Cluster of Excellence
Matter and Light for Quantum Computing (ML4Q)

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MATTER AND LIGHT FOR
QUANTUM COMPUTING

https://ml4q.d

ML4Q Platforms for Quantum Technologies course 2023

The Platforms for Quantum Technologies course is organized in the framework of the Cluster of Excellence Matter and Light for Quantum Computing (ML4Q). It aims to give the Master students the first insights into the research done in the cluster on platforms and applications for quantum technologies.

During the one week course, students will have a chance to get an overview of the most promising platforms and first applications, following up on a crisp introduction to the basic theoretical concepts needed for their understanding. In addition students will be offered to visit some of the laboratories. The course covers following topics:

A Short Dive into Quantum Algorithms and Quantum Error Correction (Markus Müller, RWTH Aachen/FZJ)

In this interactive theory and simulation workshop, we will start with a basic introduction to quantum gates and circuits, and discuss Grover's quantum search algorithm as one of the paradigmatic applications of quantum computation. Furthermore, we will explore and apply concepts of quantum error correcting codes, which lie at the heart of current research effort to build error-corrected quantum computers. This compact workshop will be a combination of short lecture blocks intertwined with hands-on programming sessions, where the discussed quantum algorithms and protocols will be implemented and explored using qiskit. The day will also include discussion with master/PhD students and local research groups.

AMO (atomic, molecular, optical) platforms (Julian Schmitt, Bonn University)

In this part student will learn the laser cooling concepts used to realize ultracold atomic quantum gases. To highlight an application of the platform, quantum simulation of magnetism with Fermions will be discussed. This part of the workshop will consist of lectures as well as exercises where students will be asked to calculate atomic dynamics in optical lattices (analytically or numerically in Python/Mathematica). The day will also include a lab tour in Bonn.

Solid state platforms (Hendrik Bluhm and Rami Barends, RWTH Aachen/FZJ)

During this day students will get an overview on the concepts, state of the art and future challenges of superconducting and semiconductor qubits. The lectures will be complemented by panel discussion on their relative merits.

Topological platforms (Yoichi Ando, University of Cologne)

This part will consist of lectures and exercises where students can get familiar with the concept of Majorana fermions and topological qubits. In the practical part students will exercise the parity extraction from the actual transmon data using Python. There will be also a possibility to take part in the lab tour to see the machine in which the data they analyzed were taken.