

Module title		Abbreviation
Optics and Quantum Physics		11-L-OAV-152-m01
Module coordinator		Module offered by
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
ECTS	Method of grading	Only after succ. compl. of module(s)
4	numerical grade	--
Duration	Module level	Other prerequisites
2 semester	undergraduate	--
Contents		
<p>1. Light: (linked to 11-E-E): Basic concepts, the speed of light, Huygens-Fresnel principle, reflection, refraction;</p> <p>2. Light in matter: Propagation velocity in the medium; dispersion, complex and frequency-dependent dielectric constant; absorption, Kramers-Kronig relation, interfaces, Fresnel equations, polarisation, generation by absorption, birefringence, optical activity (dipole);</p> <p>3. Geometrical optics: Basic concepts, Fermat's principle, optical path, Gaussian optics, reflection, refraction, plane interfaces, Snell's law, total reflection, optical tunneling, evanescent waves, prism; normal and anomalous dispersion, curved interfaces, thin and thick lenses, lens systems, lens grinder formula, aberrations, imaging errors (spherical & chromatic aberration, astigmatism, coma, distortion, correction approaches);</p> <p>4. Optical instruments: Characteristics, camera, eye, magnifying glass, microscope, telescope types, bundle beam vs. image construction (electron lenses, electron microscope), confocal microscopy;</p> <p>5. Wave optics: spatial and temporal coherence, double slit, Young's experiment, interference pattern (intensity profile), thin layers, parallel layers, wedge-shaped layers, phase shift, Newton rings, interferometer (Michelson, Mach-Zender, Fabry-Perot);</p> <p>6. Diffraction in the far field: Fraunhofer diffraction, single slit, intensity distribution, apertures, resolving power: Rayleigh & Abbé criterion, Fourier optics, optical grating, n-fold slit, intensity distribution, grating spectrometer and resolution, diffraction off atomic lattices, convolution theorem;</p> <p>7. Diffraction in the near field: Fresnel diffraction, near-field diffraction at circular apertures/disks, Fresnel zone plate, near-field microscopy, holography, Huygens-Fresnel concept; white light hologram;</p> <p>8. Failure of classical physics I - from light wave to photon: Black body radiation and Planck's quantum hypothesis; photoelectric effect and Einstein's explanation, Compton effect, light as a particle, wave-particle duality, quantum structure of nature;</p> <p>9. Failure of classical physics II - particles as waves: De Broglie's matter wave concept; diffraction of particle waves (Davisson-Germer-experiment, double slit interference);</p> <p>10. Wave mechanics: Wave packets, phase and group velocity (recap of 11-EM), uncertainty principle, Nyquist-Shannon theorem, wave function as probability amplitude, probability of residence, measurement process in quantum mechanics (double-slit experiment & which-way information, collapse of the wave function, Schrödinger's cat);</p> <p>11. Mathematical concepts of quantum mechanics: Schrödinger equation as wave equation, conceptual comparison to wave optics, free particle and particles in a potential, time-independent Schrödinger equation as eigenvalue equation, simple examples in 1D (potential step, potential barrier and tunnel effect, box potential and energy quantisation, harmonic oscillator), box potential in higher dimensions and degeneracy, formal theory of QM (states, operators, observables).</p>		
Intended learning outcomes		
<p>The students understand the basic principles and contexts of radiation, wave and quantum optics and quantum phenomena as well as Atomic and Molecular Physics. They understand the theoretical concepts and know the structure and application of important optical instruments and measuring methods. They understand the ideas and concepts of quantum theory and Astrophysics and the relevant experiments to observe and measure quantum phenomena. They are able to discuss their knowledge and to integrate it into a bigger picture.</p>		
Courses (type, number of weekly contact hours, language — if other than German)		
V (4) + V (3)		

Method of assessment (type, scope, language – if other than German, examination offered – if not every semester, information on whether module is creditable for bonus)
oral examination of one candidate each (approx. 30 minutes) Language of assessment: German and/or English
Allocation of places
--
Additional information
--
Workload
120 h
Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 53 I Nr. 1 a) (2 ECTS credits) and b) (2 ECTS credits) § 77 I Nr. 1 a) (2 ECTS credits) and c) (2 ECTS credits)
Module appears in
First state examination for the teaching degree Grundschule Physics (2015) First state examination for the teaching degree Realschule Physics (2015) First state examination for the teaching degree Gymnasium Physics (2015) First state examination for the teaching degree Mittelschule Physics (2015)