



THE UNIVERSITY of EDINBURGH
informatics

Introduction to Quantum Computing

Lecture 1: Introduction and Logistics

Raul Garcia-Patron Sanchez and Petros Wallden



THE UNIVERSITY of EDINBURGH
INFORMATICS FORUM

Contacts

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- Milos Prokop (TA)
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- Discussions and Questions on **Piazza Forum**

Structure of the course

- Lectures
 - Week 1 to 11, with a break on week 4
 - Tuesday 11 am @ AT 2.12
 - Thursday 10 am @ AT 2.12
- Tutorial
 - Tutorial 0 on week 2
 - 8 tutorials in total: weeks 3 to 11, except week 5
 - Monday 14:10-15 @ AT 2.07 Milos Prokop
 - Monday 13:10-14 @ AT 2.05 Marine Demarty
- Q&A after any lecture

Assessment

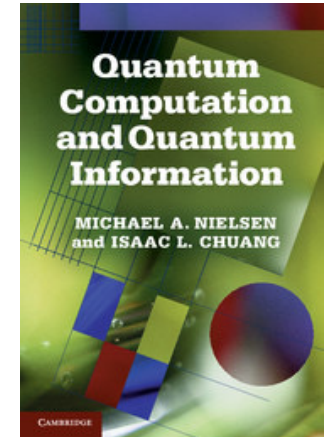
- Coursework 25%
 - One assignment released week 8 - 8th November
 - Due Wednesday 22rd November 12:00 (week 10)

- Exam 75%
 - December
 - Revision session on week 11.

Syllabus

- Intro to quantum mechanics and quantum circuits (5 lectures, Raul)
- Basic quantum algorithms (4 lectures, Raul)
- Quantum error correction (2 lectures, Raul)
- QFT and Phase-estimation (2 lectures, Raul)
- Near-term quantum algorithms (2 lectures, Petros)
- Measurement-based quantum computation (3 lectures, Petros)

- Quantum Computation and Quantum Information"
by Michael A. Nielsen & Isaac L. Chuang
- Quantum Computing Lecture Notes
by Ronald de Wolf
<https://arxiv.org/abs/1907.09415>
- Introduction to Quantum Computation
Sevag Gharibian
[Lectures notes link](#)



Store, process and communicate information exploiting the laws of quantum mechanics

Computation



Cyber Security



Quantum Cyber Security
INFR11187 during S2
Petros Wallden (CO) and Mina Doosti



Quantum Computing Ecosystem

The future of quantum computing is on the making right now!

QUANTUM COMPUTING MARKET MAP

Quantum Encryption



Q→NU
EYE
IDQ
TAQBit
MagiQ
Quintessence Labs

Hardware



Optalysys qutools
rigetti AQT TURING
IONQ qci D:wave

Tractics

Software

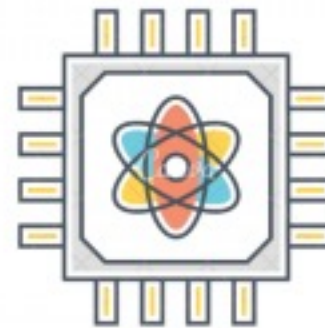


q|b STRANGE WORKS IQBit
QBITLOGIC QBranch QuSoft
Q-CTRL Artiste-qb.net

Building Quantum Computers



TURING qci
Optalysys IONQ rigetti
D:wave QILIMANJARO



Quantum AI



QBITLOGIC CQC
QINDOM XANADU

Optical Quantum Computers



PSIQ QD LASER QUANDELA
SINGLE QUANTUM Quantum Opus SPARROW QUANTUM

Quantum Cloud Computing



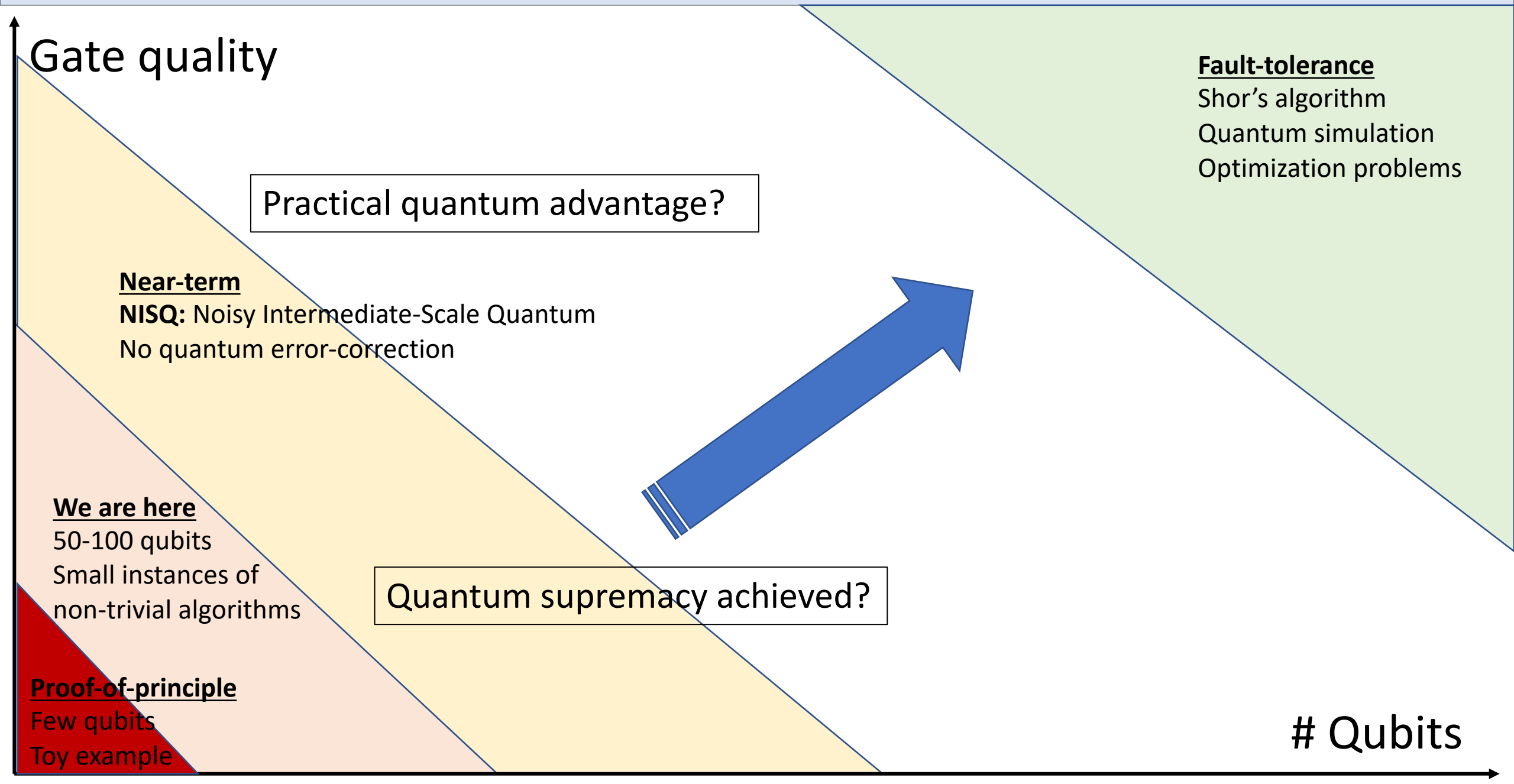
IONQ Q-CTRL
rigetti D:wave QCWARE

Quantum Circuits



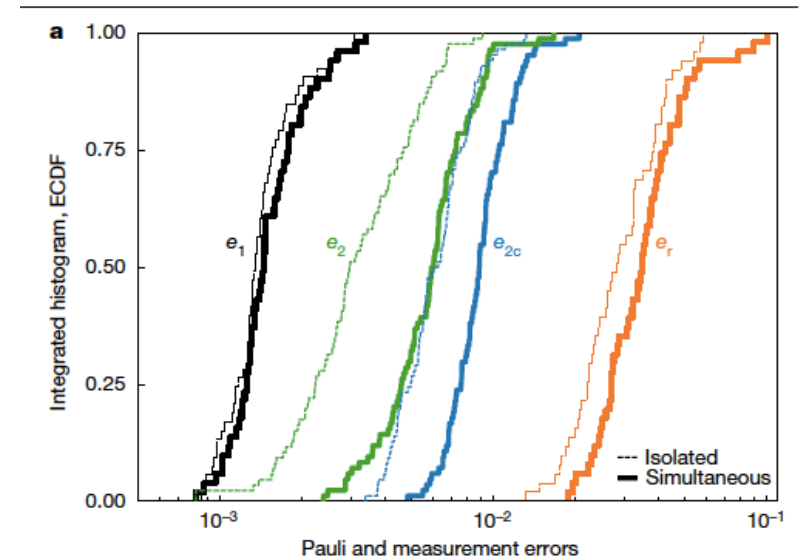
BraneCell QuTel, Inc
SILICON QUANTUM COMPUTING qci

The prospects of quantum computation



Where are we

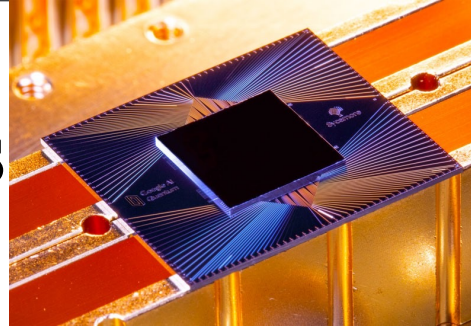
- 50 qubits
- Circuit depth ≈ 100 : 20 cycles of 5 gates
- Quality of gates
 - 1-qubit gate error: $1.6 \cdot 10^{-3}$
 - 2-qubit gate error: $6.2 \cdot 10^{-3}$
 - Measurement error: $3.8 \cdot 10^{-2}$



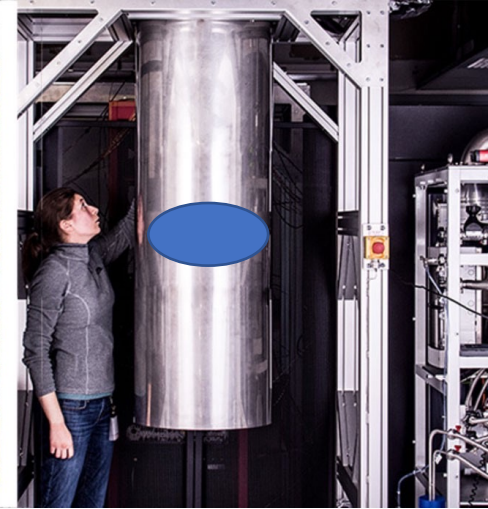
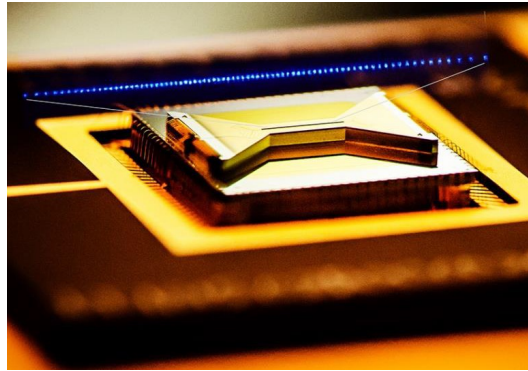
Average error	Isolated	Simultaneous
Single-qubit (e_1)	0.15%	0.16%
Two-qubit (e_2)	0.36%	0.62%
Two-qubit, cycle (e_{2c})	0.65%	0.93%
Readout (e_r)	3.1%	3.8%

Hardware architectures

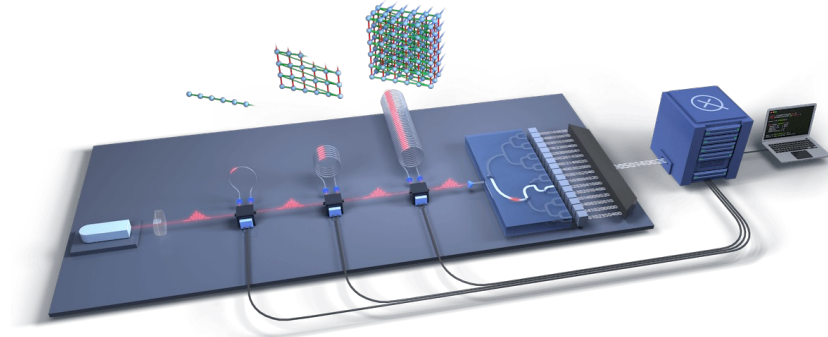
- Superconducting circuits



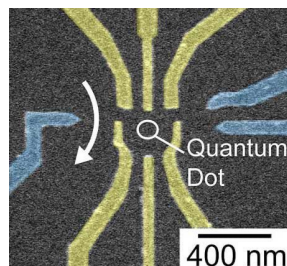
- Ion Traps



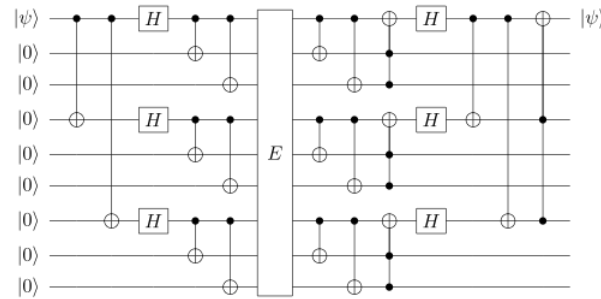
- Photonics



- Quantum dots

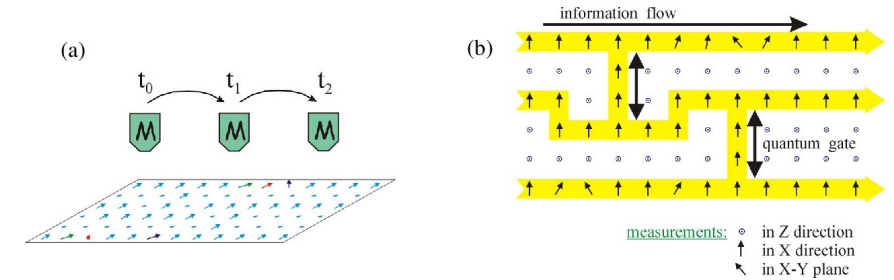


Models of Quantum Computation

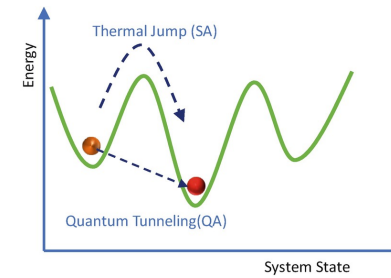


- Quantum Circuits

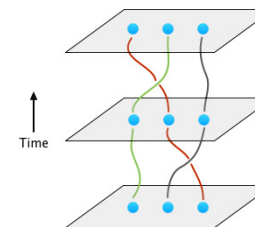
- Measurement-based Quantum Computation



- Adiabatic Quantum Computation
Quantum annealers



- Topological Quantum Computation



News

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<https://quantumcomputingreport.com/>

<https://thequantumdaily.com/>



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Publications

<https://scirate.com/>

Conferences

QIP, TQC

<https://qipconference.org/>

Workshops/schools/semesters

Simon's Institute for the Theory of Computation

<https://simons.berkeley.edu/>

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on social media

The screenshot shows the SciRate website interface. At the top, there is a navigation bar with the SciRate logo, a 'Home' link, a user profile for 'Raul Garcia-Patron', and a search bar. The main content area is divided into a left sidebar and a main feed. The sidebar contains a 'My feeds' section with various categories like 'Computational Complexity', 'Data Structures and Algorithms', etc., and an 'arXiv.org' section with categories like 'Astrophysics', 'Condensed Matter', etc. The main feed displays two articles. The first article is 'Information-theoretic bounds on quantum advantage in machine learning' by Hsin-Yuan Huang, Richard Kueng, and John Preskill, dated Jan 08 2021. It has a 'Scited' button with 156 counts and a PDF icon. The second article is 'Fault-Tolerant Operation of a Quantum Error-Correction Code' by Laird Egan, Dripto M. Debroy, Crystal Noel, Andrew Risinger, Daiwei Zhu, Debopriyo Biswas, Michael Newman, Muyuan Li, Kenneth R. Brown, Marko Cetina, and Christopher Monroe, dated Sep 25 2020. It also has a 'Scite!' button with 153 counts and a PDF icon. On the right side of the feed, there is a 'Date Published' filter set to 'Jun 08 2020 — Jun 07 2021 UTC' and a 'Recent comments' section with a comment about 'Assessing Relational Quantum Mechanics'.

The ideal life of a qubit in a nutshell

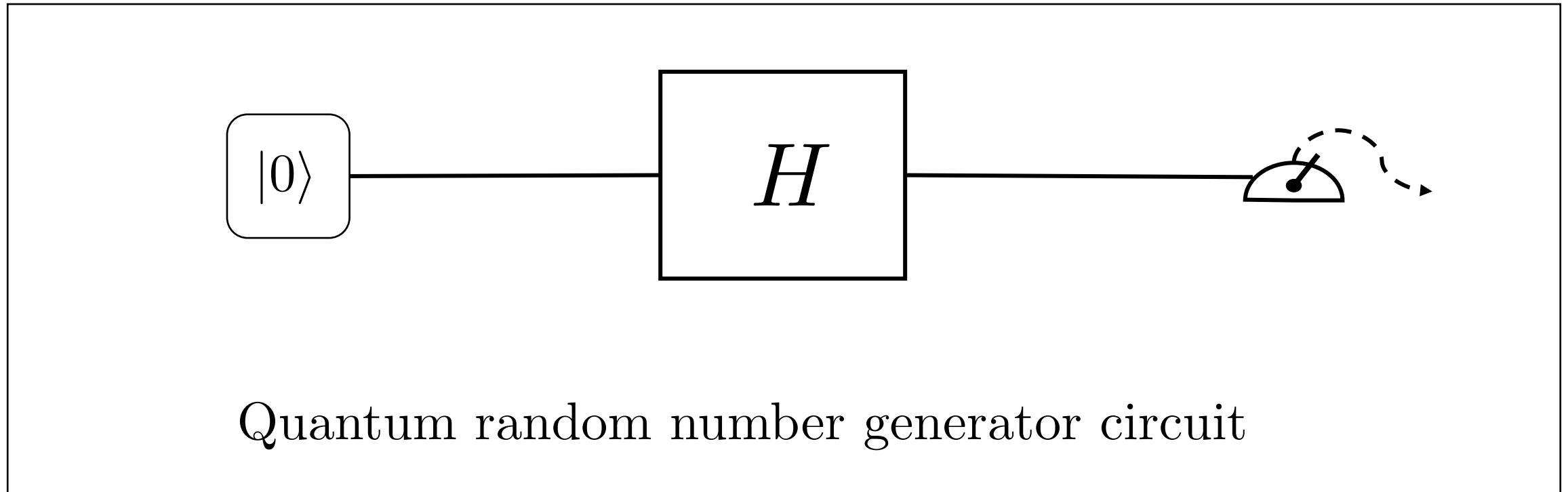
State preparation

Source of quantum states

Operation

Circuit/Gates

Measurement



References

- Additional references

- **Quantum compute architectures**

- *Quantum computers*, T. D. Ladd, F. Jelezko, R. Laflamme, Y. Nakamura, C. Monroe & J. L. O'Brien, *Nature* **464**, 45 (2010).

- **Popular Science books**

- *Logicomix: An Epic Search for Truth*, by Apostolos Doxiadis and Christos H. Papadimitriou, Bloomsbury Publishing (2009).
- *The Golden Ticket, P, NP, and the search for the impossible*, Lance Fortnow, Princeton University Press (2013).
- *Godel, Escher, Bach: An Eternal Golden Braid*, Douglas Hofstadter, Basic Books (1999).
- *Quantum Computing for Babies*, Chris Ferrie, Sourcebooks Explore (2018).

