<table>
<thead>
<tr>
<th><strong>Module</strong></th>
<th><strong>Condensed Matter Theory</strong></th>
</tr>
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<tbody>
<tr>
<td><strong>Code</strong></td>
<td>71659</td>
</tr>
<tr>
<td><strong>Instruction language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>ECTS credits</strong></td>
<td>6</td>
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<tr>
<td><strong>Credit hours</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>1 semester</td>
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<tr>
<td><strong>Cycle</strong></td>
<td>Irregularly</td>
</tr>
<tr>
<td><strong>Coordinator</strong></td>
<td>Prof. Joachim Ankerhold</td>
</tr>
<tr>
<td><strong>Lecturer</strong></td>
<td>Prof. Joachim Ankerhold</td>
</tr>
<tr>
<td><strong>Allocation to study programmes</strong></td>
<td>Physics M.Sc., elective module, 1st or 2nd semester</td>
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<tr>
<td><strong>Formal prerequisites</strong></td>
<td>None</td>
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<tr>
<td><strong>Recommended prerequisites</strong></td>
<td>Quantum Mechanics, Solid State Physics</td>
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</tbody>
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**Learning objectives**

- Students who successfully passed this module
- understand methods and concepts of the description of open classical and quantum mechanical systems
- understand basic differences in the dynamics of classical and quantum mechanical open systems
- possess advanced knowledge of quantum statistics
- are able to read relevant original literature to present it and know current experimental realizations

**Syllabus**

- There are several courses with different content, which are alternately offered for this module.
- **Decoherence and dissipation:**
  - Classical Langevin equation, Fokker-Planck equation
  - Response functions, fluctuation dissipation theorem
  - Master equations, Redfield equation
  - Born-Markov approximation
  - System + bath model
  - Harmonic oscillator: exact description
  - Correlation functions
  - Path integrals, reduced density operator
  - Dissipative tunneling
  - Real-time dynamics as a path integral
  - Paths minimal effect
- **Collective quantum phenomena:**
  - Second quantization
  - Many-body theory, quantum statistics
  - Superconductivity (BCS theory)
  - Bogoliubov-de Gennes equations
  - Josephson effect and superconducting circuits
  - Integral and fractional quantum Hall effect
Laughlin wave function and Chern-Simons theory
Bose-Einstein condensation (BEC)
BEC atomic gases
Gross-Pitaevskii equation
Elementary excitations

Many-body theory and transport:
Second quantization
Linear response theory
Green functions
Concept of quasiparticles
Perturbation theory at T = 0
S-matrix, Wick's theorem
Feynman diagrams, Dyson equation
Exactly solvable models
Approximation methods: Hartree-Fock
Hubbard model, the Kondo model
Landauer and Landauer-Büttiker formalism
Meir-Wingreen equation

Literature
Decoherence and dissipation:
Weiss, Quantum Open Systems, World Scientific
Kleinert, Path Integrals in Quantum Mechanics etc., World Scientific

Collective quantum phenomena:
De Gennes, Superconductivity of Metals and Alloys, Westview Press
Tinkham, Introduction to Superconductivity, Krieger Publishing
Yoshioka, The Quantum Hall Effect, Springer
Pitaevskii, Stringari, Bose Einstein Condensation, Oxford University Press

Many-body theory and transport:
Mahan, Many-Particle Physics, Plenum Press
Nolting, Grundkurs Theoretische Physik 7, Springer

Teaching and learning methods
Lecture (3 hours/week)
Exercise (2 hours/week)

Workload
45 hours lecture (attendance time)
30 hours exercise (attendance time)
105 hours self-study and exam preparation
Total: 180 hours

Assessment
Written or oral examination. A prerequisite for the participation in the examination is an ungraded course achievement. Form and scope of the examination and of the course achievement are determined and notified by the lecturer at the beginning of the course.

Examination
12370 Condensed Matter Theory (precourse)
12369 Condensed Matter Theory

Grading procedure
The module grade is the examination grade.

Basis for
Research in the field of Condensed Matter