Modern Physics ELECTIVE PACKAGE

Modern Physics	
Offered by	Department of Applied Physics
Language	English
Primarily interesting for	Bachelor Students in Major Applied Physics
Prerequisites	Required courses: - Recommended courses: - **General theory of relativity:** Theoretical classical mechanics (3EMX0) strongly recommended Linear Algebra (2DBN00), Advanced Calculus (2DBN10), Elements of Mathematical Physics (3BMX0) - **Quantum optics and quantum information:** Optics (3BOX0) and Applied Quantum Mechanics (3CQX0) - **Subatomic Physics:** Introduction Quantum physics (3BQX0), Advanced Calculus (2DBN10) and Electromagnetism (3AEX0)
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Content and composition

In the early 20th century new developments in physics fundamentally changed our perception of the world and the universe. This era is dominated by the development of the theory of relativity, quantum physics and nuclear physics which was followed by the discovery of elementary particles and the standard model of elementary particle physics.

The package Modern Physics contains introductory courses on the fundamentals of the theory of general relativity and of nuclear and elementary particle physics. Both subjects are not present in the major applied physics and these courses provide the opportunity to add these subjects to your study program. The third course in this package: “Quantum optics and Quantum information” describes the quantum theory of light and its application to the thriving field of quantum information processing, building on the courses “Introduction to Quantum Physics” and “Applied Quantum Physics” in the major Applied Physics

Course code	Course name	Level classification
3ERX0	General theory of relativity	3
3FQX0	Quantum Optics and Quantum information	3
3FSX0	Subatomic Physics	3

Course description

3ERX0, General theory of relativity
This course contains the fascinating story of the general theory of relativity: a geometrical interpretation of gravity as developed by Albert Einstein. The course will start with a mathematical description of the 4 dimensional space-time continuum and associated differential geometry. Subsequently the general theory of relativity and the description of gravity are introduced in this framework.
Additional topics that will be discussed are the space-time continuum of Schwarzschild and black holes. The course ends with an introduction into gravitational waves.

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3FQX0, Quantum Optics and Quantum information
This course starts with an introduction to the coherence properties of light. The basic concepts of quantum optics are then treated, including quantization of the electromagnetic field, Fock states, coherent and thermal fields. The quantum theory of light-matter interaction is developed and used to introduce the field of cavity quantum electrodynamics. The concept and applications of entanglement and nonlocality are described with several examples. Finally the basic elements of quantum information processing are introduced, including qubits, quantum cryptography, quantum sensing, quantum gates and quantum computing algorithms.

3FSX0, Subatomic Physics
The course subatomic physics starts with the experimental observations which provided insight in the size and structure of the atomic nucleus. Two early models of the nucleus will be introduced: the semi-empirical mass model and the independent particle shell model based on quantum physics. Subsequently, alpha, beta and gamma emission will be discussed as well as some applications such dating with radioactive sources as well as isotope production for medical purposes. Subsequently, accelerator induced nuclear reactions will be described followed by the concepts of nuclear fission and fusion. The use of accelerators with increasing energy finally shows the limitations of the early models of the nucleus and led to the discovery of many new elementary particles. The elementary concepts of Feynman diagrams will be discussed followed by an introduction into the classification of elementary particles and the framework of the standard model.