Elective Advanced Lectures: BCGS Courses - physics70d

Module No.	**physics70d**
Category	Elective
Credit Points (CP)	3-8
Semester	1.-2.

Module: Elective Advanced Lectures: BCGS Courses

Module Elements:

Nr	**Course**	**Course No.**	**CP**	**Type**	**Teaching hours**	**Semester**
1	Relativity and Cosmology I (T)	GR I	8	Lect. + ex.	4+2	WT
2	Relativity and Cosmology II (T)	GR II	8	Lect. + ex.	4+2	ST
3	Quantum Field Theory I (T)	QFT I	8	Lect. + ex.	4+2	ST
4	Quantum Field Theory II (T)	QFT II	8	Lect. + ex.	4+2	ST
5	Geometry in Physics (T)	GiP	8	Lect. + ex.	4+2	ST
6	Topology for Physicists (T)	Topology	6	Lect. + ex.	3+1	ST
7	Nuclear physics II (E)	Nucl. physics II	5	Lecture	3	WT
8	Physics of Detectors (E/A)	Detectors	4	Lecture	3	ST
9	Particle physics (E)	Particles	4	Lecture	3	ST
10	Groundbreaking experiments in nuclear physics (E)	ExpNuclPhys	3	Lecture	2	ST
11	Condensed Matter Physics II (E)	CondMatter II	4	Lecture	3	ST
12	Semiconductor Physics and Nanoscience (E/A)	Semicond. Phys.	3	Lecture	2	ST
13	Superconductivity (E/A)	Supercond	3	Lecture	2	ST
14	Magnetism (E/A)	Magnetism	3	Lecture	2	WT
15	Experimental methods in condensed matter physics (E/A)	Meth CondMatt	3	Lecture	2	WT
16	Physics of Surfaces and Nanostructures (E/A)	Surfaces	3	Lecture	2	WT
17	Introduction to neutron scattering (E/A)	Neutron Scatt.	3	Lecture	2	ST
18	Optical Spectroscopy (E/A)	Optical Spectr.	3	Lecture	2	WT/ST
19	Astrochemistry (E/A)	Astrochemistry	4	Lecture	2	ST
20	Fundamentals of Molecular Symmetry (E/A/T)	FundMolSym	4	Lecture	2	ST
21	Physical biology (T/A)	PhysBio	8	Lect. + ex.	4+2	ST
22	Statistical physics of soft matter and biomolecules (T/A)	SoftMatter	8	Lect. + ex.	4+2	ST
23	Statistical physics far from equilibrium (T)	StatPhysNE	8	Lect. + ex.	4+2	ST
24	Disordered systems (T)	Disorder	8	Lect. + ex.	4+2	ST
25	Nonequilibrium physics with interdisciplinary applications (T)	Nonequilibrium	4	Lect. + ex.	2+1	ST

Nr	Course	Course No.	CP	Type	Teaching hours	Semester
26	Probability theory and stochastic processes for physicists (T)	Probability	4	Lecture	3	WT

Requirements for Participation: none

Form of Examination: see with the course

Content: Advanced lectures within the Bonn Cologne Graduate School of Physics and Astronomy (BCGS).

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

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

Length of Module: 1 or 2 semester

Maximum Number of Participants: ca. 100

Registration Procedure: s. https://basis.uni-bonn.de u. http://bamawww.physik.uni-bonn.de

Note: Note: The student must achieve at least 18 CP out of all 4 Elective Advanced Modules

PDF version of this page.

Relativity and Cosmology I (T) - GR I

Course	**Relativity and Cosmology I (T)**
Course No.	GR I

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	4+2	8	WT

Requirements for Participation:

Preparation: Training in theoretical physics at the B.Sc. level

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: Introduction into Einstein's theory of general relativity and its major applications

Contents of the Course:

Gravity as a manifestation of geometry

Introduction to differential geometry

Einstein field equations

The Schwarzschild solution

Experimental tests

Gravitational waves

Recommended Literature:

T. Padmanabhan, Gravitation: Foundation and Frontiers

J. B. Hartle, Gravity: An introduction to Einstein's general relativity

PDF version of this page.

Relativity and Cosmology II (T) - GR II

Course	**Relativity and Cosmology II (T)**
Course No.	GR II

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Training in theoretical physics at the B.Sc. level

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: Application of Einstein's theory of general relativity to black holes and cosmology

Contents of the Course:

Black holes

Introduction to cosmology

The early Universe

Recommended Literature:

V. Mukhanov, Physical Foundations of Cosmology

T. Padmanabhan, Gravitation: Foundation and Frontiers

J. B. Hartle, Gravity: An introduction to Einstein's general relativity

PDF version of this page.

Quantum Field Theory I (T) - QFT I

Course	**Quantum Field Theory I (T)**
Course No.	QFT I

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Training in theoretical physics at the B.Sc. level

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: Methods of quantum field theory are in use in almost all areas of modern physics. Strongly oriented towards applications, this course offers an introduction based on examples and phenomena taken from the area of solid state physics.

Contents of the Course:

Second quantization and applications

Functional integrals

Perturbation theory

Mean-field methods

Recommended Literature: A. Altland and B.D. Simons, Condensed Matter Field Theory (Cambridge University Press, Cambridge, second edition: 2010)

PDF version of this page.

Quantum Field Theory II (T) - QFT II

Course	**Quantum Field Theory II (T)**
Course No.	QFT II

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Quantum Field Theory I

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: Quantum field theory is one of the main tools of modern physics with many applications ranging from high-energy physics to solid state physics. A central topic of this course is the concept of spontaneous symmetry breaking and its relevance for phenomena like superconductivity, magnetism or mass generation in particle physics.

Contents of the Course:

Correlation functions: formalism, and their role as a bridge between theory and experiment

Renormalization

Topological concepts

Recommended Literature: A. Altland and B.D. Simons, Condensed Matter Field Theory (Cambridge University Press, Cambridge, second edition: 2010)

PDF version of this page.

Geometry in Physics (T) - GiP

Course	**Geometry in Physics (T)**
Course No.	GiP

Category	**Type**	**Language**	**Teaching hours**	**CP**	**Semester**
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Training in theoretical physics at the B.Sc. level

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: The course introduces the background in differential geometry necessary to understand the geometrically oriented languages of modern theoretical physics. Applications include the coordinate invariant formulation of electrodynamics, phase space and symplectic mechanics, and a brief introduction to the foundations of general relativity.

Contents of the Course:

exterior calculus

manifolds

Lie groups

fibre bundles

Recommended Literature: M. Göckeler & T. Schücker, Differential geometry, gauge theory, and gravity, Cambridge University Press, 1987.

PDF version of this page.

Topology for Physicists (T) - Topology

Course	**Topology for Physicists (T)**
Course No.	Topology

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

Requirements for Participation:

Preparation: Bachelor of physics or mathematics; the basics of exterior calculus are assumed

Form of Testing and Examination: Written or oral examination

Length of Course: 1 semester

Aims of the Course: This course gives an introduction to various topological concepts and results that play an important role in modern theoretical physics.

Contents of the Course:

Elements of homotopy theory: homeomorphic spaces, homotopic maps, fundamental group, covering spaces, homotopy groups, long exact homotopy sequence of a fibration

Homology and cohomology: Poincare lemma, Mayer-Vietoris sequence, Cech-deRham complex, Hurewicz isomorphism theorem, spectral sequences

Vector bundles and characteristic classes: Euler form, Thom isomorphism, Chern classes

Applications: Berry phase; Dirac monopole problem; visualization of closed differential forms by Poincare duality; cohomology of electrical conductance; supersymmetry and Morse theory; index theorems; homotopy classification of topological insulators

Recommended Literature:

R. Bott and L.W. Tu: Differential forms in algebraic topology (Springer, 1982)

A.S. Schwarz, Topology for physicists (Springer, 1994)

PDF version of this page.

Nuclear physics II (E) - Nucl. physics II

Course	**Nuclear physics II (E)**
Course No.	Nucl. physics II

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	3	5	WT

Requirements for Participation:

Preparation: Nuclear Physics I, Quantum Mechanics

Form of Testing and Examination: Part of the obligatory courses for area of specialisation Nuclear and Particle Physics, separate oral examination is possible exceptionally.

Length of Course: 1 semester

Aims of the Course: Study of nuclear reactions, fission and fusion.

Contents of the Course:

- Kinematics in nuclear reactions
- Cross section
- Rutherford scattering
- Scattering in quantum mechanics
- The Born approximation
- Partial wave analysis
- Inelastic scattering, resonances
- Optical model
- Direct, compound, spallation and fragmentation reactions
- Neutron sources and detectors
- Neutron cross sections
- Fission
- Nuclear reactors
- Fusion
- Solar fusion
- Man-made thermonuclear fusion
- Controlled thermonuclear fusion

Recommended Literature:

A script for parts of the course will be distributed during the course.

K.S. Krane, Introductory nuclear physics, chapters 11-14

PDF version of this page.

Physics of Detectors (E/A) - Detectors

Course	**Physics of Detectors (E/A)**
Course No.	Detectors

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	3	4	ST

Requirements for Participation:

Preparation: Nuclear Physics I, Quantum Mechanics

Form of Testing and Examination: Part of the obligatory courses for area of specialisation Nuclear and Particle Physics, separate oral examination is possible exceptionally.

Length of Course: 1 semester

Aims of the Course: Study detection methods of experimental techniques in nuclear and particle physics.

Contents of the Course:

- Interaction of electrons and charged heavy particles in matter
- Coherent effects: Cherenkov and transition radiation
- Interaction of gamma-radiation in matter
- Detection of neutal particles: neutrons and neutrinos
- Measurement of 4-momentum in particle physics
- Ionisation detectors: Bragg chamber, avalanche detectors
- Position sensitive detectors: drift chambers, time-procjection chamber
- Anorganic and organic scintillators
- Energy detection, calorimeter and shower detectors
- Semiconductor detectors
- Position sensitive Si detectors (strip-, pixel-detectors)
- Ge detectors
- Low background measurements
- Lifetime measurements
- Mössbauer Spectroscopy
- Basic principles of analoge and digital signal processing

Recommended Literature:

A script or slides of the course will be distributed during the course.

R. Leo, Techniques for Nuclear and Particle Physics Experiments

K Kleinknecht, Detektoren für Teilchenstrahlung

G.F. Knoll, Radiation Detection and Measurement

PDF version of this page.

Particle physics (E) - Particles

Course	**Particle physics (E)**
Course No.	Particles

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	3	4	ST

Requirements for Participation:

Preparation: Quantum Mechanics

Form of Testing and Examination: Part of the obligatory courses for area of specialisation Nuclear and Particle Physics, separate oral examination is possible exceptionally.

Length of Course: 1 semester

Aims of the Course: Introduction into particle physics, accelerators and detectors

Contents of the Course:

- Relativistic kinematics
- Interaction of radiation with matter
- Particle accelerators
- Targets and detectors
- Symmetries in particle physics
- QED
- Weak interaction, neutrinos
- Quark model
- QCD
- Standard model
- Cosmology

Recommended Literature:

A script for course will be available on-line

D.H. Perkins: Introduction to High Energy Physics, Cambridge University Press, ISBN 0521621968

H. Frauenfelder, E.M. Henley: Subatomic Physics, Prentice Hall, ISBN 0138594309

F. Halzen: A.D. Martin: Quarks and Leptons, John Wiley and Sons, ISBN 0471887412

D. Griffiths: Introduction to Elementary Particles, John Wiley and Sons ISBN: 0471603864

B. Povh, K. Rith, C. Scholz, F. Zetsche: Teilchen und Kerne, Springer-Verlag, ISBN 3540659285

C. Berger: Elementarteilchenphysik, Springer-Verlag, ISBN 3-540-41515-7

PDF version of this page.

Groundbreaking experiments in nuclear physics (E) - ExpNuclPhys

Course	**Groundbreaking experiments in nuclear physics (E)**
Course No.	ExpNuclPhys

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

Requirements for Participation:

Preparation: Basic knowledge in Nuclear Physics

Form of Testing and Examination: Part of courses for area of specialisation Nuclear and Particle Physics, separate oral examination is possible exceptionally.

Length of Course: 1 semester

Aims of the Course: Study of original publications of fundamental experiments in nuclear physics. The students should participate actively in the course.

Contents of the Course:

- Discovery of radioactivity
- Rutherford and his many discoveries using alpha sources
- The discovery of the neutron and deuteron
- Determination of magnetic moments
- Hofstadters electron scattering experiments
- The use of cosmic rays to discover mesons
- Fermi work in neutron physics
- Properties of neutrinos
- Mößbauereffekt

Recommended Literature: Will be distributed during the course.

PDF version of this page.

Condensed Matter Physics II (E) - CondMatter II

Course	**Condensed Matter Physics II (E)**
Course No.	CondMatter II

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	3	4	ST

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics and quantum mechanics

Form of Testing and Examination: Oral examination

Length of Course: 2 semesters

Aims of the Course: Advanced topics in condensed matter physics with examples of current research.

Contents of the Course:

The entire course (Condensed Matter I & II, given in 2 semesters) covers the following topics:

Crystal structure and binding

Reciprocal space

Lattice dynamics and thermal properties

Electronic structure (free-electron gas, Fermi surface, band structure)

Semiconductors and metals

Transport properties

Dielectric function and screening

Superconductivity

Magnetism

Recommended Literature:

Skriptum (available during the course)

Ashcroft/Mermin: Solid State Physics

Kittel: Introduction to Solid State Physics

Ibach/Lüth: Festkörperphysik

PDF version of this page.

Semiconductor Physics and Nanoscience (E/A) - Semicond. Phys.

Course	**Semiconductor Physics and Nanoscience (E/A)**
Course No.	Semicond. Phys.

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: No examination

Length of Course: 1 semester

Aims of the Course:

Understanding of theoretical and experimental concepts of semiconductor physics, nanotechnology as well as aspects of future information technology.

Knowledge of basic fields and important applications of information technology.

Contents of the Course:

Semiconducting material and nanostructures represent the backbone of modern electronics and information technology. At the same time they are fundamental to the research of problems of modern solid state physics, information technology and biophysics. This lecture will provide an introduction to semiconductor physics and its applications.

Topics covered are

introduction to semiconductor physics, crystalline structure, band structure, electronic and optical properties,

heterostructures, junction and interfaces,

basic semiconductor device concepts,

up to date techniques and strategies of information technology ranging from nowadays preparation technologies and nanoscience to concepts of molecular electronic and bioelectronics.

Recommended Literature:

Skriptum (available during the course)

Bergmann/Schäfer, Experimentalphysik (Band 6: Festkörper)

Ibach/Lüth, Festkörperphysik

PDF version of this page.

Superconductivity (E/A) - Supercond

Course	**Superconductivity (E/A)**
Course No.	Supercond

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding of the fundamental aspects of superconductivity.

Contents of the Course:

The lecture provides an overview of the fundamental aspects of superconductivity, theoretical description and technological applications, including the following topics:

Basic experimental facts and critical parameters

Phenomenological description: London equations

Ginzburg-Landau theory

Magnetic flux quantization

Type I and type II superconductors, characteristic length scales, vortices

Microscopic description: BSC theory

Electron-phonon interaction, Cooper pairs

Josephson effects

Applications of superconductivity in science, transport, and medicine

Brief introduction to unconventional superconductivity with recent examples

Recommended Literature:

J. F. Annett: Superconductivity, Superfluids and Condensates (2004)

M. Tinkham: Introduction to Superconductivity (1996)

V. V. Schmidt: The Physics of Superconductors (1997)

J. R. Waldram: Superconductivity of Metals and Cuprates (1996)

D. R. Tilley and J. Tilley: Superfluidity and Superconductivity (1990)

PDF version of this page.

Magnetism (E/A) - Magnetism

Course	**Magnetism (E/A)**
Course No.	Magnetism

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding of magnetism in condensed matter systems

Contents of the Course:

The lecture introduces to the magnetism in condensed matter systems. Starting from basic concepts of the magnetic properties of free atoms it is aimed to illustrate the extremely rich field of collective magnetism that arises from the mutual interaction of an extremely large number of interacting particles.

Topics covered are

Magnetism of free atoms

Magnetism of ions in the crystal electric field

Magnetic interactions and ordering phenomena

Magnetic ground states and excitations

Itinerant magnetism

Magnetic frustration and low dimensionality

Magnetic order vs. competing ordering phenomena

Recommended Literature:

Skriptum (available during the course)

S. Blundell, Magnetism in Condensed Matter

Ashcroft/Mermin, Solid State Physics

Kittel, Festkörperphysik

PDF version of this page.

Experimental methods in condensed matter physics (E/A) - Meth CondMatt

Course	**Experimental methods in condensed matter physics (E/A)**
Course No.	Meth CondMatt

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course:

Understanding of experimental concepts in condensed matter science

Knowledge of basic fields and important applications

Contents of the Course:

The lecture introduces to modern experimental approaches in solid state physics. Basic concepts are illustrated with examples of physical problems investigated employing different methods.

Topics covered are

Introduction on sample preparation

X-ray powder diffraction

Specific heat, Thermal expansion

Magnetization and magnetic susceptibility

DC-Transport

Dielectric spectroscopy

Photo-emission spectroscopy

Inelastic scattering (neutrons, light)

THz spectroscopy / Optical spectroscopy

Scanning probe microscopy/spectroscopy (AFM, STM)

Recommended Literature:

Skriptum (available during the course)

Bergmann/Schäfer, Experimentalphysik (Band 6: Festkörper)

Ibach/Lüth, Festkörperphysik

Ashcroft/Mermin, solid state physics

PDF version of this page.

Physics of Surfaces and Nanostructures (E/A) - Surfaces

Course	**Physics of Surfaces and Nanostructures (E/A)**
Course No.	Surfaces

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

Requirements for Participation:

Preparation: Basic knowledge of solid state physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course:

Understanding of fundamental concepts in surface and nanostructure science

Knowledge of basic fields and important applications

Contents of the Course:

The lecture introduces to modern topics of surface and nanostructure physics. Basic concepts are illustrated with examples and the link to technical applications is emphasized. Topics covered are

- surface structure and defects,
- adsorption and heterogeneous catalysis,
- surface thermodynamics and energetics
- surface electronic structure and quantum dots,
- magnetism at surfaces
- epitaxy and thin film processes,
- oxide films
- ion beam processes at surfaces,
- clusters,
- graphene

Recommended Literature:

Michely: Skriptum (available during the course)

H. Ibach: Physics of Surfaces and Interfaces (Springer, Berlin 2006)

K. Oura et al: Surface Science - an introduction (Springer, Berlin 2003)

M. Prutton: Introduction to Surface Physics (Oxford University Press, 1994)

H. Lüth: Solid Surfaces, Interfaces and Thin Films, (Springer, Berlin 2001)

M. Henzler/ W. Göpel: Oberflächenphysik des Festkörpers (Teubner, Stuttgart 1994)

PDF version of this page.

Introduction to neutron scattering (E/A) - Neutron Scatt.

Course	**Introduction to neutron scattering (E/A)**
Course No.	Neutron Scatt.

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding of the basic concepts and techniques of elastic and inelastic neutron scattering experiments.

Contents of the Course:

The lecture introduces to the techniques of elastic and inelastic neutron scattering that can be used to determine the crystal or magnetic structure as well as the dispersion of nuclear or magnetic excitations. Topics covered are

Crystal structures and reciprocal space

Neutron powder diffraction

Single-crystal diffraction

Structure refinements

Inelastic neutron scattering

Phonon dispersion

Magnetic excitations

Examples of current research (high-temperature superconductors, manganates with colossal magnetoresistivity, multiferroics)

Polarized neutron scattering

Recommended Literature:

Skriptum (available during the course)

S. W. Lovesey, Theory of Neutron Scattering from Condensed Matter, Oxford (1981)

G. E. Bacon, Neutron Diffraction, Oxford (1979)

Shirane, Shapiro and, Tranquada, Neutr. Scattering with a triple-axis spectrometer, Cambridge (2002)

Izyumov, Ozerov, Magnetic Neutron Diffraction Plenum (1970)

Marshall and Lovesey, Theory of thermal neutron scattering,Oxford (1971)

Squires, Introduction to the theory of Thermal Neutron scattering, Cambridge (1978)

PDF version of this page.

Optical Spectroscopy (E/A) - Optical Spectr.

Course	**Optical Spectroscopy (E/A)**
Course No.	Optical Spectr.

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

Requirements for Participation:

Preparation: Basic knowledge in condensed matter physics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding of the basic concepts and techniques of optical spectroscopy on solid-state samples.

Contents of the Course:

Topics covered are:

Electromagnetic waves in matter, dielectric function

Electromagnetic response of metals and insulators, Drude-Lorentz model

Kramers-Kronig relations

THz spectroscopy (time domain and cw)

Fourier-transform spectroscopy

Ellipsometry

Examples of current research (phonons, magnons, orbital excitations, superconductors, . . .)

Recommended Literature:

Skriptum (available during the course)

Dressel/Grüner: Electrodynamics of Solids: Optical Properties of Electrons in Matter (Cambridge, 2002)

Klingshirn: Semiconductor Optics (Springer, 1997)

Kuzmany: Solid-State Spectroscopy: An Introduction (Springer, 2009)

PDF version of this page.

Astrochemistry (E/A) - Astrochemistry

Course	**Astrochemistry (E/A)**
Course No.	Astrochemistry

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	2	4	ST

Requirements for Participation:

Preparation: Atomic Physics, Molecular Physics and Quantum Mechanics at the level of the bachelor courses in physics, Molecular Physics I

Form of Testing and Examination: Oral Examination

Length of Course: 1 semester

Aims of the Course: The lecture introduces to astrochemistry of various astrophysical environments. Fundamental processes, such as molecular collisions, fragmentations, and chemical reactions, are explained, and implications for astrophysical observations by means of high resolution spectroscopy are treated.

Contents of the Course:

- Detection of Molecules in Space
- Elementary Chemical Processes
- Chemical Networks
- Grain Formation (Condensation)
- Properties of Grains and Ice
- Grain Chemistry
- Diffuse Clouds, Shocks, Dark Clouds, Star Forming Regions

Recommended Literature:

A.Tielens "The Physics and Chemistry of the Interstellar Medium" Cambridge University Press, 2005

S. Kwok "Physics and Chemistry of the Interstellar Medium" University Science Books, 2006

D. Rehder "Chemistry in Space, From Interstellar Matter to the Origin of Life" Wiley-VCCH, Weinheim, 2010

J. Lequeux "The interstellar Medium" Spinger, 2004

A. Shaw "Astrochemistry" Wiley, 2006

D. Whittet "Dust in the Galactic Environment", Taylor and Francis, 2nd edition, 2002

PDF version of this page.

Fundamentals of Molecular Symmetry (E/A/T) - FundMolSym

Course	**Fundamentals of Molecular Symmetry (E/A/T)**
Course No.	FundMolSym

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	2	4	ST

Requirements for Participation:

Preparation: Basic knowledge of quantum mechanics

Form of Testing and Examination: Oral Examination

Length of Course: 1 semester

Aims of the Course: Understanding the fundamental concepts of representation theory and its application to describe the symmetry of molecules

Contents of the Course:

The lecture introduces to group theory with special emphasis on representations and their use to describe the symmetry of molecules in high-resolution spectroscopy and in molecular physics generally. The theory is accompanied by a series of "prototypical" examples Topics covered are

- symmetry in general and symmetry of a molecule.
- groups and point groups.
- irreducible representations, characters.
- vanishing integral rule
- the Complete Nuclear Permutation-Inversion (CNPI) group.
- the Molecular Symmetry (MS) group).
- the molecular point group.
- classification of molecular states: electronic, vibrational, rotational, and nuclear spin states
- nuclear spin statistical weights
- hyperfine structure
- non-rigid molecules (inversion, internal rotation)

Recommended Literature:

Jensen: Script (text of powerpoint presentation files; available during the course)

P. Jensen and P. R. Bunker: The Symmetry of Molecules, in: "Encyclopedia of Chemical Physics and Physical Chemistry" (J. H. Moore and N. D. Spencer, Eds.), IOP Publishing, Bristol, 2001.

P. R. Bunker and Per Jensen: "Molecular Symmetry and Spectroscopy, 2nd Edition," NRC Research Press, Ottawa, 1998 (ISBN 0-660-17519-3).

P. R. Bunker and P. Jensen: "Fundamentals of Molecular Symmetry", IOP Publishing, Bristol, 2004 (ISBN 0-7503-0941-5).

PDF version of this page.

Physical biology (T/A) - PhysBio

Course	**Physical biology (T/A)**
Course No.	PhysBio

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Advanced statistical mechanics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Acquaintance with basic concepts of molecular and evolutionary biology; understanding of statistical issues arising in the analysis of sequence data and the application of methods from statistical physics addressing them.

Contents of the Course:

Statistics of the genome

Sequence analysis and sequence alignement

Evolutionary theory and population genetics

Theory of bio-molecular networks

Recommended Literature:

J.H. Gillespie, Population Genetics: A concise guide (Johns Hopkins University Press, 2004)

R. Durbin, S.R. Eddy, A. Krogh, G. Mitchison, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids (Cambridge University Press, 1998)

F. Kepes, Biological Networks (World Scientific, Singapore 2007)

D.J. Wilkinson, Stochastic Modelling for Systems Biology (Chapman&Hall, 2006)

PDF version of this page.

Statistical physics of soft matter and biomolecules (T/A) - SoftMatter

Course	**Statistical physics of soft matter and biomolecules (T/A)**
Course No.	SoftMatter

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Advanced statistical mechanics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding the molecular structure and mesoscopic properties of various types of soft matter systems, in particular with regard to their role in living cells.

Contents of the Course:

Colloids, polymers and amphiphiles

Biopolymers and proteins

Membranes

Physics of the cell

Recommended Literature:

J. K. G. Dhont, An Introduction to Dynamics of Colloids (Elsevier, Amsterdam, 1996).

M. Doi and S. F. Edwards, The Theory of Polymer Dynamics (Clarendon Press, Oxford, 1986).

S. A. Safran, Statistical Thermodynamics of Surfaces, Interfaces, and Membranes (Addison-Wesley, Reading, MA, 1994).

G. Gompper, U. B. Kaupp, J. K. G. Dhont, D. Richter, and R. G. Winkler, eds., Physics meets Biology — From Soft Matter to Cell Biology, vol. 19 of Matter and Materials (FZ Jülich, Jülich, 2004).

D. H. Boal, Mechanics of the Cell (Cambridge University Press, Cambridge, 2002).

PDF version of this page.

Statistical physics far from equilibrium (T) - StatPhysNE

Course	**Statistical physics far from equilibrium (T)**
Course No.	StatPhysNE

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Advanced statistical mechanics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding the generic behavior of fluctuation-dominated systems far from equilibrium, and acquaintance with the basic mathematical tools used for their description.

Contents of the Course:

Stochastic methods

Transport processes

Scale-invariant growth

Pattern formation far from equilibrium

Recommended Literature:

P.L. Krapivsky, S. Redner and E. Ben-Naim: A kinetic view of statistical physics (Cambridge University Press, 2010)

M. Kardar, Statistical Physics of Fields (Cambridge University Press, 2007)

PDF version of this page.

Disordered systems (T) - Disorder

Course	**Disordered systems (T)**
Course No.	Disorder

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	4+2	8	ST

Requirements for Participation:

Preparation: Advanced statistical mechanics

Form of Testing and Examination: Oral examination

Length of Course: 1 semester

Aims of the Course: Understanding the novel types of behaviour that arise in systems with quenched disorder, as well as the specific mathematical challenges associated with their theoretical description.

Contents of the Course:

Disorder average

Replica methods

Percolation

Phase transitions in disordered systems

Localization

Glassy dynamics

Recommended Literature:

D. Stauffer and A..Aharony, Introduction to Percolation Theory (Taylor & Francis, London 1994)

K.H. Fischer and J.A. Hertz, Spin Glasses (Cambridge University Press, Cambridge 1991)

K. Binder and W. Kob, Glassy Materials and Disordered Solids (World Scientific, Singapore 2005)

T. Nattermann, lecture notes

PDF version of this page.

Nonequilibrium physics with interdisciplinary applications (T) - Nonequilibrium

Course	**Nonequilibrium physics with interdisciplinary applications (T)**
Course No.	Nonequilibrium

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

Requirements for Participation:

Preparation: Statistical mechanics

Form of Testing and Examination: Oral examination or term paper

Length of Course: 1 semester

Aims of the Course: Acquaintance with basic concepts of nonequilibrium physics; ability to apply the basic methods for the investigation of nonequilibrium problems; application of physics-based models to interdisciplinary problems.

Contents of the Course:

Principles of nonequilibrium physics

Stochastic systems and their desription (master equation, Fokker-Planck equation,..)

Analytical and numerical methods

Nonequilibrium phase transitions

Applications to traffic, pedestrian dynamics, economic systems, biology, pattern formation,..

Recommended Literature:

A. Schadschneider, D. Chowdhury, K. Nishinari: Stochastic Transport in Complex Systems (Elsevier, 2010)

P.L. Krapivsky, S. Redner, E. Ben-Naim: A Kinetic View of Statistical Physics (Cambridge University Press, 2010)

V. Privman (Ed.): Nonequilibrium Statistical Mechanics in One Dimension (Cambridge University Press, 1997)

N.G.Van Kampen: Stochastic Processes in Physics and Chemistry (Elsevier, 1992)

PDF version of this page.

Probability theory and stochastic processes for physicists (T) - Probability

Course	**Probability theory and stochastic processes for physicists (T)**
Course No.	Probability

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture	English	3	4	WT

Requirements for Participation:

Preparation: Statistical mechanics on the bachelor level

Form of Testing and Examination: Oral examination or term paper

Length of Course: 1 semester

Aims of the Course: Acquaintance with probabilistic concepts and stochastic methods commonly used in the theory of disordered systems and nonequilibrium phenomena, as well as in interdisciplinary applications of statistical physics.

Contents of the Course:

Limit laws and extremal statistics

Point processes

Markov chains and birth-death processes

Stochastic differential equations and path integrals

Large deviations and rare events

Recommended Literature:

D. Sornette: Critical Phenomena in Natural Sciences (Springer, 2004)

N.G.Van Kampen: Stochastic Processes in Physics and Chemistry (Elsevier, 1992)

PDF version of this page.