

***Advanced Quantum Mechanics***

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-P-QMII	270 h	9 CP	1 <sup>st</sup> Semester	Every winter term	1 Semester
1	<b>Type of lessons</b> a) Lecture b) Problem Class c) Preparation for exam		<b>Contact times</b> 56 h 28 h ---	<b>Self-study times</b> 84 h 84 h 18 h	<b>Intended group size</b> 15–20 students per problem class
2	<b>Aims of the module and acquired skills</b> Building on the foundational exposition of quantum mechanics in the Bachelor course program, this course introduces the student to various themes of advanced quantum mechanics that are required knowledge for doing master thesis research in experimental or theoretical physics. The course especially caters to the needs of students specializing in condensed matter physics and nuclear physics.				
3	<b>Contents of the module</b> 1. Scattering theory <ul style="list-style-type: none"> <li>• differential cross section</li> <li>• method of partial waves and scattering phases for systems with spherical symmetry</li> <li>• optical theorem, Lippmann-Schwinger equation, Born approximation</li> <li>• time-dependent scattering theory, Moeller operators</li> <li>• scattering matrix, multichannel scattering</li> </ul> 2. The formalism of second quantization <ul style="list-style-type: none"> <li>• construction of the Fock space for fermions and bosons</li> <li>• second quantization of one- and two-body operators</li> <li>• vacuum state and normal ordering</li> <li>• quantum theory of the free electromagnetic field</li> </ul> 3. Relativistic quantum theory <ul style="list-style-type: none"> <li>• Dirac equation, invariance properties (parity, time reversal, charge conjugation)</li> <li>• hole interpretation of the positron, nonrelativistic reduction</li> <li>• Pauli equation, spinors</li> </ul> 4. Specialized topic in advanced quantum mechanics, for example, applications of group theory (theory of angular momentum and spin), the standard model of particle physics, or quantum information theory.				
4	<b>Teaching/Learning methods</b> Besides the teaching in lectures, the self-study based on books and lecture notes plays an important role. The students work individually on problem sets. In discussions with others and in the problem classes, they learn to solve challenging problems in a team and to present their approaches and results.				

5	<p><b>Requirements for participation</b></p> <p>Classical theoretical physics (mechanics and electrodynamics), basic quantum mechanics (as taught in a one-semester theoretical physics course on quantum mechanics).</p>
6	<p><b>Type of module examinations</b></p> <p>The module is passed by passing a written exam, which is held during the semester and is offered again at the beginning of the following semester. To be accepted for the written exam, students must actively participate in the problem class, solve the homework problems and register for the exam.</p>
7	<p><b>Requisites for the allocation of credits</b></p> <p>The module is passed by passing a written exam. The grade given for the module is equal to the grade of the written exam.</p>
8	<p><b>Compatibility with other Curricula</b></p> <p>As elective subject in other M.Sc. programs.</p>
9	<p><b>Significance of the module mark for the overall grade</b></p> <p>The weight of the module is <math>9/111 \approx 8.1\%</math>.</p>
10	<p><b>Module coordinator</b></p> <p>M. Zirnbauer</p>
11	<p><b>Additional information</b></p> <p>Literature: Sakurai, Modern Quantum Mechanics (Addison-Wesley), Schwabl, Advanced Quantum Mechanics (Springer)</p> <p>Version: 05.06.2015 HK</p>