19 Wave and Quantum Optics

<table>
<tr><td colspan="2">Module title</td><td colspan="4">Wave and Quantum Optics</td></tr>
<tr><td colspan="2">Term</td><td colspan="2">2nd and 3rd semester</td><td colspan="2">summer</td></tr>
<tr><td colspan="2">Duration</td><td colspan="4">2 Semester</td></tr>
<tr><td colspan="2">Responsibility</td><td colspan="4">Prof. Dr. Ulrich Wittrock</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Prof. Dr. Ulrich Wittrock</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">English</td></tr>
<tr><td colspan="2">Programs in which the module is used</td><td colspan="3">Master or Science in Photonics</td><td>compulsory module</td></tr>
<tr><td rowspan="11">WORK LOAD</td><td rowspan="4">Contact hours</td><td>Courses</td><td>credit hours</td><td>semester load</td><td>contact time</td></tr>
<tr><td>Lectures (2+2)</td><td>4</td><td>30 + 30 h</td><td rowspan="3">120 h</td></tr>
<tr><td>Exercises (1+1)</td><td>2</td><td>15 + 15 h</td></tr>
<tr><td>Laboratory Course (2+0)</td><td>2</td><td>30 + 0 h</td></tr>
<tr><td rowspan="4">Self study</td><td colspan="2">Form</td><td>semester load</td><td>self study</td></tr>
<tr><td colspan="2">Lecture</td><td>50 + 50 h</td><td rowspan="3">210 h</td></tr>
<tr><td colspan="2">Exercise</td><td>30 + 30 h</td></tr>
<tr><td colspan="2">Laboratory Course</td><td>50 + 0 h</td></tr>
<tr><td colspan="3">Total work load</td><td>330 h</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">11</td></tr>
<tr><td colspan="2">Learning objectives</td><td colspan="4">The students will have a good understanding of light propagation in structured media (thin films), in isotropic, and in anisotropic media. Scattering phenomena are treated on a level that is appropriate for practical work in the laboratory. An introduction to coherence theory and adaptive optics is given at the end of the WAVE OPTICS course. In the QUANTUM OPTICS course, the naïve view of photons as particles will be corrected. Applied topics are nonlinear optics, phase and amplitude noise, laser frequency stabilization, and a case study which encompasses almost all themes covered in this module. The students will appreciate the counter-intuitive aspects of quantum optics and loose their resentments towards abstract concepts that are required in modern physics.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">WAVE OPTICS:
- Matrix Formalism for Calculating Transmission and Reflection of Dielectric Thin Film Stacks
- Thin Film Systems and their Application
- Surface Scattering
- Harmonic Oscillator Model for the Refractive Index
- Volume Scattering (Rayleigh, Mie, Brillouin, Raman)
- Wave Propagation in Anisotropic Media (Uniaxial and Biaxial)
- Induced Anisotropy (Faraday, Kerr, Pockels)
- Stokes Parameters, Mueller Matrices, Jones Vectors and Jones Matrices
- Introduction to Coherence Theory
- Adaptive Optics</td></tr>
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	QUANTUM OPTICS: - Nonlinear Susceptibility - Phase Matching - Optical Parametric Amplifiers and Oscillators - Interferometric Autocorrelation for Measuring Ultrashort Pulses - Nonlocal Nature of the Quantum World (Einstein-Podolski-Rosen Experiment) - Quantum Cryptography - Interaction-Free Measurements - Second Quantization - Photon Statistics - Nonclassical Light - Pound-Drever-Hall Laser Frequency Stabilization - Case Study: Atmospheric Dynamics Mission AEOLUS - Laser Spectroscopy: Doppler-Free Spectroscopy
Requirements for participation	Formally: Admission to the M. Sc. Photonics. With regard to contents: Elementary Quantum Mechanics, Laser Physics, Wave Optics.
Requirements for allocation of credits	Successful completion of laboratory class. At least a passing grade for the module examination.
Exam	Oral or written exam of 45 minutes and 120 minutes, respectively.
Requirements to attend the exam	Successful completion of laboratory class.