Wintersemester 2016/2017

Winter Term

Kommentiertes Vorlesungsverzeichnis Physik-Astronomie

Veranstaltungen des Masterstudiums, von den Dozenten/innen kommentiert

Annotated Course Catalogue Physics-Astronomy

a list of advanced courses, with comments by the instructors

Herausgeber: Fachgruppe Physik-Astronomie Oktober 2016

physics611 **Particle Physics**
Tu 12-14, Th 12-14, HS, IAP
The lecture times will be synchronized with those of physics618 on October, 20th 2016

Instructor(s): I. Brock

Prerequisites:
BSc Vorlesung physik511 Physik V (Kerne und Teilchen)

Contents:
• Introduction: overview, notations

• Basics: kinematics, Lorentz systems, colliders and fixed target experiments

• Scattering processes: cross section and lifetime, Fermi's golden rule, phase space, 2- and 3-body decays, Mandelstam variables

• Dirac equation, spin and helicity, QED

• Interactions and fields

• e+e- annihilation

• Lepton-p scattering and the quark model

• Symmetries and conservation laws

• Strong interaction and QCD

• Weak interaction

• Electroweak unification and Standard Model tests

• The Higgs Boson

Literature:
The lecture does not follow a particular book but larger parts will be close to the new book by

M. Thomson, "Modern Particle Physics", Cambridge University Press

Further useful books are:

Halzen, Martin Quarks and Leptons
D. Perkins Introduction to High Energy Physics
C. Berger Elementarteilchenphysik
D. Griffith Introduction to Elementary Particles
P. Schmüser Feynman-Graphen und Eichtheorien für Experimentalphysiker

Comments:
This lecture is recommended as the first course for master students interested in (experimental) particle physics.

physics618 **Physics of Particle Detectors**
Th 14-16, Fr 13-15, HS, HISKP
The lecture times will be synchronized with those of physics611 on October, 20th 2016

Instructor(s): N. Wermes

Prerequisites:
- electrodynamics
- basics of quantum mechanics
- elementary knowledge of particle and nuclear physics useful

Contents:
1. Introduction

2. Sources of Ionizing Radiation

3. Energy Loss of Charged Particles in Matter

4. Ionization Detectors

5. Position Measurement

6. Momentum Measurement

7. Signal Processing and Acquisition

8. Interaction of Photons with Matter

9. Scintillation Detectors

10. Photon Detection

11. Particle Identification

12. Calorimetry

13. Detector Systems

Literature:
H. Kolanoski, N. Wermes; Teilchendetektoren - Grundlagen und Anwendungen" (2016)
English Edition will appear early 2018.

other Literature

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

W.R. Leo; Techniques for Nuclear and Particle Physics Experiments (Springer, Berlin, 2nd ed., 1994)

C. Grupen, B. Shwartz; Particle Detectors (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology, Band 26, 2nd ed., 2008)

C. Leroy, P.-G. Rancoita; Principles of Radiation Interaction in Matter and Detection (World Scientific, Singapore, 3rd ed., 2012)

W. Blum, W. Riegler, L. Rolandi; Particle Detection with Drift Chambers (Springer, Berlin, 2nd ed., 2008)

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

Comments:
The course is extended from 3 to 4 hours to be able to cover the content
of my book
"Teilchendetektoren - Grundlagen und Anwendungen"
"Particle Detectors - from fundamentals to applications"
in some larger detail.

In order to allow participation also to students attending the course "particle physics", the times of both lectures "Particle Physics" and "Physics of Particle Detectors" will be adjusted in the first week of the semester.

The lecture covers the in-depth study of the physics processes relevant for modern particle detectors, used e.g. in large-scale experiments at CERN, in smaller scale setups in the laboratory, and in astrophysics or medical applications. The general concepts of different detector types such as trackers, calorimeters or devices used for particle identification are introduced. Basics of detector readout techniques and the acquisition of large amount of data are discussed. This course is relevant for students who whish to major in experimental high energy physics, hadron physics or astro particle physics. It is also useful for students interested in medical imaging detectors.

The lecture will be accompanied by a tutorial and laboratory visits.

physics614 **Laser Physics and Nonlinear Optics**
Tu 10-12, Th 8-10, HS, IAP

Instructor(s): F. Vewinger

Prerequisites:
Optics, Atomic Physics, Quantum Mechanics

Contents:
- Propagation of Laser Beams, Resonators
- Atom Light Interaction
- Principles of Lasers, Laser Systems
- Properties of Laser Light
- Applications of Lasers
- Frequency Doubling, Sum and Difference Frequency Generation
- Parametric Processes, Four Wave Mixing

Literature:
- P. Miloni, J. Eberly; Lasers (Wiley, New York, 1988)
- D. Meschede; Optik, Licht und Laser (Teubner, Wiesbaden, 2005)
- F. K. Kneubühl; Laser (Teubner, Wiesbaden, 2005)
- J. Eichler, H.J. Eichler; Laser (Springer, Heidelberg, 2003)
- R. Boyd; Nonlinear Optics (Academic Press, Boston, 2003)
- Y.-R. Shen; The principles of nonlinear optics (Wiley, New York, 1984)

Comments:
The Lecture is suitable for BSc Students beginning with the 5. Semester and for Master-Students.

physics620 **Advanced Atomic, Molecular and Optical Physics**
Tu 14-16, We 14-16, HS, IAP

Instructor(s): F. Vewinger

Prerequisites:
Quantum mechanics
Atomic Physics

Contents:
Part 1: Atomic and optical physics (Matter and light)
Introduction, overview of the course
Reminder of basic atomic structure (including relativistic corrections)
Atoms in external fields
Interaction of light and matter: electric dipole transitions, selection rules;
Magnetic resonance; Ramsey interferometry, atomic clocks,
Dissipative light-matter interaction
Light forces, optical potentials, Laser cooling
Quantisation of light, cavity-QED

Part 2: Quantum information processing
Basic ideas: qubits, gates
Entanglement and quantum algorithms
Ion traps

Part 3: Molecular Physics
Basic molecules: Hydrogen Molecule;
Molecular potentials, bound states, collisions
Feshbach resonances

Part 4: Quantum gases
Evaporative cooling
Bose-Einstein Condensation;
Fundamentals of many-body physics,
Optical lattices
Ultracold Fermi gases
BEC vs. BCS

Literature:
C. Foot, "Atomic Physics"
C. Pethick/H. Smith, "Bose-Einstein condensation in dilute atomic gases"
L. Pitaevskii/S. Stringari, "Bose-Einstein condensation"
L. Nielsen/I. Chuang "Quantum Computation and Quantum Information"

Comments:

physics615 **Theoretical Particle Physics**
Mo 16-18, Tu 16, HS I, PI

Instructor(s): H.-P. Nilles

Prerequisites:
Relativistic quantum mechanics.
Introductory courses in particle physics and quantum field theory are helpful, but not essential.
Basics of Group Theory

Contents:
Classical field theory,
Gauge theories for QED and QCD,
Higgs mechanism,
Standard model of strong and electroweak interactions,
Grand unification,
Nonperturbative aspects of the standard model
Physics beyond the standard model

Literature:
Cheng and Li, Gauge theories of elementary particle physics
Halzen and Martin: Quarks and Leptons
Peskin and Schroeder: An Introduction to Quantum Field Theory
Weinberg, The Quantum Theory of Fields I + II

Comments:
The course (both lectures and tutorials) are in English.
A condition for participation in the final exam is that 50% of the homework of this class have been solved (not necessarily entirely correctly).

The first lecture will take place on Monday, October 17th

physics616 **Theoretical Hadron Physics**
We 14-17, SR I, HISKP

Instructor(s): T. Luu, A. Wirzba

Prerequisites:
Quantum Mechanics, Advanced Quantum Theory

Contents:

1. Introduction: brief overview of particle physics
2. Symmetries and Quarks: hadron spectra and interactions, hadron masses, light and heavy quarks, simple quark model,...
3. Hadron Structure: form factors and structure functions, unitarity and analyticity, vector meson dominance, dispersion relations,...
4. Introduction to QCD: QCD Lagrangian, asymptotic freedom,...
5. Chiral symmetry: spontaneous symmetry breaking, Goldstone theorem, hadron interactions at low energies,...

Literature:

- F. Halzen, A.D. Martin; Quarks and Leptons (Wiley 1984)
- D.H. Perkins; Introduction to High Energy Physics (Addison-Wesley 1987)
- J.F. Donoghue et al.; Dynamics of the Standard Model, 2nd ed. (Cambridge University Press 2014)
- A.W. Thomas, W. Weise; The Structure of the Nucleon (Wiley-VCH 2001)
- M.E. Peskin, D.V. Schroeder; An Introduction to Quantum Field Theory (Westview Press 1995)

Comments:
A basic knowledge of Quantum Field Theory is useful.

physics617 **Theoretical Condensed Matter Physics**
We 12, Th 10-12, HS, HISKP

Instructor(s): C. Kollath

Prerequisites:
Theoretical Physics I-IV

Contents:
This lecture gives an introduction to the theoretical description of the electronic properties of materials. The focus lies on the discussion of the fascinating collective quantum phenomena induced by the interaction between many particles as for example superconductivity and magnetic ordering.

Outline:
Structure of solids
Electrons in a lattice, Bloch theorem, band structure
Fermi liquid theory
Magnetism
Superconductivity
Mott insulator transition

Literature:
N. W. Ashcroft and N. D. Mermin, "Solid State Physics"
P. W. Anderson, "Basic Notions of Condensed Matter Physics", Addison-Wesley 1997
A. Altland & B. Simons, "Condensed Matter Field Theory",
Cambridge University Press 2006
M.P. Marder, "Condensed Matter Physics", John Wiley & Sons
J. M. Ziman: "Principles of Solid State Physics", Verlag Harry Deutsch 75
C. Kittel: "Quantum Theory of Solids", J. Wiley 63

Comments:
This course teaches basic concepts of condensed matter theory. The macroscopic manifestation of quantum mechanics leads to surprising properties of novel materials.

physics719 **BCGS intensive week (Advanced Topics in High Energy Physics)**
October 10th - 14th

Instructor(s): E. von Törne

Prerequisites:
For the exercises, basic knowledge of C would be good

Contents:
BCGS Intensive Week, "From Hits to Higgs" - a Discovery Simulation for Physics at the LHC
10-14. October, Conference room-II, Physikalisches Institut Bonn

This course will of interest both for students starting their master studies, students who start their master project soon, Ph.D. students from other fields of physics who wish to broaden their horizon. The BCGS intensive week aims at providing a detailed insight of an LHC detector and the experiments that are done with them to address important questions of fundamental physics today.

What does one need to know to analyse LHC data? While following these lines, particular emphasis is given to
- the scientific and technical requirements of LHC detectors
- the physics of tracking and energy detectors
- the theoretical background of LHC physics (Standard Model + Higgs physics)
- the experimental methods to address these physics questions
Of course, not all topics can be addressed to depth within one week. Thus an effort is made that students will receive an overview and understand the most important mechanisms.

About half of the course is devoted to a hand-on project which will be organized as a simulation game (planspiel). Participants will use toy data to reconstruct proton proton collisions. Starting from uncalibrated hits we will create our own algorithms and finally search for new physics at the LHC. Students will learn several aspects of C++ and its applications in high energy physics.

Literature:

Comments:
The course is an all-day workshop, starting on October 10 at 9:15. Students from Cologne: There is a regional express train at 8:38 from Köln-Süd that brings you to Bonn in time for the lecture. This train is free with your student ticket.

physics732 **Optics Lab**
4 to 6 weeks on agreement

Instructor(s): F. Vewinger, M. Köhl, S. Linden, D. Meschede, M. Weitz

Prerequisites:
BSc

Contents:
The Optics Lab is a 4-6 week long practical training/internship in one of the research groups in Photonics and Quantum Optics, which can have several aspects:
- setting up a small experiment
- testing and understanding the limits of experimental components
- simulating experimental situations

Credit points can be obtained after completion of a written report.

Literature:
Will be given by the supervisor

Comments:
For arranging the topic and time of the internship, please contact the group leader of the group you are interested in directly. Please note that a lead time of a few weeks may occur, so contact the group early. In case you are unsure if/where you want to do the optics lab, please contact Frank Vewinger for information.

physics738 **Lecture on Advanced Topics in Quantum Optics**
Th 10-12, HS, IAP

Instructor(s): A. Alberti, D. Meschede

Prerequisites:
BSc, Quantum Mechanics

Contents:
The lecture will foster 3 topics:

1 - Fundamental Results and Applications of Cavity QED (CQED) (5 lectures)
2 - Topological States of Matter (5 lectures)
3 - Indistinguishability (4 lectures)

Literature:
- will be given later -

Comments:
2 hours lecture
1 hour exercises (time slot to be fixed in first lecture)

physics740 **Hands-on Seminar: Experimental Optics and Atomic Physics**
Mo 9-11, IAP

Dozent(en): M. Weitz u.M.

Erforderliche Vorkenntnisse:
Optik- und Atomphysik Grundvorlesungen, Quantenmechanik

Inhalt:
Diodenlaser
Optische Resonatoren
Akustooptische Modulatoren
Spektroskopie
Radiofrequenztechnik
Spannungsdoppelbrechung
und vieles mehr

Literatur:
wird gestellt

Bemerkungen:
Vorbesprechung am Montag, den 17.10.16, 9 c.t.,
Konferenzraum IAP, 3. Stock Wegelerstr. 8
Auf Wunsch der Hörer kann das Hands-on Seminar wegen Überlapp zu anderen Veranstaltungen eventuell auf beispielsweise Freitagvormittag verschoben werden; genaueres in der Vorbesprechung.

Seminartermine ab 24.10.16

physics7501 **Advanced Quantum Field Theory**
We 10-12, Th 9, SR II, HISKP

Instructor(s): A. Rusetsky

Prerequisites:
Quantum Mechanics 1+2, Quantum Field theory 1

Contents:

- Renormalization group and asymptotic behavior
- Quantization of fields in the path integral formalism
- Quantization of constrained systems: gauge fields
- Symmetries and Ward identities
- Anomalies
- Renormalization in spontaneously broken theories

Literature:

1. M. Peskin and D. Schroeder, An Introduction to Quantum Field Theory
2. L.H. Ryder, Quantum Field Theory
3. A. Zee, Quantum Field Theory in a Nutshell
4. S. Weinberg, The Quantum Theory of Fields II
5. C. Itzykson and J.-B. Zuber, Quantum Field Theory
6. T.-P. Cheng and L.-F. Li, Gauge theory of elementary particle physics
7. L.-D. Faddeev and A.A. Slavnov, Gauge Fields: An Introduction To Quantum Theory

Comments:

physics753 **Theoretical Particle Astrophysics**
Mo 12-14, Tu 9, HS, HISKP

Instructor(s): M. Drees

Prerequisites:
Knowledge of (relativistic) Quantum Mechanics, and basic knowledge of the Standard Model of particle physics, will be assumed. Knowledge of Quantum Field Theory and General Relativity is helpful, but not essential.

Contents:
Application of particle physics to astrophysical and cosmological problems. Emphasis will be on the physics of the early universe, basically the first few seconds (after inflation).

Literature:
Kolb and Turner, "The Early Universe", Addison Wesley
V. Mukhanov, Physical foundations of cosmology, Cambridge University Press

Comments:
Particle astrophysics works at the interface of traditional particle physics on the one hand, and astrophysics and cosmology on the other. This field has undergone rapid growth in the last one or two decades, and many fascinating questions remain to be answered.

physics7503 **Selected Topics in Modern Condensed Matter Theory**
We 14, Fr 12-14, HS I, PI

Instructor(s): J. Kroha

Prerequisites:
Quantum mechanics I, e.g. physik420
Statistical Physics, e.g. physik521

Contents:
Over the past few years, research in condensed matter physics has witnessed several novel developments, which are revolutionizing our understanding of many-body systems. Among those developments are
- the simulation of many-body problems in ultracold atomic gas systems;
- quantum phase transitions as a means for realizing exotic states of matter;
- topological aspects of Hilbert space.

The course will discuss these developments and provide some of the necessary theoretical techniques.

Specific topics are:
- Feynman diagram technique;
- The method of slave fields for strong interactions;
- Phase transitions, critical phenomena, renormalization group method;
- Topological structure of the Hilbert space and consequences for the properties condensed matter systems. Topological insulators.

Literature:
R. D. Mattuck, A Guide to Feynman Diagrams in the Many-Body Problem.
N. Goldenfeld, Lectures on Phase Transitions and the Renormalization Group.
B. A. Bernevig, Topological Insulators and Topological Superconductors.

Comments:
The topics of this course are coordinated such that it can be taken in parallel to physics617 (Theoretical Condensed Matter Physics).

physics772 **Physics in Medicine: Fundamentals of Analyzing Biomedical Signals**
Mo 10-12, We 12, SR I, HISKP

Instructor(s): G. Ansmann, K. Lehnertz

Prerequisites:
Bachelor

Contents:
Introduction to the theory of nonlinear dynamical systems
- regularity, stochasticity, deterministic chaos, nonlinearity, complexity, causality, (non-)stationarity, fractals
- selected examples of nonlinear dynamical systems and their characteristics (model and real world systems)
- selected phenomena (e.g. noise-induced transition, stochastic resonance, self-organized criticality)
Time series analysis
- linear methods: statistical moments, power spectral estimates, auto- and cross-correlation function, autoregressive modeling
- univariate and bivariate nonlinear methods: 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)

Literature:
M. Priestley: Nonlinear and nonstationary time series analysis, London, Academic Press, 1988.

H.G. Schuster: Deterministic chaos: an introduction. VCH Verlag Weinheim; Basel; Cambridge, New York, 1989

E. Ott: Chaos in dynamical systems. Cambridge University Press, Cambridge UK, 1993

H. Kantz, T. Schreiber T: Nonlinear time series analysis. Cambridge University Press, Cambridge UK, 2nd ed., 2003

A. Pikovsky, M. Rosenblum, J. Kurths: Synchronization: a universal concept in nonlinear sciences. Cambridge University Press, Cambridge UK, 2001

Comments:
Beginning: Mon, Oct 17, 10:00 ct

physics774 **Electronics for Physicists**
Tu 14, We 10-12, HS, HISKP

Instructor(s): P.-D. Eversheim, C. Honisch

Prerequisites:
Elektronikpraktikum

Contents:
One of the "classic" abilities of an experimentalist is to build those instruments himself he needs but can not get otherwise. In this context the knowledge of electronics - in view of the growing electronics aided acquisition and control of experiments - becomes a key skill of an experimentalist.
The intention of this lecture is to enable the students by means of exemplary experiments to work out concepts to solutions for given problems. A focus of this lecture is to show that many of these solutions or concepts to solutions, respectively, are used in other fields of physics too (quantum mechanics, optics, mechanics, acoustics, . . .).

At the end of this lecture, the student should:
i) have an overview over the most common parts in electronics.
ii) be concious about the problems of handling electronic parts and assemblies.
iii) understand the concepts that allow an analysis and synthesis of the dynamic properties of systems.

Literature:
1) The Art of Electronics by Paul Horowitz and Winfield Hill,
Cambridge University Press
- "The practitioners bible" -
2) Elektronik für Physiker by K.-H. Rohe,
Teubner Studienbücher
- A short review in analogue electronics -
3) Laplace Transformation by Murray R. Spiegel,
McGraw-Hill Book Company
- A book you really can learn how to use and apply Laplace Transformations -
4) Entwurf analoger und digitaler Filter by Mildenberger,
Vieweg
- Applications of Laplace Transformations in analogue electronics -
5) Aktive Filter by Lutz v. Wangenheim,
Hüthig
- Comprehensive book on OP-Amp applications using the Laplace approach -
6) Mikrowellen by A.J.Baden Fuller,
Vieweg
- The classic book on RF and microwaves basics -
7) Physikalische Grundlagen der Hochfrequenztechnik by Meyer / Pottel
Vieweg
- An interesting approach to explain RF behaviour by acoustic analogies -

Comments:

physics776 **Physics in Medicine: Physics of Magnetic Resonance Imaging**
Tu 14-16, Th 16, SR II, HISKP

Instructor(s): T. Stöcker

Prerequisites:
Lectures Experimental Physics I-III (physik111-physik311)

Contents:
- 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

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
- Z.P. Liang, P.C. Lauterbur, Principles of Magnetic Resonance Imaging: A Signal Processing Perspective, SPIE 1999

Comments:

physics652 **Seminar Photonics/Quantum Optics**
Mo 14-16, HS, IAP

Instructor(s): D. Meschede

Prerequisites:
Bachelor education in physics, espcially quantum physics

Contents:
Seminar description:
This seminar will be about how quantum mechanics can be applied to modern research problems in the field of atomic, molecular, condensed matter and laser physics. In this research field, a strong theoretical and experimental/technical knowledge is required, which is why this seminar will cover both quantum theory and experimental quantum physics.
The seminar will be based on the book “The quantum mechanics solver” by J.-L. Basdevant and J. Dalibard (provided). In this book, each chapter gives a theoretical and experimental overview of selected topics (see below), including exercise questions. This provides a solid base for further exploration of the topic. Seminar attendees are required to select and present one of these topics in a 45min talk (+ discussions) and to actively contribute in discussions during the seminar. The preparation of the talk will require to recall the required theoretical background by solving the exercise questions as well as to understand experimental observations and techniques used. We will explicitly support the use of computer algebra systems (i.e. Mathematica) for preparing solutions and simulations. Furthermore, own literature research (research paper, books, …) will be required in order to set the chosen topic into context with more recent experiments in this research field.
Examples from the table of contents:

Particles and Atoms

Neutrino Oscillations, Atomic Clocks, Neutron Interferometry, Spectroscopic Measurement on a Neutron Beam, Analysis of a Stern-Gerlach Experiment, Measuring the Electron Magnetic Moment Anomaly, Decay of a Tritium Atom, The spectrum of Positronium, The Hydrogen Atom in Crossed Fields, Energy Loss of Ions in Matter.

Quantum Entanglement and Measurement

The EPR Problem and Bell’s inequality, Schrödingers Cat, Quantum Cryptography, Direct Observation of Field Quantization, Ideal Quantum Measurement, The Quantum Eraser, A Quantum Thermometer.

Complex Systems

Exact Results for the Three-Body Problem, Properties of a Bose-Einstein Condensate, Magnetic Excitons, A Quantum Box, Colored Molecular Ions, Hyperfine Structure in Electron Spin Resonance, Probing Matter with Positive Muons, Quantum Reflection of Atoms from a Surface, Laser Cooling and Trapping, Bloch Oscillations.

Literature:
“The quantum mechanics solver”
by J.-L. Basdevant and J. Dalibard, (Springer, Heidelberg 2000)

** available from the library as an e-book
** available at the IAP library (on shelf)

Comments:
Technical Organization:
- Participants freely choose a topic from the book by Basdevant/Dalibard (one topic/participant)
- At least 5 weeks of preparation with guidance by the lecturers are expected
- 45 min talks will present the concept, a problem, and an experimental verification
- A 2-page summary is requested for completion of the course before the end of the term
Credits: 4 cps on successful completion

physics655 **Computational Physics Seminar on Analyzing Biomedical Signals**
Mo 14-16, SR I, HISKP

Instructor(s): K. Lehnertz, B. Metsch

Prerequisites:
Bachelor, basics of programming language (e.g., Fortran, C, C++, Pascal)

Contents:
- time series: chaotic model systems, noise, autoregressive processes, real world data
- generating time series: recursive methods, integration of ODEs
- statistical properties of time series: higher order moments, autocorrelation function, power spectra, corsscorrelation function
- state-space reconstruction (Takens theorem)
- characterizing measures: dimensions, Lyapunov-exponents, entropies, testing determinism (basic algorithms, influencing factors, correction schemes)
- testing nonlinearity: making surrogates, null hypothesis tests, Monte-Carlo simulation
- nonlinear noise reduction
- measuring synchronisation and interdependencies

Literature:
- H. Kantz, T. Schreiber T: Nonlinear time series analysis. Cambridge University Press, Cambridge UK, 2nd
ed., 2003
- A. Pikovsky, M. Rosenblum, J. Kurths: Synchronization: a universal concept in nonlinear sciences. Cambridge University Press, Cambridge UK, 2001
- WH. Press, BP. Flannery, SA. Teukolsky, WT. Vetterling: Numerical Recipes: The Art of Scientific Computing. Cambridge University Press
- see also: http://www.mpipks-dresden.mpg.de/~tisean/ and http://www.nr.com/

Comments:
Location: Seminarraum I, HISKP
Time: Mo 14 - 16 and one lecture to be arranged
Beginning: Mo October 24 (preliminary discussion)

6818 **Praktikum in der Arbeitsgruppe: Polarisiertes Target / Laboratory in the Research Group: Polarized Target (D/E)**
http://polt05.physik.uni-bonn.de
pr, ganztägig, Dauer n. Vereinb., PI

Instructor(s): H. Dutz, S. Goertz u.M.

Prerequisites:
Basics in Thermodynamics, Quantum Mechanics and Solid State Physics.

Contents:
The intention is to provide an overview about the research topics of the working group to the participating students within 4 weeks.

Introduction to the following research activities:

Development of dedicated target cryostats, development of new types of so called internal superconducting magnets, research and diagnostics on new polarizable target materials, improvements in the field of NMR techniques for polarization measurement.
Students will have the oportunity to work on a small research project by their own and to give a final report to the group members.

Literature:
The lectures does not follow a particular text book. Recommendations on background literature will be provided during the course.

Comments:

6821 **Research Internship / Praktikum in der Arbeitsgruppe (SiLab): Detector Development: Semiconductor pixel detectors, pixel sensors, FPGAs and ASIC Chips (Design and Testing) (D/E) (http://hep1.physik.uni-bonn.de),**
whole day, ~4 weeks, preferred during off-teaching terms, by appointment, PI

Instructor(s): F. Hügging, H. Krüger, E. von Törne, N. Wermes u.M.

Prerequisites:
Lecture on detectors and electronics lab course (E-Praktikum)

Contents:
Research Internship:

Students shall receive an overview into the activities of a research group:

here: Development of Semiconductor Pixel Detectors and Micro-Electronics

Literature:
will be handed out

Comments:
early application necessary

6822 **Research Internship / Praktikum in der Arbeitsgruppe:**
Proton-Proton-Collisions at the LHC (D/E)
(http://hep1.physik.uni-bonn.de)
lab, whole day, ~4 weeks, preferred during off-teaching terms, by appointment, PI

Instructor(s): M. Cristinziani, J. Kroseberg, T. Lenz, E. von Törne, N. Wermes

Prerequisites:
Lecture(s) on Particle Physics

Contents:
Within 4 weeks students receive an overview/insight of the research carried out in our research group.

Topics: Analyses of data taken with the ATLAS Experiment at the LHC
especially: Higgs and Top physics, tau-final states and b-tagging

The exact schedule depends on the number of applicants appearing at the same time.

Literature:
will be handed out

Comments:
Early application is required
Contacts: E. von Törne, T. Lenz, M. Cristinziani, J. Kroseberg, N. Wermes

6823 **Research Internship / Praktikum in der Arbeitsgruppe: Analysis of proton-proton (ATLAS) collisions.**
pr, all day, 3-4 weeks, preferably in the semester break, Applications to brock@physik.uni-bonn.de, PI

Instructor(s): I. Brock u.M.

Prerequisites:
Introductory particle physics course

Contents:
Introduction to the current research activities of the group (physics analysis with data from ATLAS (LHC) and
ZEUS (HERA)), introduction to data analysis techniques for particle reactions, opportunity for original research on a topic of own choice, with concluding presentation to the group.

Literature:
Working materials will be provided.

Comments:
The course aims to give interested students the opportunity for practical experience in our research group
and to demonstrate the application of particle physics experimental techniques.

Depending on the students' preferences the course will be given in German or in English.

6824 **Praktikum in der Arbeitsgruppe: Detektorentwicklung und Teilchenphysik an einem Elektron-Positron-Linearcollider / Laboratory in the Research Group: Detector Development and Particle Physics at an Electron-Positron Linear Collider (D/E)**
pr, ganztägig, ca. 4 Wochen n. Vereinb., vorzugsweise in den Semesterferien, PI

Instructor(s): K. Desch, P. Bechtle

Prerequisites:
Vorlesungen über Teilchenphysik

Contents:
In einem 4 wöchigen Praktikum wird den Studierenden die Möglichkeit gegeben

anhand eines eigenen kleinen Projektes einen Einblick in die Arbeitsweise

der experimentellen Hochenergiephysik zu bekommen.

Themen werden bei der Vorbesprechung vereinbart.

Möglichkeiten (Beispiele):

- Simluation von Prozessen am International Linear Collider

- Messungen an einer Zeitprojektionskammer

Literature:
wird ausgegeben

Comments:
Eine frühe Anmeldung ist erwünscht bei Prof. Desch, Dr. P. Bechtle oder Dr. J. Kaminski

6826 **Praktikum in der Arbeitsgruppe: Neurophysik, Computational Physics, Zeitreihenanalyse**
pr, ganztägig, ca. 4 Wochen, n. Vereinb., HISKP u. Klinik für Epileptologie

Instructor(s): K. Lehnertz u.M.

Prerequisites:
basics of programming language (e.g. C, C++, Pascal, Python)

Contents:
This laboratory course provides insight into the current research activities of the Neurophysics group.

Introduction to time series analysis techniques for biomedical data, neuronal modelling, cellular neural networks. Opportunity for original research on a topic of own choice, with concluding presentation to the group.

Literature:
Working materials will be provided.

Comments:
Contact:

Prof. Dr. K. Lehnertz

email: klaus.lehnertz@ukb.uni-bonn.de

6833 **Praktikum in der Arbeitsgruppe: Aufbau und Test optischer und spektroskopischer Experimente, Erstellung von Simulationen / Laboratory in the Research Group: Setup and Testing of Optical and Spectroscopical Experiments, Simulation Programming (D/E)**
pr, ganztägig, Dauer ca. 4-6 Wochen, n. Vereinb., IAP

Instructor(s): D. Meschede u.M.

Prerequisites:
Two years of physics studies (undergraduate/ bachelor program)

Contents:
Practical training in the research group can have several aspects:

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

The minimum duration is 30 days, or 6 weeks.

Literature:
will be individually handed out

Comments:
Projects are always available. See our website.

6834 **Praktikum in der Arbeitsgruppe: Vorbereitung und Durchführung optischer und atomphysikalischer Experimente, Mitwirkung an Forschungsprojekten der Arbeitsgruppe / Laboratory in the Research Group: Preparation and conduction of optical and atomic physics experiments, Participation at research projects of the group (D/E)**
pr, ganztägig, 2-6 Wochen n. Vereinb., IAP

Dozent(en): M. Weitz u.M.

Erforderliche Vorkenntnisse:
Optik und Atomphysik Grundvorlesungen, Quantenmechanik

Inhalt:
Studenten soll frühzeitig die Möglichkeit geboten werden, an aktuellen Forschungsthemen aus dem Bereich der experimentellen Quantenoptik mitzuarbeiten: Ultrakalte atomare Gase, Bose-Einstein-Kondensation, kollektive photonische Quanteneffekte. Die genaue Themenstellung des Praktikums erfolgt nach Absprache.

Literatur:
wird gestellt

Bemerkungen:
Homepage der Arbeitsgruppe:

http://www.iap.uni-bonn.de/ag_weitz/

astro841 **Radio astronomy: tools, applications, and impacts**
Tu 16, Th 16-18, Raum 0.012, AIfA
Exercises arranged by appointment

Instructor(s): U. Klein

Prerequisites:
introduction to astronomy, electrodynamics, interstellar medium

Contents:

1. Introduction
history
astrophysics and radio astronomy

2. Single-dish telescopes
Cassegrain and Gregory foci
geometries and ray tracing
antenna diagrams
antenna parameters

3. Fourier optics
Fourier transform
aperture – farfield relations
spatial frequencies and filtering
power pattern
convolution and sampling
resolving power

4. Influence of earth's atmosphere
ionosphere, troposphere
plasma frequency
Faraday rotation
refraction, scintillation
absorption / emission
radiation transport

5. Receivers
total-power and heterodyne systems
system temperature
antenna temperature, sensitivity
Dicke-, correlation receiver
amplifiers
hot-cold calibration

6. Wave propagation in conductors

coaxial cables, waveguides
matching, losses
quasi optics

7. Backend
continuum, IF-polarimeter
spectroscopy
filter spectrometer
autocorrelator
acousto-optical spectrometer
pulsar backend

8. mm and submm techniques
telescope parameters and observables
atmosphere, calibration, chopper wheel
error beam
SIS receivers
bolometers

9. Single-dish observing techniques
on-off, cross-Scan, Raster
continuous mapping, OTF, fast scanning
frequency-switching, wobbling technique

10. Data analysis
sampling theorem
spectroscopy
multi-beam observations
image processing, data presentation

11. Interferometry basics
aperture - image plane
complex visibility
delay tracking
fringe rotation
sensitivity

12. Imaging
Fourier inversion
cleaning techniques
self-calibration
zero-spacing correction

13. VLBI
station requirements
processor
calibration and imaging
retarded baselines
geodesy

14. Spectroscopy
XF and FX correlation
data cubes

15. Polarimetry
cross dipoles
circular feeds
spurious polarization

16. Future developments and science
projects, telescopes
LOFAR, SKA, ALMA, SOFIA, Planck
impacts: ISM, IGM, cosmology ...

<u>Literature:</u>
Lecture Notes (fully spelled-out text, for free, handed out in the class)

<u>Comments:</u>

astro8503 **Radio and X-Ray Observations of Dark Matter and Dark Energy**
Fr 13-15, Raum 0.008, AIfA
Exercises/lab course arranged by appointment

Instructor(s): T. Reiprich, Y. Zhang

Prerequisites:
Introduction to astronomy.

Contents:
Introduction into the evolution of the universe and the theoretical background of dark matter and dark energy tests.
Optical, radio, and X-ray studies of clusters of galaxies.
Cosmic microwave background.
HI observations prior and during the epoch of re-ionization.
High redshift supernovae.
Sunyaev-Zeldovich effect.
LOFAR/SKA technology and observations.
Warm Hot Intergalactic medium.
Cosmology with clusters of galaxies.

Literature:
The lecture notes will be distributed during the course.

Comments:

astro8531 **The Physics of Dense Stellar Systems**
Mo 15-18, Raum 0.012, AIfA
Exercises arranged by appointment

Instructor(s): P. Kroupa

Prerequisites:
Vordiploma or BSc in physics

Contents:
Stars form in groups or clusters that are far denser than galactic fields. Understanding the dynamical processes within these dense stellar systems is therefore important for understanding the properties of stellar populations of galaxies. The contents of this course are:

Fundamentals of stellar dynamics: distribution function, collisionless Boltzmann equation, Jeans equations, Focker-Planck equation, dynamical states,
relaxation, mass segregation, evaporation, ejection, core collapse.
Formal differentiation between star clusters and galaxies.
Binary stars as energy sinks and sources.
Star-cluster evolution.
Cluster birth, violent relaxation.
Birth of dwarf galaxies.
Galactic field populations.

Literature:
1) Lecture notes will be provided.
2) J. Binney, S. Tremaine: Galactic Dynamics (Princeton University Press 1988)
3) D. Heggie, P. Hut: The gravitational million-body problem (Cambridge University Press 2003)
4) Initial Conditions for Star Clusters:
http://adsabs.harvard.edu/abs/2008LNP...760..181K
5) The stellar and sub-stellar IMF of simple and composite populations:
http://adsabs.harvard.edu/abs/2011arXiv1112.3340K
6) The universality hypothesis: binary and stellar populations in star clusters and galaxies:
http://adsabs.harvard.edu/abs/2011IAUS..270..141K

Comments:
Aims: To gain a deeper understanding of stellar dynamics, and of the birth, origin and properties of stellar populations and the fundamental building blocks of galaxies. See the webpage for details.

Start: Monday, 17.10.2016, 15:15

astro856 **Quasars and Microquasars**
Th 13-15, Raum 0.01, MPIfR

Instructor(s): M. Massi

Prerequisites:

Contents:
Stellar-mass black holes in our Galaxy mimic many of the phenomena seen in quasars but at much shorter timescales. In these lectures we present and discuss how the simultaneous use of multiwavelength observations has allowed a major progress in the understanding of the accretion/ejection phenomenology.

1. Microquasars and Quasars
   Definitions
   Stellar evolution, white dwarf, neutron star, BH

2. Accretion power in astrophysics
   Nature of the mass donor: Low and High Mass X-ray Binaries
   Accretion by wind or/and by Roche lobe overflow
   Eddington luminosity
   Mass function: neutron star or black hole ?

3. X-ray observations
   Temperature of the accretion disc and inner radius
   Spectral states
   Quasi Periodic Oscillations (QPO)

4. Radio observations
   Single dish monitoring and VLBI
   Superluminal motion (review, article)
   Doppler Boosting
   Synchrotron radiation
   Plasmoids and steady jet

5. AGN

Literature:

Comments:
http://www3.mpifr-bonn.mpg.de/staff/mmassi/#microquasars1

6957 **IMPRS-Seminar**
Mo 13-14, MPIfR, HS 0.01

Instructor(s): R. Mauersberger

Prerequisites:
Doctoral candidate in Astronomy

Contents:
In this seminar, doctoral candidates give 20 min. status reports on their thesis work about once a year. A presentation is followed by a scientific discussion. All participants provide feedback on the presentation technique using a standardized format.

Literature:
J. Kuchner: Marketing for Scientists, Island Press

Comments:

6952 **Seminar on theoretical dynamics**
Fr 14-16, Raum 3.010, AIfA

Instructor(s): P. Kroupa, J. Pflamm-Altenburg

Prerequisites:
Diploma/masters students and upwards

Contents:
Formation of planetray and stellar systems
Stellar populations in clusters and galaxies
Processes governing the evolution of stellar systems

Literature:
Current research papers.

Comments:

6954 **Seminar on galaxy clusters**
Th 15-17, Raum 0.006, AIfA

Instructor(s): T. Reiprich, Y. Zhang

Prerequisites:
Introduction to astronomy.

Contents:
The students will report about up to date research work on galaxy clusters based on scientific papers.

Literature:
Will be provided.

Comments:

6961 **Seminar on stars, stellar systems, and galaxies**
Di 16-17:30, Raum 3.010, AIfA

Instructor(s): P. Kroupa, J. Pflamm-Altenburg

Prerequisites:
10th semester and upwards

Contents:
Current research problems

Literature:
Current research papers

Comments:
Students and postdocs meet once a week for a presentation and discussion of a relevant recent and published research results.