

Module No.:
 Credit Points (CP):
 Category:
 Semester:

ECThPhysics
 7
 Elective
 1.



Module: Elective Courses Theoretical Physics

Module Elements:

Nr.	Course Title	Number	CP	Type	Workload	Sem.
1.	Advanced Quantum Theory	physics606	7	Lect. + ex.	210 hrs	WT
2.	Group Theory (T)	physics751	7	Lect. + ex.	210 hrs	WT
3.	General Relativity and Cosmology (T)	physics754	7	Lect. + ex.	210 hrs	ST
4.	Quantum Field Theory (T)	physics755	7	Lect. + ex.	210 hrs	ST
5.	Computational Physics (T)	physics760	7	Lect. + ex. + proj.	210 hrs	WT/ST
6.	Advanced Quantum Field Theory (T)	physics7501	7	Lect. + ex.	210 hrs	WT

Requirements for Participation:

for physics606: none

for all other modules: physics606

Form of Examination:

written examination

Content:

see with the course

Aims/Skills:

see with the course

Course achievement/Criteria for awarding cp's:

successful work with the exercises

Length of Module: 1 semester

Maximum Number of Participants: ca. 100

Registration Procedure:

s. <https://basis.uni-bonn.de> u. <http://bamawww.physik.uni-bonn.de>

at least 7 cp out of this area must be achieved

Module:	Elective Courses Theoretical Physics
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Module No.: ECThPhysics

Course:	 Advanced Quantum Theory
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Course No.: physics606

Category	Type	Language	Teaching hours	CP	Semester
Required	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:
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Preparation:

Theoretical courses at the Bachelor degree level
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Form of Testing and Examination:

Requirements for the module examination (written examination): successful work with exercises

Length of Course:

1 semester

Aims of the Course:

Ability to solve problems in relativistic quantum mechanics, scattering theory and many-particle theory

Contents of the Course:

Born approximation, partial waves, resonances
 advanced scattering theory: S-matrix, Lippman-Schwinger equation
 relativistic wave equations: Klein-Gordon equation, Dirac equation
 representations of the Lorentz group
 many body theory
 second quantization
 basics of quantum field theory
 path integral formalism
 Greens functions, propagator theory

Recommended Literature:

L. D. Landau, E.M. Lifschitz; Course of Theoretical Physics Vol.3 Quantum Mechanics (Butterworth-Heinemann 1997)

J. J. Sakurai, Modern Quantum Mechanics (Addison-Wesley 1995)

F. Schwabl, Advanced Quantum Mechanics. (Springer, Heidelberg 3rd Ed. 2005)

Modules: ECThPhysics **Elective Courses Theoretical Physics**
 physics70c **Elective Advanced Lectures: Theoretical Physics**

Course:  **Group Theory (T)**

Course No.: physics751

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation:

physik421 (Quantum Mechanics)

Form of Testing and Examination:

Requirements for the examination (written): successful work with the

Length of Course:

1 semester

Aims of the Course:

Acquisition of mathematical foundations of group theory with regard to applications in theoretical physics

Contents of the Course:

Mathematical foundations:

Finite groups, Lie groups and Lie algebras, highest weight representations, classification of simple Lie algebras, Dynkin diagrams, tensor products and Young tableaux, spinors, Clifford algebras, Lie super algebras

Recommended Literature:

B. G. Wybourne; Classical Groups for Physicists (J. Wiley & Sons 1974)
 H. Georgi; Lie Algebras in Particle Physics (Perseus Books 2. Aufl. 1999)
 W. Fulton, J. Harris; Representation Theory (Springer, New York 1991)

Modules:

ECThPhysics Elective Courses Theoretical Physics
 physics70c Elective Advanced Lectures: Theoretical
 Physics

Course:

General Relativity and Cosmology (T)

Course No.: physics754

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	ST

Requirements for Participation:**Preparation:**

physik221 and physik321 (Theoretical Physics I and II)
 Differential geometry

Form of Testing and Examination:

Requirements for the examination (written): successful work with the exercises

Length of Course:

1 semester

Aims of the Course:

Understanding the general theory of relativity and its cosmological implications

Contents of the Course:

Relativity principle
 Gravitation in relativistic mechanics
 Curvilinear coordinates
 Curvature and energy-momentum tensor
 Einstein-Hilbert action and the equations of the gravitational field
 Black holes
 Gravitational waves
 Time evolution of the universe
 Friedmann-Robertson-Walker solutions

Recommended Literature:

S.Weinberg; Gravitation and Cosmology (J. Wiley & Sons 1972)
 R. Sexl: Gravitation und Kosmologie, Eine Einführung in die Allgemeine Relativitätstheorie (Spektrum Akadem. Verlag 5. Aufl 2002)
 L.D. Landau, E.M. Lifschitz; Course of Theoretical Physics Vol.2: Classical field theory (Butterworth-Heinemann 1995), also available in German from publisher Harry Deutsch

Modules: ECThPhysics **Elective Courses Theoretical Physics**
 physics70c **Elective Advanced Lectures: Theoretical Physics**

Course:  **Quantum Field Theory (T)**

Course No.: physics755

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	ST

Requirements for Participation:

Preparation:

Advanced quantum theory (physics606)

Form of Testing and Examination:

Requirements for the examination (written): successful work with the exercises

Length of Course:

1 semester

Aims of the Course:

Understanding quantum field theoretical methods, ability to compute processes in quantum electrodynamics (QED) and many particle systems

Contents of the Course:

Classical field theory
 Quantization of free fields
 Path integral formalism
 Perturbation theory
 Methods of regularization: Pauli-Villars, dimensional
 Renormalizability
 Computation of Feynman diagrams
 Transition amplitudes in QED
 Applications in many particle systems

Recommended 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)
 L. H. Ryder; Quantum Field Theory (Cambridge University Press 1996)
 S. Weinberg; The Quantum Theory of Fields (Cambridge University Press 1995)

Modules: ECThPhysics **Elective Courses Theoretical Physics**
 physics70c **Elective Advanced Lectures: Theoretical Physics**

Course:  **Computational Physics (T)**

Course No.: physics760

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises and project work	English	2+2+1	7	WT/ST

Requirements for Participation:

Knowledge of a modern programming language (like C, C++)

Preparation:

Theoretical courses at the Bachelor degree level

Form of Testing and Examination:

successful participation in exercises,
 presentation of an independently completed project

Length of Course:

1 semester

Aims of the Course:

ability to apply modern computational methods for solving physics problems


Contents of the Course:

Statistical Models, Likelihood, Bayesian and Bootstrap Methods
 Random Variable Generation
 Stochastic Processes
 Monte-Carlo methods
 Markov-Chain Monte-Carlo

Recommended Literature:

W.H. Press et al.: Numerical Recipes in C (Cambridge University Press)
<http://library.lanl.gov/numerical/index.html>
 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)

Modules: ECThPhysics **Elective Courses Theoretical Physics**
 physics70c **Elective Advanced Lectures: Theoretical Physics**

Course:  **Advanced Quantum Field Theory (T)**

Course No.: physics7501

Category	Type	Language	Teaching hours	CP	Semester
Elective	Lecture with exercises	English	3+2	7	WT

Requirements for Participation:

Preparation:

3-year theoretical physics course with extended interest in theoretical physics and mathematics

Form of Testing and Examination:

Requirements for the module examination (written examination): successful work with exercises

Length of Course:

1 semester

Aims of the Course:

Introduction to modern methods and developments in Theoretical Physics in regard to current research

Contents of the Course:

Selected Topics in Modern Theoretical Physics for example:

Anomalies

Solitons and Instantons

Quantum Fluids

Bosonization

Renormalization Group

Bethe Ansatz

Elementary Supersymmetry

Gauge Theories and Differential Forms

Applications of Group Theory

Recommended Literature:

M. Nakahara; Geometry, Topology and Physics (Institute of Physics Publishing, London 2nd Ed. 2003)

R. Rajaraman; Solitons and Instantons, An Introduction to Solitons and Instantons in Quantum Field Theory (North Holland Personal Library, Amsterdam 3rd reprint 2003)

A. M. Tsvelik; Quantum Field Theory in Condensed Matter Physics (Cambridge University Press 2nd Ed. 2003)

A. Zee; Quantum Field Theory in a Nutshell (Princeton University Press 2003)