Module	***Condensed Matter Theory A: Quantum Mechanics on Macroscopic Scales***
Code	76067
Instruction language	English
ECTS credits	6
Credit hours	5
Duration	1 semester
Cycle	Winter Semester
Coordinator	Dean of Physics Studies
Lecturer	Prof. Joachim Ankerhold, Dr. Björn Kubala, Dr. Ciprian Padurariu
Allocation to study programmes	Physics M.Sc., elective module, 1st or 2nd semester
Formal prerequisites	None
Recommended prerequisites	Quantum Mechanics, Solid State Physics, Thermodynamics/Statistics
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	The lecture explores theoretical and experimental developments in solid state physics over the past twenty years that describe and access quantum mechanical properties on growing length scales and with growing complexity. Low-temperature properties of condensed matter systems are governed by quantum mechanics. Many-bodyeffects are crucial and may lead to completely new phenomena, determined by the dynamics of new collective degrees of freedom. In superconducting devices, the quantum dynamics of these collective variables can be observed, manipulated and exploited for applications, e.g., for quantum-information technologies. In this course, we will study the physics underlying such devices and introduce tools for their analysis and description. • Introduction • Macroscopic quantum oscillator • Nonlinear oscillator: Josephson junction • From artificial atoms to circuit-QED • Basics of open quantum systems: master equation • Single charge transfer • From circuit-QED to Josephson photonics
Literature	• Michel Devoret, Quantum fluctuations in electrical circuits, Les Houches Lectures, with Uri Vool, arXiv:1610.03438 • Tero T. Heikkilä,The Physics of Nanoelectronics: Transport and Fluctuation Phenomena at Low Temperatures

	• P. Breuer and F. Petruccione, The Theory of Open Quantum Systems, Oxford University Press
Teaching and learning methods	Lecture (3 hours per week) Exercise (2 hours per week)
Workload	45 hours lecture (attendance time) 30 hours exercise (attendance time) 105 hours self-study and exam preparation Total: 180 hours
Assessment	The module examination consists of graded weekly assignments and a larger end-of-term project. The latter will be presented in a seminar-style short talk or in written form, depending on the number of participants. While the weekly assignments cover the taught topics and closely follow the lecture, in the end-of-term project students will go deeper into one particular topic and apply acquired methods and concepts to read, understand, and present research-level material. A passing grade in the weekly assignments counts as study achievement and is required for participation in the end-of-term project work. Topics and material will be assigned after the first half of the course. Marking will be based 50% on the assignments and 50% on the presentation.
Examination	16567 Condensed Matter Theory A: Quantum Mechanics on Macroscopic Scales (precourse) 16067 Condensed Matter Theory A: Quantum Mechanics on Macroscopic Scales
Grading procedure	The module grade is the examination grade.
Basis for	Research in the field of Condensed Matter