Wintersemester 2014/2015
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 2014

**physics606** **Advanced Quantum Theory**
**Mo 12-14, We 13, HS I, PI**

Instructor(s): M. Drees

Prerequisites:
Theoretical courses at the Bachelor degree level: classical mechanics and electrodynamics, quantum mechanics

Contents:

- Symmetries: symmetries in quantum mechanics: translations, rotations of vectors and spinors, discrete symmetries
- Time-dependent perturbation theory: interaction picture, Dyson equation, Fermis golden rule, absorption and emission of radiation
- Scattering theory: Lippmann-Schwinger equation, Born approximation, optical theorem, method of partial waves, scattering phase shifts, S-matrix, resonances, scattering of identical particles
- Path integrals: motivation, expression for transition amplitude, applications: harmonic oscillator, Aharonov-Bohm effect
- Relativistic quantum mechanics: relativistic wave equations: Klein-Gordon and Dirac equations, free solutions, antiparticles, Coulomb problem, non-relativistic limit, Lorentz transformations, bilinear covariants
- Second quantisation: identical particles and many-particle states: bosons and fermions, Fock space, field operators, application: electron gas

Literature:

1. J.J. Sakurai, Modern Quantum Mechanics, Addison Wesley
2. J.D. Bjorken, S.D. Drell, Relativistic Quantum Mechanics, McGraw-Hill
3. F. Schwabl, Quantum Mechanics, Springer
4. F. Schwabl, Advanced Quantum Mechanics, Springer
5. A. Messiah, Quantum Mechanics, Dover

Comments:
The lecture and exercises will be held in English. More information and additional literature is given on the lecture web page.

**physics607** **Advanced Quantum Field Theory**
**Mo 12-14, We 13, HS, HISKP**

Instructor(s): B. Kubis

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

Contents:

- Renormalization group and asymptotic behavior
- Quantization of fields in the path integral formalism
- Divergences and regularization
- Quantization of constrained systems: gauge fields
- Symmetries and Ward identities, renormalization
- 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

Comments:

**physics611** **Particle Physics**
**Tu 14-16, HS I, PI, Th 14-16, HS, HISKP**

Instructor(s): K. Desch

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

Contents:
- Basics
  notations, kinematics Lorentz systems, Mandelstam variables,
  cross sections and lifetimes, 2-body and 3-body decays, Colliders and
  Fixed-target experiments
- Dirac Equation, Spin and helicity, QED
- e+e- Annihilation
- ep scattering and the quark model
- Symmetries and Conservation Laws
- QCD
- Weak interaction
- Electro-Weak 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:
C. Berger Elementarteilchenphysik
D. Griffith Introduction to Elementary Particles
D. Perkins Introduction to High Energy Physics
Halzen, Martin Quarks and Leptons
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.

**physics612** **Accelerator Physics**
**We, Th 10-12, SR I, HISKP**

Instructor(s): W. Hillert

Prerequisites:
Mechanics, Electrodynamics

Contents:
Die neuere experimentelle Physik basiert zum Teil auf dem Einsatz von Teilchenbeschleunigern, insbesondere im Bereich der Hochenergiephysik, der Materialforschung und der Erforschung der Substruktur der Atomkerne und der Hadronen. Durch die aktuellen wissenschaftlichen Fragestellungen wurden und werden auch weiterhin ständig gesteigerte Herausforderungen an den Betrieb und die Entwicklung von Teilchenbeschleunigern gestellt, was zum Einsatz modernster Technologien aus einer Vielzahl von physikalischen Bereichen führte. Als Beispiele mögen hier der Aufbau des ca. 27 km langen, fast vollständig supraleitenden Large Hadron Colliders (LHC) am CERN / Genf oder des 1 Angström Röntgenlasers (XFEL) am DESY / Hamburg dienen. Im Zuge dieser Entwicklungen und systematischen Untersuchungen der physikalischen Vorgänge in Beschleunigern entstand die Beschleunigerphysik als eigenständiger Fachbereich der angewandten Physik.

Die vorliegende Vorlesung ist eine Einführung in die Beschleunigerphysik. Sie gibt einen Überblick über die verschiedenen Funktionsweisen unterschiedlicher Beschleunigertypen und führt, neben einer physikalischen Behandlung der wichtigsten Subsysteme (Teilchenquellen, Magnete, Hochfrequenzresonatoren), in die transversale und longitudinale Strahldynamik ein.

More recent experimental physics is partly based on the use of particle accelerators, especially in high energy physics, materials research and exploration of the substructure of atomic nuclei and hadrons. Due to the current scientific questions, more and more demanding challenges have been and still are posed to the operation and development of particle accelerators, thus leading to the use of state-of-the-art high technology taken from a multitude of fields in physics. As examples may be cited the construction of the 27 km, almost entirely superconducting Large Hadron Collider (LHC) at CERN / Geneva or the Angström X-ray laser (XFEL) at DESY / Hamburg. In the course of these developments and systematic investigation of the physical processes in particle accelerators, particle accelerator physics emerged as a stand-alone field of applied physics.

The present lecture is meant as an introduction into particle accelerator physics. It provides an overview of the various functional principles of different accelerator types and provides, alongside a physical treatment of the most important subsystems (particle sources, magnets, resonant cavities), an introduction into transversal and longitudinal orbit dynamics.

Inhaltsverzeichnis / Table of Contents:
- Einführung / Introduction
- Überblick über Beschleunigertypen / Elementary Overview
- Bauelemente von Teilchenbeschleunigern / Subsystems of Particle Accelerators

- Lineare Strahloptik / Linear Beam Optics

Literature:


H. Wiedemann, Particle Accelerator Physics I,
3rd edition, Springer 2007, Berlin, ISBN 978-3-540-49043-2

F. Hinterberger, Physik der Teilchenbeschleuniger und
Ionenoptik, 2. Ausgabe, Springer 2008, Berlin,
ISBN 978-3-540-75282-0

K. Wille, Physik der Teilchenbeschleuniger und
Synchrotronstrahlungsquellen, 2. überarb. und erw. Aufl.,
Teubner 1996, Stuttgart, ISBN 3-519-13087-4

K. Wille, The physics of particle accelerators, Oxford Univ. Press 2005, Oxford, ISBN 0-19-850550-7

S. Y. Lee, Accelerator Physics, 3rd edition,
World Scientific, New Jersey 2012, ISBN 978-981-4374-94-1 (pbk)

D.A. Edwards, M.J. Syphers, An Introduction to the Physics of
High Energy Accelerators, Wiley & Sons 1993, New York,
ISBN 0-471-55163-5

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Comments:

Es ist vorgesehen, den Lernstoff durch detaillierte Besichtigungen und praktische Studien an der Beschleunigeranlage ELSA des Physikalischen Instituts sowie Exkursionen zu anderen Beschleunigeranlagen zu veranschaulichen und zu vertiefen.

Zu dieser Vorlesung wird ein Script im Internet (pdf-Format, Englisch) zur Verfügung gestellt. (http://www-elsa.physik.uni-bonn.de/~hillert/Beschleunigerphysik/)

The opportunity will be offered to exemplify and deepen the subject matter by detailed visits and practical studies at the institute of physics' accelerator facility ELSA and excursions to other accelerator facilities.

Accompanying the lecture, a script (pdf-format, english) will be provided on the internet. (http://www-elsa.physik.uni-bonn.de/~hillert/Beschleunigerphysik/)

**physics618** **Physics of Particle Detectors**
**Tu 12, Th 12-14, SR I, HISKP**

Instructor(s): B. Ketzer

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:
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:
This 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 tutorials and by regular laboratory visits and demonstrations.

**physics614** **Laser Physics and Nonlinear Optics**
**Tu 10-12, Th 14-16, HS, IAP**

Instructor(s): D. Meschede

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-/Diplom Students.

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

Instructor(s): H. Dreiner

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

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
M. Thompson: Modern Particle Physics (2013!!)

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).

**physics634** **Magnetism and Superconductivity**
**Tu, Th 8-10, HS, IAP**
**Diplom: VEXP, WPVEXP**

Instructor(s): E. Soergel

Prerequisites:

Contents:
In der Vorlesung wird zunächst eine Einführung in die Tieftemperatur-Physik gegeben bis hin zur Superfluidität. Der zweite Teil behandelt die Supraleitung und der dritte Teil der Vorlesung beschäftigt sich dann mit der Thematik des Magnetismus.

The lecture's first part covers an introduction to low-temperature phyics, thereby also touching the fascinating subject of superfluidity. The second part will be dedicated to superconductivity and the thirs and last part to magnetism.

Literature:
Wird im Lauf der Vorlesung angegeben.

Will be given during the course.

Comments:
If required, the lecture will be given in English.

Beginn der Vorlesung am 7. Oktober.
Start is on October 7'th.

**physics713** **Particle Detectors and Instrumentation**
**nach Vereinbarung, erstes Treffen 9.10. um 16:30 Uhr im HS I, PI**

Instructor(s): J. Kaminski

Prerequisites:

Contents:
In this semester the seminar will deviate from the module description: Students will plan, design and construct a spark chamber, which will later be available for display in the 'Physiksammlung' of the PI.

The aim is to introduce students to the detector construction from the technical aspects: technical drawings, attending the production, assembling and commissioning the detector.

The design will be split into different tasks to be completed by students.
These tasks are:
1. Mechanical layout of detector
2. Caging
3. Gas supply
4. HV generation and distribution
5. Triggering detectors (scintillators)
6. Trigger electronics
7. (optional) Filming with a USB camera, reconstruction and analysis

Depending on the task the students will learn
how to work with a CAD program and produce a technical drawing,
how to use a PCB layout program,
how to solder,
communication with engineers, technicians, mechanics and industry,
project planning.

Literature:
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)
C. Grupen, B. A. Shwartz, Particle Detectors, (Cambridge Monography on PP, NP and Cosmology, 2nd edition, 2008)

Comments:
The timing structure less formal:
1. Meeting on October 9th at 16:30 in Hörsaal 1 of PI
   => Tasks will be distributed !
2. individual meetings with students/groups to discuss the particular challenges of the task
3. working on tasks by groups, computers are available
4. producing the components, testing them individually

5. assemble detector
6. write a documentation of task

**physics717** **High Energy Physics Lab**
**4 to 6 weeks on agreement**

Instructor(s): E. von Törne

Prerequisites:

Contents:
This course offers students in their first year of their Master studies the opportunity to participate in research activities. We plan to replace this course by a module that covers all research areas. Projects in high energy physics will still be possible. For questions, please contact Lecturer E. von Törne, evt@physik.uni-bonn.de.

Literature:

Comments:
The students join one of the high energy physics groups groups and conduct their own small research project for typically 4 weeks. We recommend to participate in a project during term break (either in spring or summer/ early fall) but projects during the semester are also possible. More information here: http://heplab.physik.uni-bonn.de/

**physics719** **BCGS intensive week (Statistical and Computational Methods for Experimental Particle Physics at LHC)**

Instructor(s): E. von Törne

Prerequisites:

Contents:
BCGS Intensive Week, Statistical and Computational Methods for Experimental Particle Physics at LHC 22-26. September, 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.

About half of the course is devoted to hand-on projects. We will offer two topics in parallel:
- C++ in high energy physics
- FPGA (hardware-near programming)

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.

Literature:

Comments:
see web page http://pi.physik.uni-bonn.de/~evt/teaching/intensiveweek14/
The course is an all-day workshop, starting at September 22 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 the 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.

**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 6.10.14, 9 c.t.,
Konferenzraum IAP, 3. Stock Wegelerstr. 8

Seminartermine ab 13.10.14

**physics741** **Modern Spectroscopy**
**We 14-16, HS, IAP**

Instructor(s): F. Vewinger

Prerequisites:
Lecture on atoms & molecules on BSc-level

Contents:
The lecture gives an introduction in the field of optical spectroscopy, covering fundamental concepts as well as applications of spectroscopy.
On the fundamental side, the lecture focusses on the physical principles of atomic and molecular spectra, as well as the principles of different spectroscopy techniques. Here both the fields of low and high resolution spectroscopy are discussed. The lecture also covers important research applications of spectroscopy, for example the determination of fundamental constants and their possible time variation. The "real-world" applications discussed in the lecture include topics such as trace gas analysis, optical clocks and lasers in medicine.

Literature:
Original literature will be given in the lecture. Some useful textbooks include the follwing:

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)

Comments:

**physics742** **Ultracold Atomic Gases: Experiment and Theory**
**Tu 14-16, Th 12-14, HS, IAP**

Instructor(s): M. Köhl, C. Kollath

Prerequisites:
Atomic physics (e.g. phys411); Quantum mechanics (e.g. phys420)

Contents:
Almost hundred years ago, in 1924, A. Einstein and S.N. Bose predicted the existence of a new state of matter, the so-called Bose-Einstein condensate.
It took 70 years to successfully realize this macroscopic quantum state in the lab using ultracold atomic gases (Nobel prize 2001). The main challenge was to achieve cooling to Nanokelvin temperatures, the coolest temperatures ever reached by mankind.
Nowadays, ultracold gases are exciting systems to study a broad range of quantum phenomena. These phenomena range from the direct observation of quantum matter waves and superfluidity over the creation of artificial crystal structures as analogous to solids, to the realization of complex quantum phase transitions of interacting atoms, e.g. the formation of a bosonic Mott-insulator or the BCS superconducting state for Fermions. In this lecture we will discuss both the experimental and theoretical concepts of ultra-cold atomic gases.
Outline: Introduction and revision of basic concepts, Fundamentals of atom-laser interaction
Laser cooling & trapping, Bose-Einstein condensation of atomic gases.
Dynamics of Bose-Einstein condensates
Optical lattices: strongly interacting atomic gases and quantum phase transitions
The crossover of Fermi-gases between a BCS superconducting state and a Bose-Einstein condensate of molecules.

Literature:
C. J. Pethick and H. Smith, Bose-Einstein Condensation in Dilute Gases (Cambridge University Press)

Comments:

**physics751** **Group Theory**
**We 14-17, SR I, HISKP**

Instructor(s): C. Hanhart, S. Krewald, T. Luu, A. Wirzba

Prerequisites:
quantum mechanics, some knowledge of linear algebra

Contents:

1. Motivation: symmetries and groups in physics
2. Finite groups
3. Group representations and character theory
4. SU(2), SU(3) and the Poincaré group
5. Permutation group and Young tableaux
6. Lie groups and algebras

Literature:

- H.F. Jones, Groups, representations and physics, 2nd ed. (Taylor & Francis, New York, 1998)
- P. Ramond, Group Theory - A Physicist's Survey, (Cambridge University Press, Cambridge, 2010)
- H. Georgi, Lie algebras in particle physics, 2nd ed. (Perseus, Reading, Mass., 1999)
- F. Stancu, Group theory in subnuclear physics (Clarendon, Oxford, 1996)
- M. Hamermesh, Group theory and its application to physical problems (Dover, New York, 1989)
- L. Pontrjagin, Topological Groups (Princeton University Press, 1946)
- Lecture notes 'Group Theory' by S. Scherer, University of Mainz, Summer Term 2010: http://www.kph.uni-mainz.de/T/members/scherer/GT/Skript_GT_SS_WS09_10_SS10.pdf

Comments:

**physics767** **Computational Methods in Condensed Matter Theory**
**Tu 12-14, SR I, PI, Th 11, Konferenzraum I, W 0.027, PI**

Instructor(s): H. Monien

Prerequisites:
Some basic knowledge of computer programming is helpful.

Contents:
Modern computational methods for dealing with typical problems arising in condensed matter physics.
The focus of this lecture is practical working methods for dealing with rather complex problems.

- Introduction to object oriented programming (using Python as an example)
- Overview over methods of computational linear algebra methods
- Representation of quantum statistical models on computers
- Monte Carlo methods (including Quantum Monte Carlo)
- Exact diagonalization
- Numerical renormalisation group
- Density matrix renormalisation group
- Dynamical mean field theory

Literature:
We will use ALPS to explore many of the methods mentioned in the contents.

http://alps.comp-phys.org/mediawiki/index.php/Main_Page

Comments:
At the end of the course each student has to run a one week project with a report. This is the equivalent of
the usual test.

**physics771** **Environmental Physics & Energy Physics**
**Th 14-16, HS118, Raum 1.019, AVZ I**

Instructor(s): B. Diekmann

Prerequisites:
Bachelor ( Prediploma for diploma students)
basics in thermodynamics would be helpful
A look into the courses from SS 13 (655) and WS 13/14 (655)
as stored under ecampus under the instructors account would be useful.
Access code will be handed on request

Contents:
time schedule ( very preliminary)

Thur 9.10 Introduction :energy consumption
worldwide & in germany ( after turnover)
Thur 16 .10 Introduction continued ( global interference )
Thur 23.10 Summary of the fall meeting , energy' of german phys. Society
Bad Honnef 1/2 .10
Thur 30.10 Physics basics on ‚energy'
Thur 6.11 Fossile fuels & environmental aspects of their use
Thur 13.11 Fossiles & environment (continue, greenhouse warming)
Thur 20.11 Nuclear Energy, Introduction and radioactivity
Thur 27.11 Nuclear reactors und safety aspects with special emphasis on fukushima, nuclear fuel chain
no lecture on 4.12
Thur 11.12 Nuclear fusion
Thur 18.12 Renewables I Sun:Thermal energy Photosynthesis, Biomass
Thur 8.1 Renewables II Sun: Photovoltaics
Thur 15.1 Renewables III Wind & Water & waves, Geothermal sources
Thur 22.1 Energy Transport & Storage
Thur 29.1 The difficult attempt to disentangle the Gordian knot:
No nuclear, as much as achievable renewables, minimized fossile: Summary, prep of seminar in summerterm 2015
Thur 5.2 Examinations
Thur 9.2 left for reexaminations

Special emphasis will be on environmental aspects of energy use (*)
but also other sources will be evaluated according to the criteria
risk = (accdents probability * accidents consequence ) and
gain = output energy/input energy
(*) Espt. those from use of nuclear energy after Fukushima will be a main issue (a) worldwide and (b) in germany after 'switch off' decision

Literature:

Diekmann,B., Heinloth,K.: Physikalische Grundlagen der Energieerzeugung, Teubner 1997,
Diekmann, Rosenthal, Energie, Teubner 2013
Pelte D. , University of heidelberg, Energy Physics, 2003, as e@book
Mc Kay, Sustainable Energy without hot Air
more from www.http://withouthotair.com/
Schiffer Energiemarkt Deutschland TÜV Verlag, 2014
Have a look into previous courses via 'ecampus' with an acces given
by Bernd Diekmann on authorized request

Comments:

The course will be honoured by 3 CP's for master students
Let me know in advance, if diploma students are intending to participate to sort out the feasibility of an VANG status of the course

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

Instructor(s): K. Lehnertz

Prerequisites:

Vordiplom, 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 13, 10:00 ct

**physics774** **Electronics for Physicists**
**Tu 14-16, Th 12, HS, HISKP**

Instructor(s): P.-D. Eversheim

Prerequisites:
Practical course in electronics

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:

**physics651** **Higgs ... and now? - Seminar on current forefront research in particle physics**
**Do 16-18, Konferenzraum II, PI 1.049, PI**

Instructor(s): I. Brock, K. Desch, J. Dingfelder, N. Wermes

Prerequisites:
Required: Introductory particle physics course Physik511 (Physik V).
Useful: Physics611 (Particle Physics) can be attended in parallel.

Contents:
In 2012, the ATLAS and CMS experiments at CERN announced the discovery of a new particle consistent
with a Higgs boson. However, several further studies are still needed to determine whether all properties of
the observed boson are exactly as predicted in the Standard Model. Will these studies
turn out to be a window to new physics? And is there only one or maybe several Higgs bosons?
In this seminar, we will discuss a variety of analyses (incl. experimental techniques) that will help pin down
the exact nature of the observed boson as well as ongoing and future searches for new physics at the LHC
and future colliders.

Some possible topics for the seminar are:

Higgs phenomenology at hadron colliders
Higgs discovery in various decay channels
Measurements of the Higgs properties (QNs, width, Yukawa couplings, ...)
Searches for Higgs bosons beyond the Standard Model
Higgs as a window to new physics (invisible decays, differential distributions, ...)
Precision Higgs physics at future colliders (e+e- linear collider, ...)
Does the Higgs unitarize the Standard Model (vector boson scattering, ...)?
Non-Higgs searches for new physics at the LHC (top sector, SUSY, ...)

Literature:
Material will be provided to the speaker for each topic/talk.

Comments:
Talks will be assigned during the first seminar date (Thu., Oct. 9, 16:15).

**physics652** **Seminar on Ultracold Atoms - Exploring physics in the Nanokelvin temperature regime**
**Mo 14-16, HS, IAP**

Instructor(s): M. Köhl

Prerequisites:

Contents:
Possible topics (each topic contains several possibilities for talks):
1) Bose-Einstein condensation: theoretical description, preparation and detection, basic properties, phase transition and critical behaviour.
2) Interference of matter waves: spontaneous symmetry breaking, measurement of the density matrix, phase fluctuations of Bose-Einstein condensates
3) Correlations: Hanbury Brown and Twiss experiments with atoms
4) Phonons: generation and detection of sound waves
5) Vortices and superfluidity: vortex lattices and their excitations, measurement of the critical velocity, solitons
6) Light scattering from Bose-Einstein condensates: superradiance, Dicke quantum phase transition, storage and retrieval of light in a cold gas
7) Optical lattices: periodic potentials of light, band structure, Bloch oscillations
8) One-dimensional Bose gases: fermionization of bosons, Tonks gas, phase flcutuations in one-dimensional Bose gases
9) Two-dimensional Bose gases: Berezinkskii-Kosterlitz-Thouless transition
10) Josephson effect: tunneling between superfluids
11) Superfluid-Mott insulator quantum phase transition
12) Ultracold Fermi gases: Fermi sea, Fermi surfaces, momentum distributions
13) Feshbach resonances: controlling atom-atom interaction, creation of molecules and molecular Bose-Einstein condensates
14) Ultracold fermions in optical lattices: Fermi surfaces, Mott insulator, quantum simulation/Hubbard model
15) Polarons in Fermi gases: creation and observation of quasiparticles
16) Superfluidity of Fermi gases: (Cooper-) pairing, vortices

Literature:
Background material: C. J. Pethick and H. Smith, Bose-Einstein Condensation in Dilute Gases (Cambridge University Press);

Comments:
The seminar has thematic overlap with the lecture course physics742: Ultracold Atomic Gases.

**physics653** **Seminar on Current Topics in Experimental and Theoretical Particle Physics: Hunting for Physics Beyond the Standard Model**
**We 10-12, SR II, HISKP**

Instructor(s): M. Drees, H. Dreiner, C. Hanhart, S. Krewald, T. Luu, A. Wirzba

Prerequisites:
Introductory particle physics course.

Contents:
Possible topics for talks are:
1.) Evidence and indirect searches for Dark Matter
2.) Direct searches for Dark Matter
3.) How to establish a deviation from the SM in g_mu - 2
4.) Searches for dark photons at colliders
5.) Models of neutrino masses
6.) Supernovae as particle physics laboratories
7.) Axions
8.) Electric Dipole Moments of nucleons and nuclei
9.) Variable coupling "constants"
10.) Big Bang Nucleosynthesis and the variation of quark masses
11.) Dark Energy
12.) The hierarchy problem in the SM and its possible solutions
13.) Proton decay

Literature:
There are mini-reviews on many of these topics in the pages of the Particle Data Group, http://pdg.lbl.gov/ . Additional literature will be provided by the supervisor of the talk.

Comments:
Seminar will be in English.

**physics654** **Seminar on computational physics: How to simulate the physical world?**
**Mo 14-16, SR II, HISKP**

Instructor(s): C. Kollath

Prerequisites:
Quantum Mechanics (no knowledge of programming is required, but you will have to try it.)

Contents:
n the field of physics, computational tools are widely employed as for the analysis of experimental data as well for the description and simulation of physical systems. The motivation to use computational tools is to explore the complex physical world better than otherwise possible with analytical tools. The seminar will cover some of the most commonly used computational methods to simulate physical phenomena. Each student is suppose to understand an algorithm, to apply it to a physical situation mostly from quantum physics and to present the results in a presentation.

The subjects will reach from:
* Time-evolution of Schrödinger equations (e.g. Runge-Kutta and Crank-Nicolson,
split step methods). Physical examples are two-level atoms excited by a light field, a single particle moving in a time-dependent external potential, or the evolution of a Bose-Einstein condensate after an excitation.

* Variational methods and exact solutions for quantum many body systems
The solution of eigenvalue problems lies at the heart of the description of quantum mechanical systems. We will introduce the variational principle and show how this can be applied to describe, e.g., the hydrogen atom. More complicated variational ansaetze as the Gutzwiller ansatz, for bosonic atoms in a periodic potential
can be introduced and the quantum phase transition between a superfluid and a Mott-insulator demonstrated. This is an example of the attractive field of ultracold quantum gases.

* Quantum Monte-Carlo methods
Stochastic methods as the quantum Monte-Carlo method are indispensable to treat systems with a large number of coupled degrees of freedom. Examples are the simulation of quantum gases or classical spin systems. Thereby
we focus the discussion on critical phenomena and the calculation of statistical averages.

Literature:
1) T. Pang 'An Introduction to Computational Physics'
2) H. Gould and J. Tobochnik 'An Introduction to Computer Simulation methods'
3) J. Thijssen, Computational Physics (Cambridge University Press)
4) 'Numerical Recipes: The Art of Scientific Computing', (Cambridge University Press)
5) W. Krauth, Statistical Mechanics: Algorithms and Computations (Oxford University Press)

Comments:

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

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

Prerequisites:
Vordiplom, 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 13

**6810** **Random Walks and Stochastic Interacting Particle Systems**
**Do 15-17, SR II, HSIKP**

Instructor(s): G. Schütz

Prerequisites:
Thermodynamics, Quantum Mechanics I

Contents:
Random walks, Stochastic Interacting particle systems, Large Scale Dynamics, Single-File Diffusion

Literature:
G. Schütz, Exactly solvable models for many-body systems far from equilibrium, vol. 19 of Phase Transitions and Critical Phenomena. (Academic Press, London, 2001)

Comments:

**6821** **Research Internship / Praktikum in der Arbeitsgruppe (SiLab): Semiconductor pixel detector development and materials, 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): L. Gonella, 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): 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, M. Cristinziani, J. Kroseberg, N. Wermes

**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)

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

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/quantenoptik

**6839** **Public presentation of Science / Öffentliche Präsentation von Wissenschaft**
**2 SWS, Termin nach Vereinbarung**

Dozent(en): H. Dreiner

Erforderliche Vorkenntnisse:
Interesse an der öffentlichen Präsentation von Physik.

Inhalt:
Vorbereitung und Durchführung einer öffentlichen Physikshow.

Literatur:

Bemerkungen:

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

Instructor(s): U. Klein, N. Ben Bekhti

Prerequisites:
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 (for free; fully spelled out)

Tools of Radio Astronomy
Kristen Rohfs, Thomas L. Wilson
Springer

Radio Astronomy
John D. Kraus
Cygnus-Quasar Books

The Fourier Transform and its Applications
Ronald N. Bracewell
McCraw-Hill Book Company

<u>Comments:</u>

**astro853** **The physics of dense stellar systems**
**Mo 15-18, Raum 3.010, 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, 20.10.2014, 15:15

**astro893** **Seminar on stellar systems, and galaxies**
**Tu 16:15-17:30, Raum 3.010, AIfA**

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

Prerequisites:
Vordiplom or Bachelor in physics;
The lecture "Stars and Stellar Evolution" (astro811);
The lecture "Astrophysics of Galaxies" (astro821)

Contents:
The newest literature (e.g. papers from the electronic pre-print server) relevant to research on stars, stellar populations, galaxies and dynamics;
current and preliminary research results by group members and guests on the above topics.

Literature:
Latest astro-ph pre-prints, or recently published research papers.

Comments:
This course is worth 4 credit points. The corresponding certificate ("Schein") is awarded if the student (a) attends the seminar and (b) holds a presentation. The certificate can be picked up either from P.Kroupa or in the office of the secretary on the third floor (AIfA) at the end of the semester.

The students will be introduced to the newest state of knowledge in the field of stellar astrophysics, star clusters, galaxies and dynamics. They will familiarise themselves with open questions and acquire knowledge on the newest methods in research.