine

Contents of the Course:

Introduction to physical imaging methods and medical imaging; Physical fundamentals of transmission computer tomography (Röntgen-CT), positron emission computer tomography (PET), magnetic resonance imaging (MRI) and functional MRI

detectors, instrumentation, data acquisition, tracer, image reconstruction, BOLD effect; applications: analysis of structure and function.

Neuromagnetic (MEG) and Neuroelectrical (EEG) Imaging; Basics of neuroelectromagnetic activity, source models

instrumentation, detectors, SQUIDs; signal analysis, source imaging, inverse problems, applications

Recommended Literature:

K. Lehnertz: Scriptum zur Vorlesung

S. Webb; The Physics of Medical Imaging (Adam Hilger, Bristol 1988)

O. Dössel; Bildgebende Verfahren in der Medizin (Springer, Heidelberg 2000)

W. Buckel; Supraleitung (Wiley-VCH Weinheim 6. Aufl. 2004)

E. Niedermeyer/F. H. Lopes da Silva; Electroencephalography (Urban & Schwarzenberg, 1982)

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Electronics for Physicists (E/A) - physics774

Course	**Electronics for Physicists (E/A)**
Course No.	physics774

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

Requirements for Participation:

Preparation: Electronics laboratory of the B.Sc. in physics programme

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

Length of Course: 1 semester

Aims of the Course: Comprehension of electronic components, methods to derive the dynamical performance of circuits and mediation that these methods are widely used in various fields of physics

Contents of the Course: Basics of electrical engineering, RF-electronics I: Telegraph equation, impedance matching for lumped circuits and electromagnetic fields, diodes, transistors, analogue and digital integrated circuits, system analysis via laplace transformation, basic circuits, circuit synthesis, closed loop circuits, oscillators, filters, RF-electronics II: low-noise oscillators and amplifiers

Recommended Literature:

P. Horrowitz, W. Hill; The Art of Electronics (Cambridge University Press)

Murray R. Spiegel; Laplace Transformation (McGraw-Hill Book Company)

A.J. Baden Fuller; Mikrowellen (Vieweg)

Lutz v. Wangenheim; Aktive Filter (Hüthig)

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Nuclear Reactor Physics (A) - physics775

Course	**Nuclear Reactor Physics (A)**
Course No.	physics775

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	2	3	ST

Requirements for Participation:

Preparation: Fundamental nuclear physics

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: Deeper understanding of nuclear power generation (fisson and fusion)

Contents of the Course:

Physics of nuclear fission and fusion, neutron flux in reactors, different reactor

types, safety aspects, nuclear waste problem, future aspects

and

Excursion to a nuclear power plant

Recommended Literature:

H. Hübel: Reaktorphysik (Vorlesungsskript, available during the lecture)

M. Borlein: Kerntechnik, Vogel (2009)

W. M. Stacey: Nuclear Reactor Physics, Wiley & Sons (2007)

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Physics in Medicine: Physics of Magnetic Resonance Imaging (A) - physics776

Course	**Physics in Medicine: Physics of Magnetic Resonance Imaging (A)**
Course No.	physics776

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

Requirements for Participation:

Preparation: Lectures Experimental Physics I-III (physik111-physik311) respectively

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 principles of Magnetic Resonance Imaging Physics

Contents of the Course:

- Theory and origin of nuclear magnetic resonance (QM and semiclassical approach)
- Spin dynamics, T1 and T2 relaxation, Bloch Equations and the Signal Equation
- Gradient echoes and spin echoes and the difference between T2 and T2*
- On- and off-resonant excitation and the slice selection process
- Spatial encoding by means of gradient fields and the k-space formalism
- Basic imaging sequences and their basic contrasts, basic imaging artifacts
- Hardware components of an MRI scanner, accelerated imaging with multiple receiver
- Computation of signal amplitudes in steady state sequences
- The ultra-fast imaging sequence EPI and its application in functional MRI
- Basics theory of diffusion MRI and its application in neuroimaging
- Advanced topics: quantitative MRI, spectroscopic imaging, X-nuclei MRI

Recommended Literature:

- T. Stöcker: Scriptum zur Vorlesung
- E.M. Haacke et al, Magnetic Resonance Imaging: Physical Principles and Sequence Design, John Wiley 1999
- M.T. Vlaardingerbroek, J.A. den Boer, Magnetic Resonance Imaging: Theory and Practice, Springer, 20
- Z.P. Liang, P.C. Lauterbur, Principles of Magnetic Resonance Imaging: A Signal Processing Perspective, SPIE 1999

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Internships in the Research Groups - physics799

Course	**Internships in the Research Groups**
Course No.	physics799

Category	Type	Language	Teaching hours	CP	Semester
Elective	Research Internship	English		4	WT/ST

Requirements for Participation: Students are asked to contact one of the BCGS lecturers prior to the start of their internship. Lecturers provide help if needed to find a suitable research group and topic. Not all groups may have internships available at all times, thus participation may be limited.

Preparation: A specialization lecture from the research field in question or equivalent preparation.

Form of Testing and Examination: A written report or, alternatively, a presentation in a meeting of the research group.

Length of Course: 4-6 weeks

Aims of the Course: Students conduct their own small research project as a part-time member of one of the research groups in Bonn. The students learn methods of scientific research and apply them to their project.

Contents of the Course:

One of the following possible items:

- setting up a small experiment,
- analyzing data from an existing experiment,
- simulating experimental situations,
- numerical or analytical calculations in a theory group.

Recommended Literature: provided by the supervisor within the research group.

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