Welcome to the Quantum Computation Reading Group at KAUST

A revolution is coming in computing – not a paradigm *shift*, but a *new* paradigm that will *complement* the classical computing infrastructure of today's science, society, technology, and economy. Quantum computing is not yet a practical, reliable, or cost-effective technology rivaling classical computing for many (if any) purposes, but it is already a tantalizing object of study – quantum hardware, quantum software, quantum algorithms, and their beneficial implications for the sustainable future of humanity.

Furthermore, no organization, company, or nation can afford to be without "quantum sovereignty." Q-day is coming when gate-based quantum processors boasting approximately 5000 logical qbits will apply Shor's algorithm to break RSA 2048 encryption, exposing communications that have not been migrated to post-quantum cryptography. Well before Q-day arrives, such quantum technologies (decryption and post-quantum encryption) will be embargoed. Those left on the outside will rue the years lost in getting ready and training the quantum workforce. Therefore, we at KAUST are getting started by gathering regularly to report on our readings of developments in quantum computing and to hear from vendors and early users.

This website carries our announcements and points to our online resources.

Our short-term goals
- Identify thrusts in the KAUST research mission that may benefit currently or in the future from quantum computation
- Place KAUST on the "on-ramp" for a significant thrust of the Economies of the Future RDIA pillar, which is likely to become a Saudi national initiative in 2025
- Propose a "wish list" of speakers for visits to KAUST, potentially as a part of a workshop on quantum computation to be offered Kingdom-wide in 2025
- Prepare the KAUST community to make early use of quantum hardware acquired by NEOM (ORCA) and Aramco (Pasqal), as well as quantum computing systems available remotely for free or low-cost exploration in research clouds abroad
- Burst the hype bubble of quantum computing and come to a realistic appraisal of its evolving implications for advancing science and engineering

Our longer term prospects
- Spawn additional specialty groups, as appropriate, to go deeper into aspects of quantum computation relevant to particular areas but requiring more background in physics, mathematics, or computer science than the group has a whole possesses, such as quantum computing and materials discovery, quantum computing and optimization, quantum computing and machine learning, quantum computing and cybersecurity, etc.
- Arrive at a syllabus for a three-credit KAUST graduate course in quantum computation to be proposed first locally then, after refinement, on-line

- Evaluate the prospects of a quantum attached processor (quantum processing unit, or QPU) for a classical computing system in the KAUST Supercomputing Laboratory, possibly Shaheen3

Some directions and content to be determined

- Participant-led presentations of research papers on quantum computation, such as the 435 papers describing the 65 algorithms in the Quantum Algorithm Zoo at https://quantumalgorithmzoo.org/
- Presentations from the major academic quantum computing research centers
- Presentations from the quantum software, hardware, and services vendor community, such as the 79 quantum computing companies listed at https://thequantuminsider.com/2023/12/29/quantum-computing-companies/
- Hands-on exercises using quantum frameworks such as (to name a few) cuQuantum, PennyLane, Qisket, Cirq, etc.

Prerequisites

- Willingness to confront the unknown and the mysterious and perhaps to be removed from familiar foundations
- Commitment to be patient with what may appear at times to be a too slow or a too fast pace for the group as a whole

Logistics

- Meet approximately every other week for an hour, with the possibility of joining by video conference

Suggested preparatory reading

- Olivier Ezratty, *Understanding Quantum Technologies*, 2023
- Alexander Dalzell et al., *Quantum Algorithms*, 2023
- Torsten Hoefler et al*., Disentangling Hype from Practicality: On Realistically Achieving Quantum Advantage,* 2023
- Hyperion, *4th Annual Global QC Market: Robust and on the Rise*, 2024
- World Economic Forum*, State of Quantum Computing: Building a Quantum Economy, 2022*
- Saudi Center for the Fourth Industrial Revolution*, Quantum Economy Project, First Workshop, 2024*

Courtesy of Dr. Samar Aseeri, who will co-organize the group, these readings are available at https://github.com/samaraseeri/project_downloads . They include descriptions of high-level Saudi expectations, a global market analysis, an assessment of the crossover point of classical to quantum advantage, an introduction to quantum computing technologies, and introductions to numerous topics from the quantum computing perspective in physics, chemistry, optimization, cryptanalysis, finance, and machine learning.

Registration
https://forms.gle/A3qSSnLgRRRHWVBA7

Not included
Besides quantum computation, the Quantum Information Sciences (QIS) include quantum sensing and quantum communication. These other two domains of QIS are significantly more mature than quantum computation. They have their own constituent communities at KAUST and it is likely that enquirers from these other areas can find intellectual resources and group meetings to consider joining already.

KAUST background
In October 2023, three commercial quantum computing companies ran orientation sessions at KAUST, in person or by teleconference, and several other such companies have recently expressed interest in helping to develop the KAUST quantum computing ecosystem. These sessions were well received, but probably failed to reach some interested members of the community. The Quantum Computation Reading Group (QCRG) will provide a nucleus for publicity of future such sessions.

KAUST's Shaheen-3 is a hardware platform that will be able to emulate up to an estimated 50 reliable qbits for quantum algorithm development.

Saudi background
Many quantum technologies, including quantum computing, are listed in the Saudi Arabia's Research, Development and Innovation Authority (RDIA) "Economies of the Future" Pillar.

Saudi Arabia is a member of the World Economic Forum's Quantum Economy Hub. According to https://www.weforum.org/agenda/2024/04/towards-saudi-blueprint-robust-quantum-economy/

> Saudi Arabia's Vision 2030 is a national strategic plan that aims to diversify the country's economy beyond oil and transform its society into a vibrant, ambitious society. While still in its early stages, the field of quantum technologies holds immense potential to contribute significantly to these ambitious goals.
>
> Quantum technologies and applications hold tremendous potential to revolutionize various sectors, such as finance and logistics, healthcare, Artificial Intelligence (AI), cybersecurity, and energy...

Contacts
Professor David Keyes, convenor
Dr. Samar Aseeri, co-convenor and facilitator