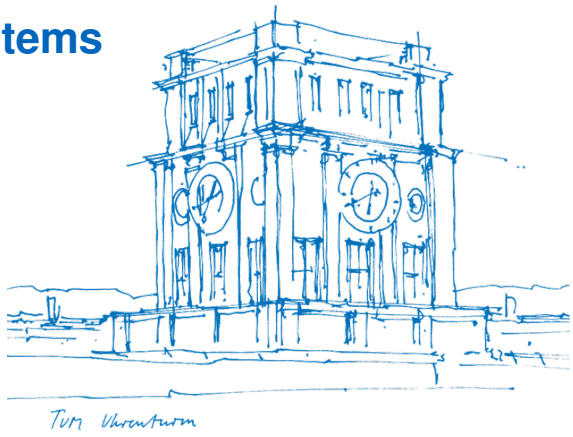
Chair of Computer Architecture and Parallel Systems
Department of Computer Engineering
Technical University of Munich

Seminar on Integration of QPU Accelerators with HPC Systems



Amr Elsharkawy
Muhammad Arslan Ansari
Jonas Winklmann
Xiaorang Guo
Salvatore Zammuto

Chair of Computer Architecture and Parallel Systems
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February 10th, 2026

About Us

Amr Elsharkawy
TUM, MQV,
BMW and LRZ

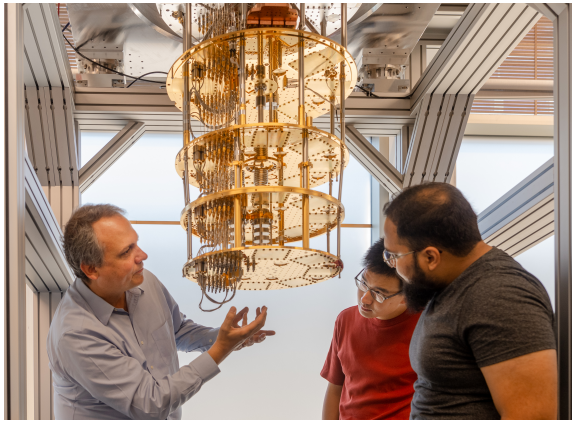
Muhammad
Arslan Ansari
TUM, MQV and
LRZ

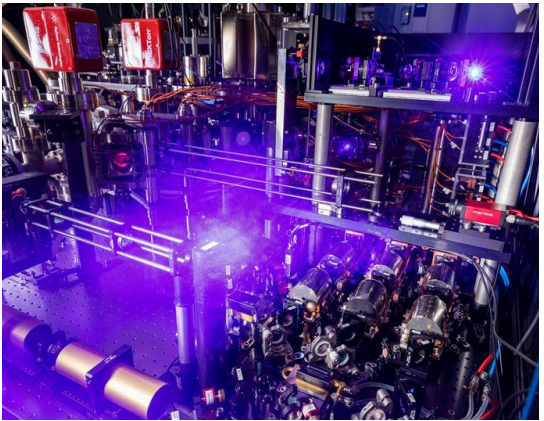
Jonas
Winklmann
TUM & MQV

Xiaorang Guo
TUM & MQV

Salvatore
Zammuto
TUM & MQV

What are we working on? What is MQV?

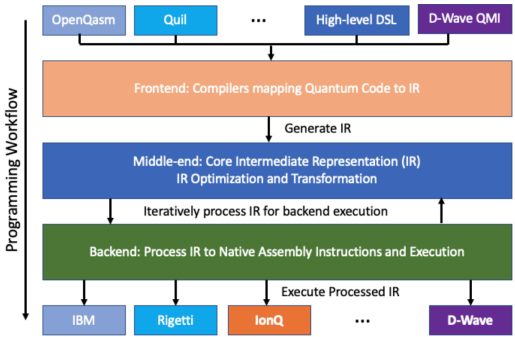


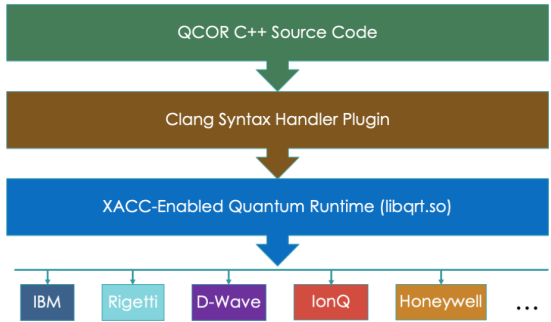


Topics Overview

- Quantum Computing and Modalities
- HPCQC compilation toolchain
- Quantum Compiler optimization
- Data Environment for Hybrid Workflows
- Deconvolution of neutral atom images
- Atom sorting algorithms
- Quantum control processor
  - Quantum ISA & Microarchitecture
  - ML for Fast Qubit Readout
  - Quantum Error Correction
- *... suggest your own topic!*

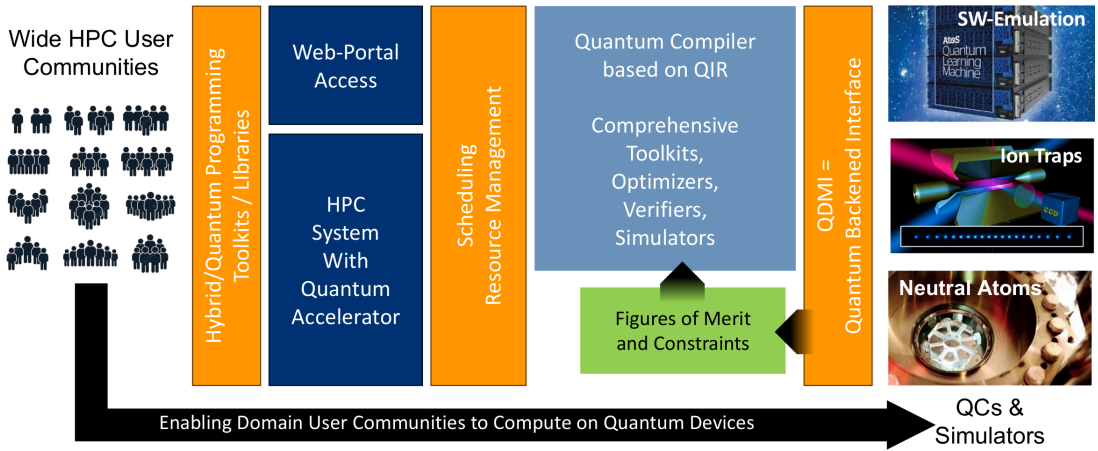
HPCQC Compilation Toolchain



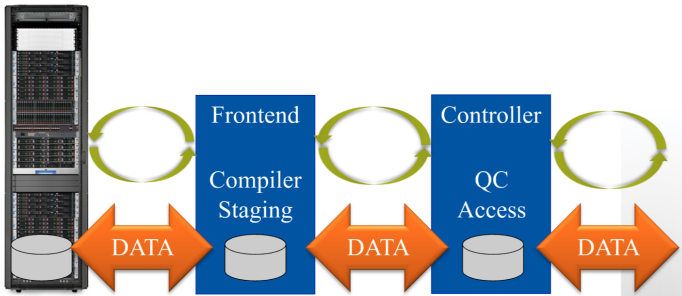


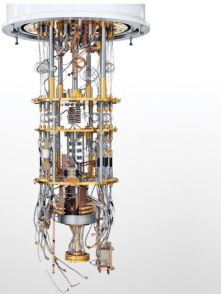
- [3]: XACC: a system-level software infrastructure for heterogeneous quantum–classical computing.
- [2]: Extending C++ for Heterogeneous Quantum-Classical Computing.

Quantum Compiler Optimization



Data Environment for Hybrid Workflows



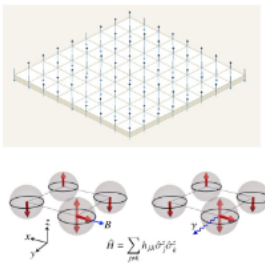


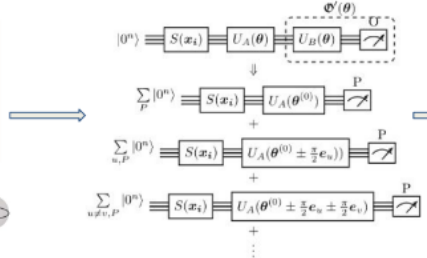
QuaST Kickoff Presentation

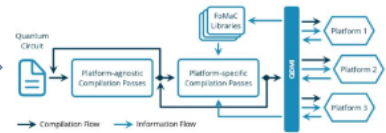
- How can problem be decomposed?
- What data needs to be transferred?
- Where can data be stored for next operation?

Algorithms-Stack Co-Design

- Near-term Hybrid Algorithms for Scientific Computing Tasks (e.g., quantum chemistry, condensed matter physics, optimization, etc.)
- Build and evaluate quantum-classical algorithms tailored to HPCQC

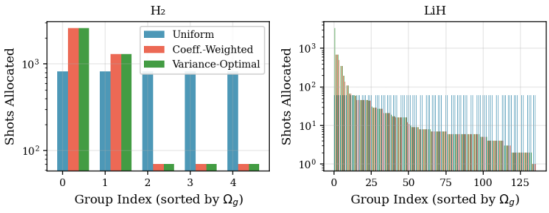


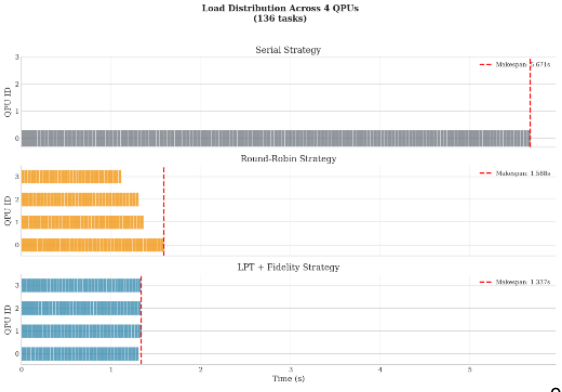




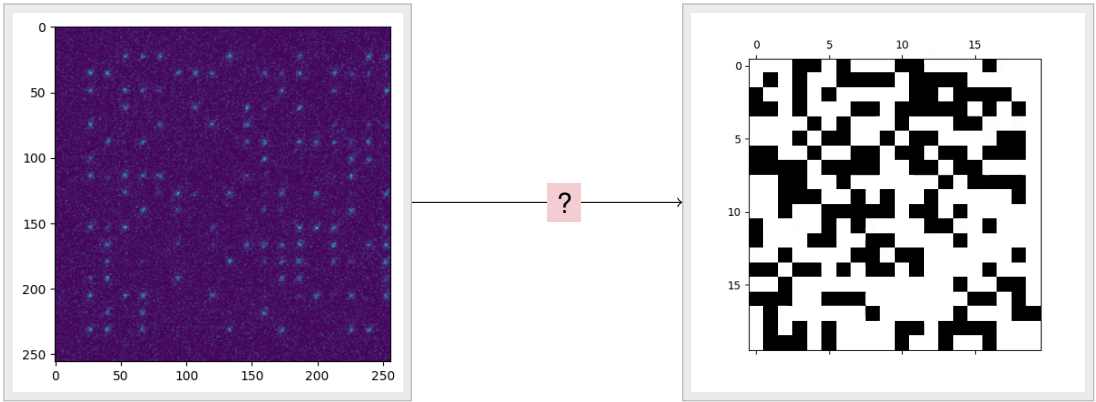
Algorithms-Stack Co-Design

- Co-design a software stack that supports tightly-coupled workflows across heterogeneous resources
- Management, Orchestration and Scheduling on HPCQC Systems



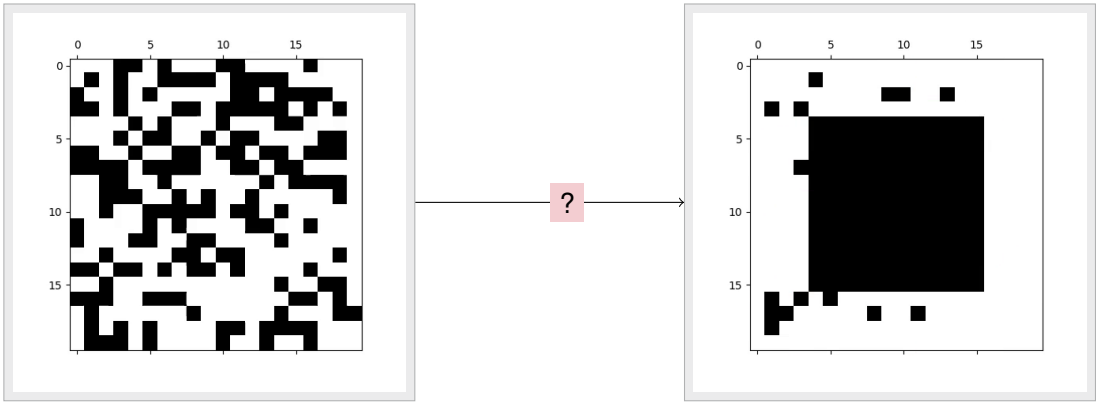


Deconvolution of Neutral Atom Images



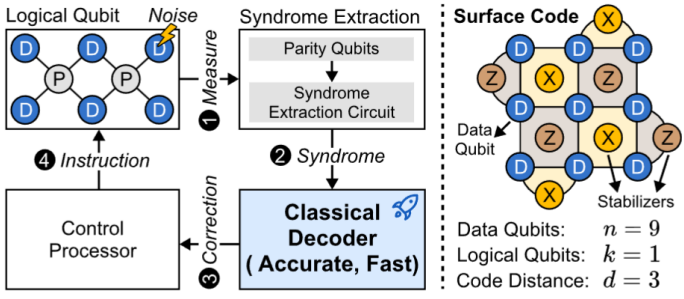
- [4]: Low-Entropy States of Neutral Atoms in Polarization-Synthesized Optical Lattices
- [5]: Single-Atom Resolved Fluorescence Imaging of an Atomic Mott Insulator

Atom Sorting Algorithms



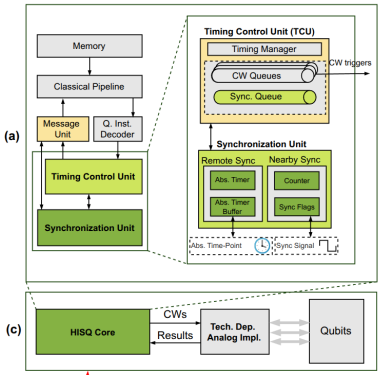
- [4]: Low-Entropy States of Neutral Atoms in Polarization-Synthesized Optical Lattices
- [1]: Quantum phases of matter on a 256-atom programmable quantum simulator

Quantum Error Correction



- Algorithm Development: Neural Network-Based, MWPM
- Vegapunk: https://doi.org/10.1145/3725843.3756084 (MICRO '25).

A Distributed Quantum Control Architecture



- System architecture for distributed control; synchronization principles; Microarchitecture development
- Distributed-HISQ : https://doi.org/10.1145/3725843.3756048 (MICRO ’25).

Organization

- Paper/prototype and talk, both mandatory (one fail = all fail), 1:1 grade weight.
- Implement and document a prototype or demonstration (if applicable).
- Reviewing at least two colleagues' papers gives you 0.3 bonus, warmly recommended!
- Bonus grade only if the review is accepted by the author.
- Talk should be 15 minutes + 10 minutes discussion.
- Use TUM paper template provided on Moodle
- Paper should have a length of 6 - 8 pages. Hard paper deadlines (23:59).
- You have to be present for all presentations (doctor's note necessary for absence)
- Information will be provided via Moodle

Deadlines

- Submit a draft (Release Candidate) 1 week before presentation, offering your paper for reviewing by your colleagues.
- Submit a short review/feedback for a colleague's paper up to the day after her presentation.
- Submit your final paper two weeks after your presentation.

Registration

- Via the matching tool (access the matching system: 12.02.2026 to 17.02.2026)
- Topic selection via Moodle
- Deadline for de-registration: 01.05.2026 (otherwise 5.0)

Schedule

- Tuesdays 14:00 - 16:00
- Room MI 01.06.020
- We only meet if a presentation is scheduled or individually if you want to.
- We will post the detailed presentation schedule on the Moodle page.

References I

S. Ebadi, T. T. Wang, H. Levine, A. Keesling, G. Semeghini, A. Omran, D. Bluvstein, R. Samajdar, H. Pichler, W. W. Ho, S. Choi, S. Sachdev, M. Greiner, V. Vuletić, and M. D. Lukin.
Quantum phases of matter on a 256-atom programmable quantum simulator.
Nature, 595 7866:227–232, 2020.

A. Mccaskey, T. Nguyen, A. Santana, D. Claudino, T. Kharazi, and H. Finkel.
Extending c++ for heterogeneous quantum-classical computing.
ACM Transactions on Quantum Computing, 2(2):1–36, 2021.

A. J. McCaskey, D. I. Lyakh, E. F. Dumitrescu, S. S. Powers, and T. S. Humble.
Xacc: a system-level software infrastructure for heterogeneous quantum–classical computing.
Quantum Science and Technology, 5(2):024002, 2020.

C. Robens, J. Zopes, W. Alt, S. Brakhane, D. Meschede, and A. Alberti.
Low-entropy states of neutral atoms in polarization-synthesized optical lattices.
Phys. Rev. Lett., 118:065302, Feb 2017.

References II

J. Sherson, C. Weitenberg, M. Endres, M. Cheneau, I. Bloch, and S. Kuhr.
Single-atom resolved fluorescence imaging of an atomic mott insulator.
Nature, 467:68–72, 09 2010.