Wintersemester 2020/2021
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 2020

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

Instructor(s): C. Hanhart, B. Kubis

Prerequisites:
Theoretical courses at the Bachelor degree level, in particular, quantum mechanics; fundamentals of the

theory of complex functions.

Contents:

- Relativistic quantum mechanics: relativistic wave equations: Klein-Gordon equation,
  Dirac equation; representations of the Lorentz group: Lorentz transformations of vectors and spinors; non-
  relativistic limit: Pauli equation and spin; free solutions.
- Many-body quantum theory: occupation number representation and second quantization; field operators; absorption and emission of radiation; spin-statistics theorem; fundamentals of propagator theory;
- Scattering theory: partial wave expansion, scattering phase shift; Lippmann-Schwinger
  equation; Born approximation; optical theorem.

Literature:
Relativistic quantum mechanics:[li]R. Shankar, Principles of Quantum Mechanics
[li]F. Schwabl, Advanced Quantum Mechanics, Springer
[li]J.D. Bjorken, S.D. Drell, Relativistic Quantum Mechanics, McGraw-Hill

Many-body quantum theory:[li]L. D. Landau, E. M. Lifshitz, Course of Theoretical Physics, Vol. 3: Quantum
Mechanics

Scattering theory:[li]J.J. Sakurai, Modern Quantum Mechanics, Addison Wesley
[li]R. Shankar, Principles of Quantum Mechanics

Comments:
The lecture course will, in particular, provide the fundamentally new insights that stem from the combination
of quantum mechanics with special relativity and from the many-body formulation of quantum mechanics.
The lecture and exercises will be given in English.
More information and additional literature will be given on the lecture web page.

physics612 **Accelerator Physics**
Tu 12-14, Th 8-10, HS, HISKP

Instructor(s): K. Desch

Prerequisites:
Experimental Physics 1-5, Theoretical Electrodynamics, Electronics useful.

Contents:
Understanding of the functional principle of different types of particle accelerators Layout and design of simple magneto-optic systems. Basic knowledge of radio frequency engineering and technology Knowledge of linear beam dynamics in particle accelerators.

Elementary overview of different types of particle accelerators: electrostatic and induction accelerators, RFQ,
Alvarez, LINAC, Cyclotron, Synchrotron, Microtron
Subsystems of particle accelerators: particle sources, RF systems, magnets, vacuum systems
Linear beam optics: equations of motion, matrix formalism, particle beams and phase space
Circular accelerators: periodic focusing systems, transverse beam dynamics, longitudinal beam dynamics.

Literature:
Main book for the course:
K. Wille, The Physics of Particle Accelerators: An Introduction (Oxford University Press)

Others:
K. Wille; Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen (Teubner)
F. Hinterberger; Physik der Teilchenbeschleuniger und Ionenoptik (Springer)
H. Wiedemann; Particle Accelerator Physics (Springer)
D. A. Edwards, M.J. Syphers; An Introduction to the Physics of High Energy Accelerators (Wiley & Sons)
S. Y. Lee, Accelerator Physics and Technology, (World Scientific)
Chao, Mess, Tigner, Zimmer, Handbook of Accelerator Physics and Engineering (World Scientfic)
and many more

Comments:

physics618 **Physics of Particle Detectors**
Tu 14-16, HS I, PI, Do 14-16, HS, HISKP

Instructor(s): E. von Törne

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

Contents:
1. Introduction

2. Interaction of particles with matter

3. Gaseous detectors

4. Silicon detectors

5. Photon detection, scintillation and Cherenkov detectors

6. Electromagnetic calorimeters

7. Hadron calorimeters

8. Detector Systems

Literature:
main text:
H. Kolanoski, N. Wermes; Particle detectors" (Oxford U. Press 2020) or the German version (Springer 2016).

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 lectures is 3hrs + 1 hr exercise. We have reserved 4 weekly hours. This will also include the exercises (2hrs every other week.)

Course materials are on ecampus.

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 wish to major in experimental high energy physics, hadron physics or astro-particle physics. It is also useful for students interested in medical imaging detectors.

physics620 **Advanced Atomic, Molecular and Optical Physics**
Tu 12-14, Th 8-10, HS, IAP

Instructor(s): S. Stellmer

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 and atomic clocks;
Light forces, optical potentials, laser cooling and trapping;
Quantisation of light;
Cavity-QED;
Optical lattice clocks;

Part 2: Molecular Physics
Basic molecules, hydrogen Molecule;
Molecular potentials, bound states, collisions;
Feshbach resonances;

Part 3: Quantum gases
Evaporative cooling;
Bose-Einstein Condensation;
Fundamentals of many-body physics;
Optical lattices;
Ultracold Fermi gases;
BEC vs. BCS;

Part 4: Quantum information processing
Basic ideas: qubits, gates;
Entanglement and quantum algorithms;
Ion traps;

Literature:
C. Foot, "Atomic Physics"
H. Metcalf/P. van der Straten, "Laser Cooling and Trapping"
C. Pethick/H. Smith, "Bose-Einstein condensation in dilute atomic gases"
L. Pitaevskii/S. Stringari, "Bose-Einstein condensation"

Comments:
Lectures and tutorials will be online only.

Please see eCampus for up to date information.

physics631 **Quantum Optics**
Tu, Th 14-16, HS, IAP

Instructor(s): M. Weitz

Prerequisites:
Optik und Atomphysik-Grundvorlesung, Quantenmechanik
Optics and Atomic Physics Lectures, Quantum Mechanics

Contents:
Atom-Light Interaction, Bloch Vectors
Coherence of Light Fields
Quantisation of the Light Field
Two and Three Level Atoms
Laser Cooling of Atoms
Quantum Information
Cavity QED

Literature:
R. Loudon; The quantum theory of light (Oxford University Press 2000)
G. J. Milburn, D. F. Walls; Quantum Optics (Springer 1994)
D. Meschede; Optik, Licht und Laser (Teubner, Wiesbaden 2nd edition. 2005)
M. O. Scully, M. S. Zubairy; Quantum Optics (Cambridge 1997)
P. Meystre, M. Sargent; Elements of Quantum Optics (Springer 1999)

Comments:
Lecture: 3 Teaching hours (3 Semesterwochenstunden)
Exercises: 1 Teaching hour (1 Semesterwochenstunde)
The exercises, in two hour blocks, alternate every two weeks with a lecture.

Times:
Tuesday 14 c.t.-16
Thursday 14 c.t.-16
First lecture: Tuesday, 3. November 2020.

The lecture will take place in Online format by Zoom.
Details will follow, also regarding the format of the exercises.

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

Instructor(s): M. Drees

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

Contents:
Classical field theory,
Gauge theories for QED and QCD,
Higgs mechanism,
Standard model of strong and electroweak interactions

Literature:
Cheng and Li, Gauge theories of elementary particle physics
Peskin and Schroeder: An Introduction to Quantum Field Theory
Aitchison and Hey: Gauge Theories in Particle Physics

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 26

The exact format of the lecture in times of Corona is not clear yet; please watch the web page listed above.

physics616 **Theoretical Hadron Physics**
We 9-12, HS, HISKP

Instructor(s): U. Meißner, A. Rusetsky

Prerequisites:
Quantum Mechanics, Advanced Quantum Theory

Contents:

1. Symmetries and hadron classification schemes
2. Quark models of hadrons
3. Hadronic reactions, kinematics, scattering amplitudes and cross sections
4. Introduction to the dispersion relations
5. Introduction to the chiral symmetry. Chiral effective field theories.
6. Introduction to heavy quark physics. Heavy quark effective field theory.

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)
- F.E. Close; An introduction to Quarks and Partons (Academic Press 1980)
- J.P. Elliott, P.G. Dawber; Symmetry in Physics (Oxford University Press 1985)
- W.E. Burcham, M. Jobes; Nuclear and Particle Physics (Prentice Hall 1995)
- H. Georgi; Lie Algebras in Particle Physics (Westview Press 1999)
- G. Barton; Introduction to Dispersion Techniques in Field Theory (W.A.Benjamin1965)
- S. Scherer, M.R. Schindler; A Primer for Chiral Perturbation Theory (Springer 2012)
- A. Manohar, M.Wise; Heavy Quark Physics (Cambridge University Press 2000)

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

physics719 **BCGS intensive week (Test beam measurements with a pixel telescope at the DESY electron test beam)**
February/March 2021

Instructor(s): I. Gregor

Prerequisites:
Basic knowledge of particle physics at the bachelor or master level is assumed. Some programming knowledge (C or C++) would also be very useful but are not mandatory.

Contents:
This course will be of interest for students starting their master studies, students who start their master project soon, and Ph.D. students from other fields of physics who wish to broaden their horizon. We will discuss particle detectors as mostly used in particle physics with focus on silicon tracking detectors. In the afternoons tests with a pixel telescope will be performed at the DESY test beam and the obtained data analysed. An overview of important parameters for detector testing will be given and some of them tested in laboratory tests. This course will be at DESY in Hamburg (travel costs will be covered)!!

While following these lines, particular emphasis is given to

- Overview on detectors for particle physics
- Passage of particles through matter
- Basics on tracking detectors with focus on  semi-conductor detectors
- Reconstruction of hits
- Important parameters for detector testing and  how to measure those
- Radiation damage effects
- Simulation of tracks
- Taking data with a pixel telescope (electrons at DESY test beam)
- Test beam data analysis

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 concepts. The course is an all-day seminar starting on Monday morning of the selected week.

Registration: To take part please register on eCampus:
https://ecampus.uni-bonn.de/goto_ecampus_crs_1861366.html

before the end of January 2021.

Students who wish to receive course credits also need to register on BASIS!

Registrations opens on November 1st 2021 until end of January 2021. As the Corona situation does not allow an in-person course at DESY, an all-online course will be offered in the week starting February 22, 2021.

Form of Testing and Examination: Seminar talk. Students who would like to obtain course credit for the intensive week give a seminar talk during or after the intensive week. Please contact gregor@physik.uni-bonn.de as soon as you registered if you would like to give a presentation. The course can also be taken without course credit.

Literature:
Will be provided.

Comments:
The course is an all-day workshop in the lecture free time: starting February 22 2021 running all week.

The Intensive Week will have lectures in the morning and hands-on exercises in the afternoon.

physics740 **Hands-on Seminar: Experimental Optics and Atomic Physics**

Instructor(s): M. Weitz u.M.

Prerequisites:
Optik- und Atomphysik Grundvorlesungen, Quantenmechanik

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

Literature:
wird gestellt

Comments:
Vorbesprechung am Montag, den 2.11.2020, um 9 c.t.,

Die Vorbesprechung findet Online per Zoom statt, wobei Zugangsdaten auf ecampus zu finden werden sind.

Seminartermine ab 16.11.2020

physics760 **Computational Physics**
Tu 10-12, SR I, HISKP

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

Prerequisites:
Knowledge of a modern programming language (for example, C and/or C++)

Contents:
Aim of the course: Develop the ability to apply modern computational methods for solving physics problems

Main Topics:
- Lattice Monte Carlo Methods
- Direct Methods/Integral Equations
- Bayesian Inference

Final projects and participation in homework assignments required for successful completion of course.

Literature:
W.H. Press et al.: Numerical Recipes in C (Cambridge University Press)
C.P. Robert and G. Casella: Monte Carlo Statistical Methods (Springer 2004)
Tao Pang: An Introduction to Computational Physics (Cambridge University Press)
Vesely, Franz J.: Computational Physics: An Introduction (Springer)
Binder, Kurt and Heermann, Dieter W.: Monte Carlo Simulation in Statistical Physics (Springer)
Fehske, H.; Schneider, R.; Weisse, A.: Computational Many-Particle Physics (Springer)

Comments:
Course will be given online and in English

physics7502 **Random Walks and Diffusion**

Instructor(s): G. Schütz

Prerequisites:
Quantum mechanics, statistical physics, ordinary and partial differential equations

Contents:
Random walks, diffusion, central limit theorem, first passage problems, interacting particle systems

Literature:
Beginning of the course on 5th Nov.

Comments:
This is an updated and more demanding version of the course with the same title taught previously. Some knowledge in solving partial differential equations (including nonlinear partial differential equations) are required to follow.

physics7508 **Quantum Computing**
Mo 10-12, HS, HISKP, We 10, SR I; HISKP

Instructor(s): C. Urbach

Prerequisites:
Quantum Mechanics
Knowledge of a programming language like python or R might be helpful.

Contents:
Understand the theory of quantum computing and apply it to existing hardware.
- Quantum circuits
- Quantum algorithms
- Quantum computers
- Quantum noise and quantum operations
- Quantum error correction

Example problems will be implemented and run on IBM's Q experience.

Literature:
M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, Cambridge university press.

Comments:

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

Instructor(s): 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: Mo October 26

physics776 **Physics in Medicine: Physics of Magnetic Resonance Imaging**
Tu 10-12, Th 16-18, HS, IAP

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 receivers
- Computation of signal amplitudes in steady state sequences (Phase Graphs)
- Advanced MRI Sequences: quantifying flow, diffusion, susceptibility and more
- Applications 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:

physics653 **Seminar on Recent Topics in Hadron Physics**
Fr 12-14, SR I, HISKP

Instructor(s): A. Thiel

Prerequisites:

Contents:
This seminar will cover different topics, which are currently of interest in the field of hadron physics. These topics will - among others - include:
- Magnetic moment of the proton
- Proton radius puzzle
- Investigation of Proton Polarizabilities via Compton scattering
- Baryon spectroscopy - Excited states of protons and neutrons
- the d(2380)-hexaquark and its implications for Astrophysics
- Investigation of exotic states like hybrids and glueballs
- Pentaquark states
- Charmonium spectroscopy
- D-meson spectroscopy
- Magnetic moment of the muon
- Electric Dipole Moment measurements
- Future Developments

Literature:
Will be provided during the seminar.

Comments:

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 26 (preliminary discussion)

6823 **Research Internship / Praktikum in der Arbeitsgruppe:**
Analysis of proton-proton (ATLAS) collisions. Emphasis on top-quark physics and/or machine learning.
pr, all day, 3-4 weeks
Applications to brock@physik.uni-bonn.de, PI

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

Prerequisites:
Master level particle physics lecture.

Contents:
Analysis of Run 2 data from the ATLAS experiment with emphasis on top quark production in association with
other heavy particles. Further development of machine learning techniques for use in high-energy physics.

Literature:

Comments:

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

Contents:
This laboratory course provides insight into the current research activities of the Neurophysics group.
Introduction to time series analysis techniques, neuronal modelling, complex 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@ukbonn.de

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

Instructor(s): M. Weitz u.M.

Prerequisites:
Optik und Atomphysik Grundvorlesungen, Quantenmechanik

Contents:
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.

Literature:
wird gestellt

Comments:
Homepage der Arbeitsgruppe:

https://www.qo.uni-bonn.de/

6835 **Special Topics in Quantum Field Theory: Anomalies and their consequences**
Blockvorlesung: 26.10. bis 30.10.2020

Instructor(s): E. Kraus

Prerequisites:
Quantum field theory (physics 755)
Basics of quantization of gauge theories

Contents:
The anomaly of the axial current
Nonrenormalization of the anomaly
Anomalies in gauge theories: Nonrenormalizabiliy and symmetries

Literature:
N. N. Bogoliubov, D.V. Shirkov; Introduction to the theory of quantized fields (J. Wiley & Sons 1959)
M. Kaku, Quantum Field Theory (Oxford University Press 1993)
M. E. Peskin, D.V. Schroeder; An Introduction to Quantum Field Theory (Harper Collins Publ. 1995)

Comments:
27.10. 8-10
28.10. 10-12
29.10. 8-10 und 12-14
jeweils im HS I des PI.

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, F. Pacaud

Prerequisites:
Introduction to astronomy.

Contents:
Introduction into the evolution of the universe and the theoretical background of dark matter and dark energy tests.
Cosmology with clusters of galaxies using X-rays and the Sunyaev-Zeldovich effect.
Cosmic microwave background.
Cosmic distance scale.
Cosmic baryon budget and the warm hot intergalactic medium.

Literature:
A lecture script will be distributed.

Comments:

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

6954 **Seminar on galaxy clusters**
Th 15-16:30, Raum 0.006, AIfA

Instructor(s): T. Reiprich

Prerequisites:
Introductory astronomy course.

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

Literature:
Will be provided.

Comments: