Quantum Computing Reading Group

Exploring Frontiers of Computation

April 30, 2025 | Samar Aseeri, KAUST

Why Quantum, Why Now?

"Quantum computing is no longer a distant dream. Universities, researchers, and innovators are actively shaping the quantum future."

Top Quantum Research Universities (Papers per student 📈):

1️⃣ Stanford University – 571 papers (0.0357 per student)
2️⃣ Duke University – 474 papers (0.0296 per student)
3️⃣ Yale University – 347 papers (0.0267 per student)
4️⃣ University of Oxford – 496 papers (0.0207 per student)
5️⃣ Harvard University – 1,266 papers (0.0171 per student)
6️⃣ Fudan University – 531 papers (0.0171 per student)
7️⃣ Shanghai Jiao Tong University – 640 papers (0.0160 per student)
8️⃣ Seoul National University – 457 papers (0.0163 per student)
9️⃣ University of Cambridge – 376 papers (0.0157 per student)
🔟 University of Chicago – 263 papers (0.0146 per student)

Data Source: https://thequantuminsider.com/2025/03/26/top-universities-for-quantum-research-2025/

The Goal of This Reading Group

- 🔍 Build a foundational and critical understanding of quantum computing
- 💬 Engage in discussions grounded in science—not hype
- 🤝 Create a collaborative learning space
- 📚 Read, reflect, and decode cutting-edge research together

Grounding Ourselves — Classical vs Quantum

- Quantum is not universally faster — it's problem-specific
- Algorithms like Shor’s and Grover’s show quantum advantage
- We're still in early days: real-world, scalable quantum machines are in progress

Key Differences

Aspect	Classical Computing Algorithms	Quantum Computing Algorithms
Basic Unit	Bits (0 or 1)	Qubits (can be 0, 1, or a superposition of both)
State Representation	Deterministic (either 0 or 1 at any time)	Probabilistic (can exist in a superposition of states)
Parallelism	Sequential processing (limited parallelism)	Quantum parallelism (can process multiple states simultaneously)
Speed	Polynomial time for many problems (e.g., O(n^2), O(n log n))	Exponential speedup for specific problems (e.g., Shor's algorithm for factoring)
Error Correction	Reliable with classical error correction	Requires quantum error correction (more complex due to decoherence and noise)
Algorithm Design	Based on logic gates (AND, OR, NOT, etc.)	Based on quantum gates (Hadamard, CNOT, Pauli-X, etc.)
Problem Suitability	Best for deterministic and structured problems	Best for problems involving large search spaces, optimization, and factorization
Examples	Sorting algorithms (QuickSort), graph algorithms (Dijkstra's)	Shor's algorithm (factoring), Grover's algorithm (search)
Resource Usage	Requires more memory and time for large-scale problems	Can solve certain problems with exponentially fewer resources
Decoherence	Not applicable	Major challenge (qubits lose coherence over time, requiring error correction)
Hardware	Silicon-based transistors	Quantum systems (e.g., superconducting qubits, trapped ions, photonic qubits)
Scalability	Easier to scale with current technology	Challenging due to qubit stability and error rates
Applications	General-purpose computing, databases, traditional AI	Cryptography, quantum simulations, optimization, machine learning

Quantum Myths — Let’s Bust Them!

❌ “Quantum computers are faster at everything”
✅ Only for certain problems like optimization or cryptography

❌ “Quantum will replace classical”
✅ It’s a complement, not a replacement

❌ “Qubits are magical”
✅ They obey real, though non-intuitive, scientific principles

What’s Coming Up in This Series

- 📘 Upcoming topics: Quantum algorithms, hardware, real-world use cases
- 🛠️ Hands-on: Toolkits like Qiskit, Cirq, and simulators
- 📡 Community: Invited speakers, open Q&A, and group-led mini-presentations

Final Thoughts for Today

- Keep an open, questioning mindset
- It’s okay to not understand everything right away
- This space is for exploration, not perfection
- Stay curious about quantum computing

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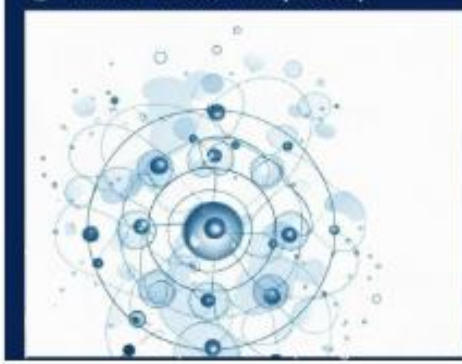

Key Highligkts:

- ✓ Hybrid Quantum-Classical Workflows
- ✓ Multi-language Quantum SDKs (Python, Julia, C++, Rust, etc.)
- ✓ Photonic Quantum Computers up to 1000 Qubits
- ✓ Accessible Quantum Solutions for Research and Industry

→ **Registration:** https://qcrg.kaust.edu.sa
Contact: David.keyes@kaust.edu.sa
(Hosted by KAUST Quantum Computing Reading Group)

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