Cluster of Excellence

Matter and Light for Quantum Computing (ML4Q)

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ML4Q
MATTER AND LIGHT FOR
QUANTUM COMPUTING

https://ml4q.d

ML4Q Platforms for Quantum Technologies course 2024

18 – 22 March 2024

Schedule overview

Date	Topic	Lecturer	Location
Mon 18.03.	Introduction to Quantum Information and Algorithms	Markus Müller	FZJ
Tue 19.03.	Quantum optics for quantum computing with ultracold atoms and semiconductors	Andrea Bergschneider & Nina Stiesdal	Bonn
Wed 20.03.	Superconducting and semiconductor qubits	Hendrik Bluhm, Rami Barends, Seyed Akbar Jafari, Vincent Mourik	Aachen
Thu 21.03.	Topology and computation in the quantum Hall effects & Basics of quantum circuits	Erwann Bocquillon & Xhek Turkeshi	Cologne
Fri 22.03.	Quantum Cryptography & Open quantum systems and Lindbad master equation, with an application to the topological phase transition in Su–Schrieffer–Heeger model	Glaucia Murta & Andrea Nava	Düsseldorf

Content overview

Day 1, Monday 18.03.2024 (FZJ)

On this day students will get a brief hands-on introduction to quantum information and quantum circuits. We will discuss ingredients of quantum algorithms, and in particular discuss Grover's quantum search algorithm. Furthermore, we will introduce basic theoretical concepts and recent experimental breakthroughs in quantum error correction, which will be crucial to protect future scalable quantum computers against noise. In addition lab tours and discussions with other quantum technology research groups at Forschungszentrum Jülich are planned.

Day 2, Tuesday 19.03.2024 (Bonn)

During this day, we explore how information can be transferred between qubits using photons. We will give a basic introduction to light-matter coupling on the example of the two-level system. We will use this formalism to treat specific realistic quantum systems and discuss how to reach sizeable coupling between single photons and those systems, for instance by using cavities or collective effects. After that, we will give an overview on ML4Q projects done in Bonn followed by lab tours and a Meet&Greet poster session with the Bonn PhD students.

Day 3, Wednesday 20.03.2024 (Aachen)

The focus of this days would be on solid-state qubits. The general introduction to the topic would be followed by discussion of scaling concepts for spin qubits with a focus on electron shuttling, as well as challenges in scaling for superconducting qubits. In addition students will have a chance to get an overview of department research activities during a poster session and lab tours.

Day 4, Thursday 21.03.2024 (Cologne)

The aim of this day is to introduce students to two notions of quantum computation. First, we'll describe basics of topological quantum computation, and potential implementations in quantum Hall circuits. Secondly, we will discuss quantum circuits and explain what one can or cannot do. We also introduce digital quantum simulators and give an overview of where the fields is heading. In addition there will be short talks from ML4Q groups and lab tour.

Day 5, Friday 22.03.2024 (Düsseldorf)

The last day of the course will focus on understating of how to prove the security of quantum key distribution and its application to secure communication. In addition students will be introduces to the concept of topological phase transitions and edge states with intuitive and simple examples.