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| Module | ***Condensed Matter Theory*** |
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| Code | 71659 |
| Instruction language | English |
| ECTS credits | 6 |
| Credit hours | 5 |
| Duration | 1 semester |
| Cycle | Irregularly |
| Coordinator | Prof. Joachim Ankerhold |
| Lecturer | Prof. Joachim Ankerhold |
| Allocation to study programmes | Physics M.Sc., elective module, $1^{st}$ or $2^{nd}$ semester |
| Formal prerequisites | None |
| Recommended prerequisites | Quantum Mechanics, Solid State Physics |
| Learning objectives | Students who successfully passed this module<br>• understand methods and concepts of the description of open classical and quantum mechanical systems<br>• understand basic differences in the dynamics of classical and quantum mechanical open systems<br>• possess advanced knowledge of quantum statistics<br>• 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.<br>**Decoherence and dissipation:**<br>• Classical Langevin equation, Fokker-Planck equation<br>• Response functions, fluctuation dissipation theorem<br>• Master equations, Redfield equation<br>• Born-Markov approximation<br>• System + bath model<br>• Harmonic oscillator: exact description<br>• Correlation functions<br>• Path integrals, reduced density operator<br>• Dissipative tunneling<br>• Real-time dynamics as a path integral<br>• Paths minimal effect<br>**Collective quantum phenomena:**<br>• Second quantization<br>• Many-body theory, quantum statistics<br>• Superconductivity (BCS theory)<br>• Bolgoliubov-de Gennes equations<br>• Josephson effect and superconducting circuits<br>• Integral and fractional quantum Halll effect |

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| | • Laughlin wave function and Chern-Simons theory<br>• Bose-Einstein condensation (BEC)<br>• BEC atomic gases<br>• Gross-Pitaevskii equation<br>• Elementary excitations<br>**Many-body theory and transport:**<br>• Second quantization<br>• Linear response theory<br>• Green functions<br>• Concept of quasiparticles<br>• Perturbation theory at T = 0<br>• S-matrix, Wick's theorem<br>• Feynman diagrams, Dyson equation<br>• Exactly solvable models<br>• Approximation methods: Hartree-Fock<br>• Hubbard model, the Kondo model<br>• Landauer and Landauer-Büttiker formalism<br>• Meir-Wingreen equation |
| Literature | **Decoherence and dissipation:**<br>• Weiss, Quantum Open Systems, World Scientific<br>• Breuer, Petruccione, The Theory of Open Quantum Systems, Oxford<br>• Kleinert, Path Integrals in Quantum Mechanics etc., World Scientific<br>**Collective quantum phenomena:**<br>• De Gennes, Superconductivity of Metals and Alloys, Westview Press<br>• Tinkham, Introduction to Superconductivity, Krieger Publishing<br>• Yoshioka, The Quantum Hall Effect, Springer<br>• Pitaevskii, Stringari, Bose Einstein Condensation, Oxford University Press<br>**Many-body theory and transport:**<br>• Mahan, Many-Particle Physics, Plenum Press<br>• Nolting, Grundkurs Theoretische Physik 7, Springer |
| Teaching and learning methods | Lecture (3 hours/week)<br>Exercise (2 hours/week) |
| Workload | 45 hours lecture (attendance time)<br>30 hours exercise (attendance time)<br>105 hours self-study and exam preparation<br>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)<br>12369 Condensed Matter Theory |
| Grading procedure | The module grade is the examination grade. |
| Basis for | Research in the field of Condensed Matter |