Foundations of Quantum Technologies: Matter, Light and Information

Module No.: MN-P-PAoS-QT, MN-P-SAoS-QT, MN-P-WaMa Version: 03.11.2025 MB

Course: Platforms for Quantum Technologies

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Category	Type	Language	Teaching Hours	CP	Semester
Specialized Course	Lecture	English	2	3	WiSe

Requirements for participation:
Quantum mechanics, basic knowledge of condensed matter physics

Type of module examinations:
In case a grade is needed: graded journal club presentation after the course.

Duration of the course:
Block course (equivalent to 2 hours per week during the term)

Aims of the course:
Recently, elusive concepts of quantum mechanics such as superposition and entanglement – which have long been regarded as curiosities of quantum mechanics with no practical purposes – have become the key elements of several technological applications. These fledgling quantum technologies define a new field of physics and engineering, and can be roughly structured into quantum communication, quantum sensing, quantum simulations, and, last but not least, quantum computing.

Researchers at excellence cluster 'Matter and Light for Quantum Computing (ML4Q)' combine expertise in condensed matter physics, quantum optics, quantum devices, and quantum information to push the frontiers of the field. Together they develop novel forms of quantum hard- and software - from fundamental research on quantum matter over quantum information devices to operation protocols and software.

During this one-week course, students get an overview about various problems being explored by our scientists at all cluster sites. Furthermore, students have a chance to visit some of the laboratories. On the final day, participants can meet representatives from the quantum industry, explore career opportunities, and learn about technology transfer and entrepreneurship in the quantum field.

Contents of the course:
The course concentrates on the following topics:

Introduction to Quantum Information and Algorithms
Quantum Optics for Quantum Computing: Theory and Experiment
Introduction to Graphene and related 2D Materials for Quantum Technologies
Introduction to Anyons
Basics of Quantum Circuits
Quantum Resources and Out of Equilibrium Phenomena