

Alice In Quantum Wonderland



Google says it has achieved 'quantum supremacy' with super computer that 'can complete TEN THOUSAND years' work in just three minutes'

- Google created a test to put its Sycamore quantum processor through its paces
- The device had to produce random numbers using a specific quantum circuit
- Simulating the same work on even the fastest supercomputer is challenging
- Quantum machines may one day revolutionise complex computer-based tasks
- Applications could run from seeking new medicines to city planning and beyond

By IAN RANDALL FOR MAILONLINE

UPDATED: 12:58 BST, 23 October 2019

Bitcoin could be in danger as quantum computing advances

Updated on: 25 July 2023 

QUANTUM PHYSICS

Quantum computers could break the internet. Here's how to save it

Scientists are figuring out how to send information securely in a future era of quantum hackers

Chinese Researchers Claim They Cracked Encryption With Quantum Computers

Skeptical technology experts believe the declaration is a hoax intended to cause panic.



By [Jason Nelson](#)

 Jan 6, 2023

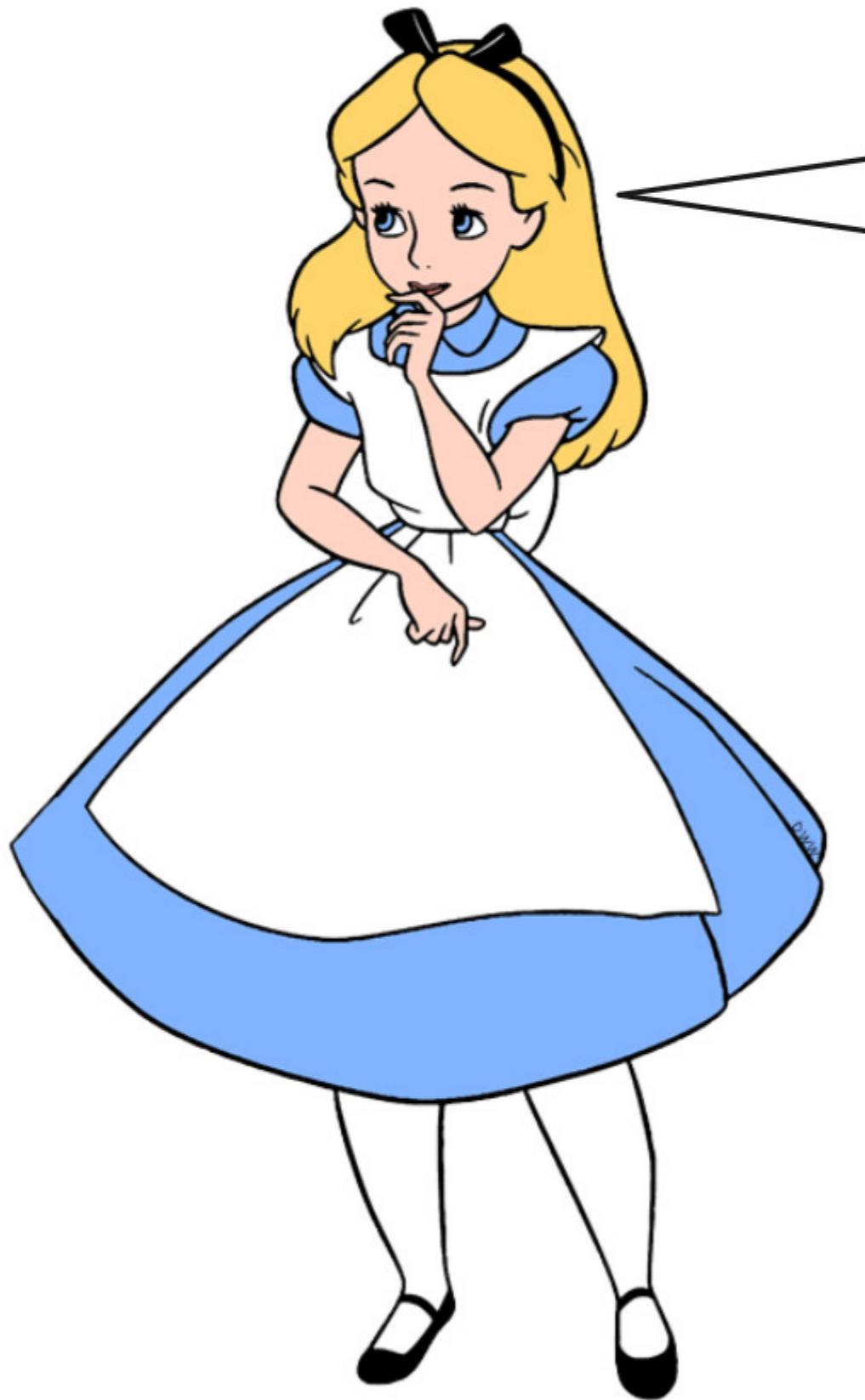
 5 min read

Think AI is scary now? Wait till it gets boosted by quantum computing

By [Alex Mitchell](#)

Published April 12, 2023

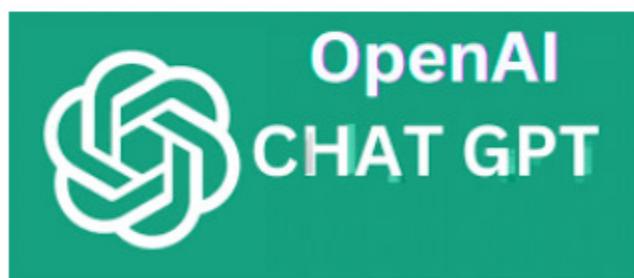
Updated April 12, 2023, 7:06 p.m. ET



**Is quantum
computing just
another buzzword, or
is it the real deal?**



yahoo!

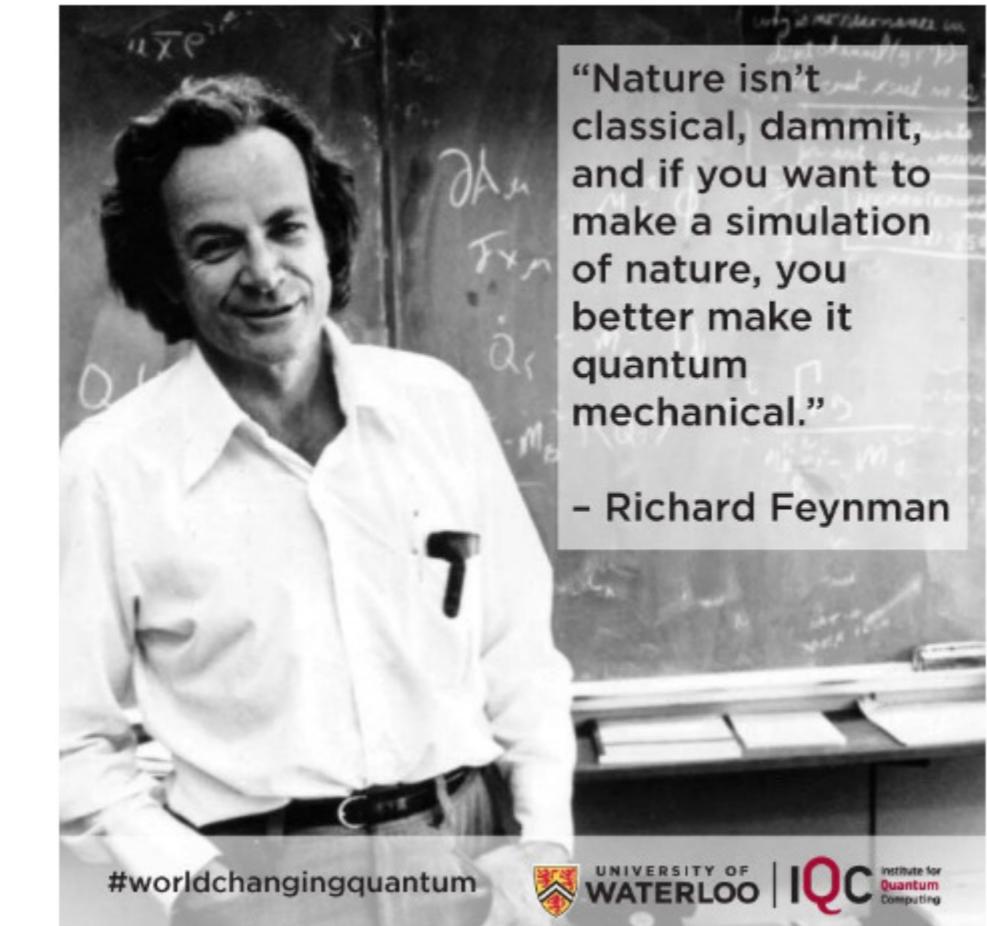
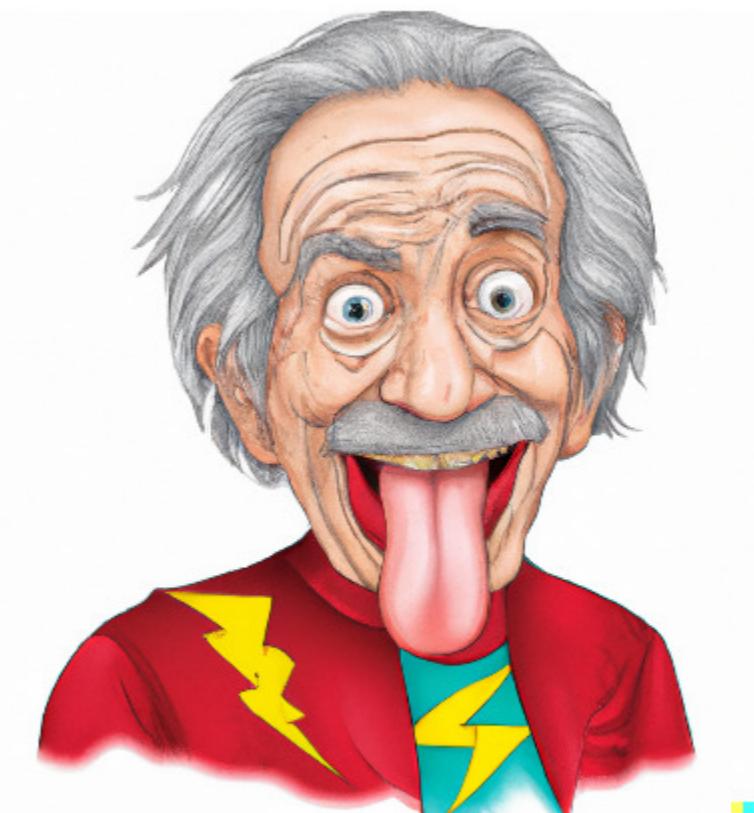
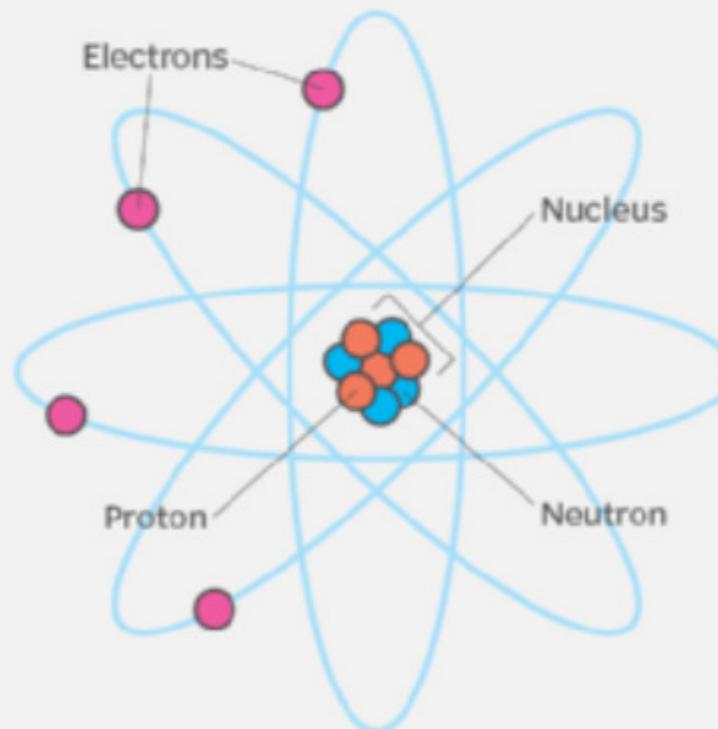


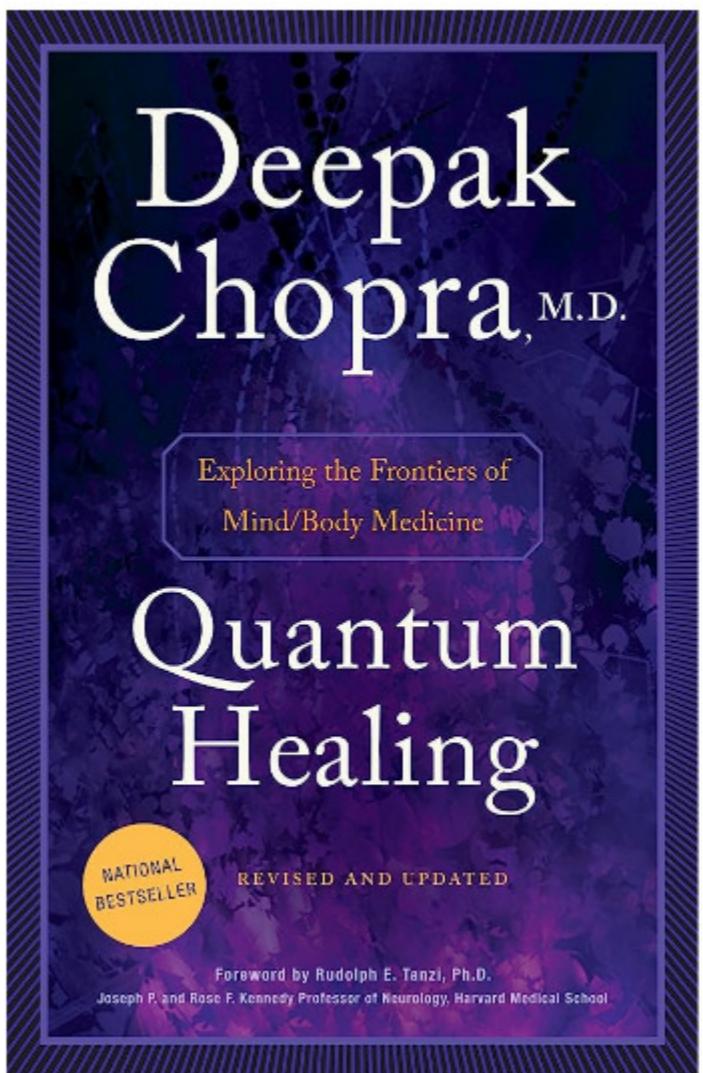
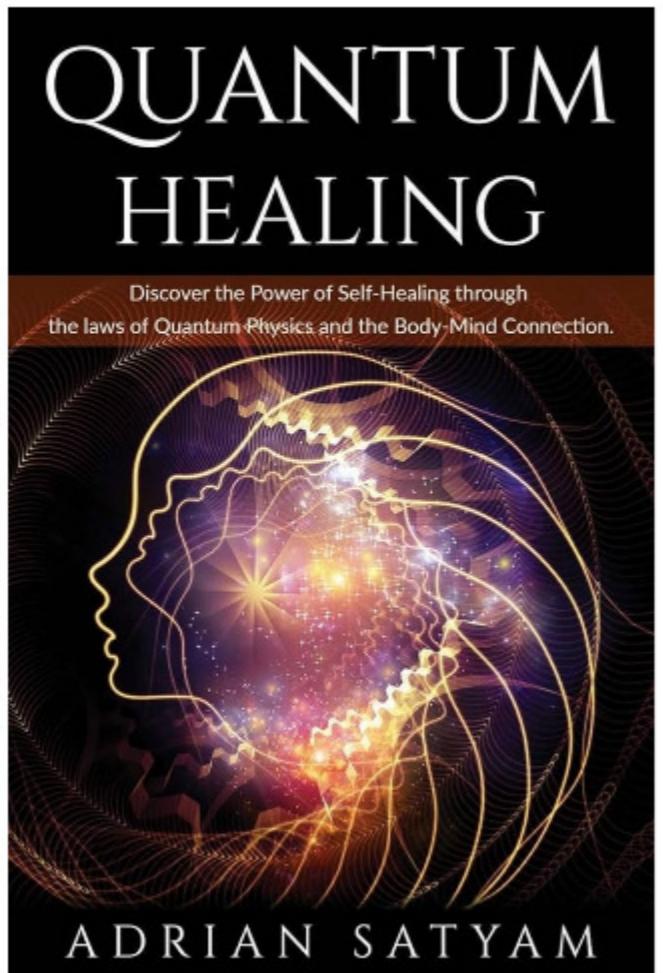
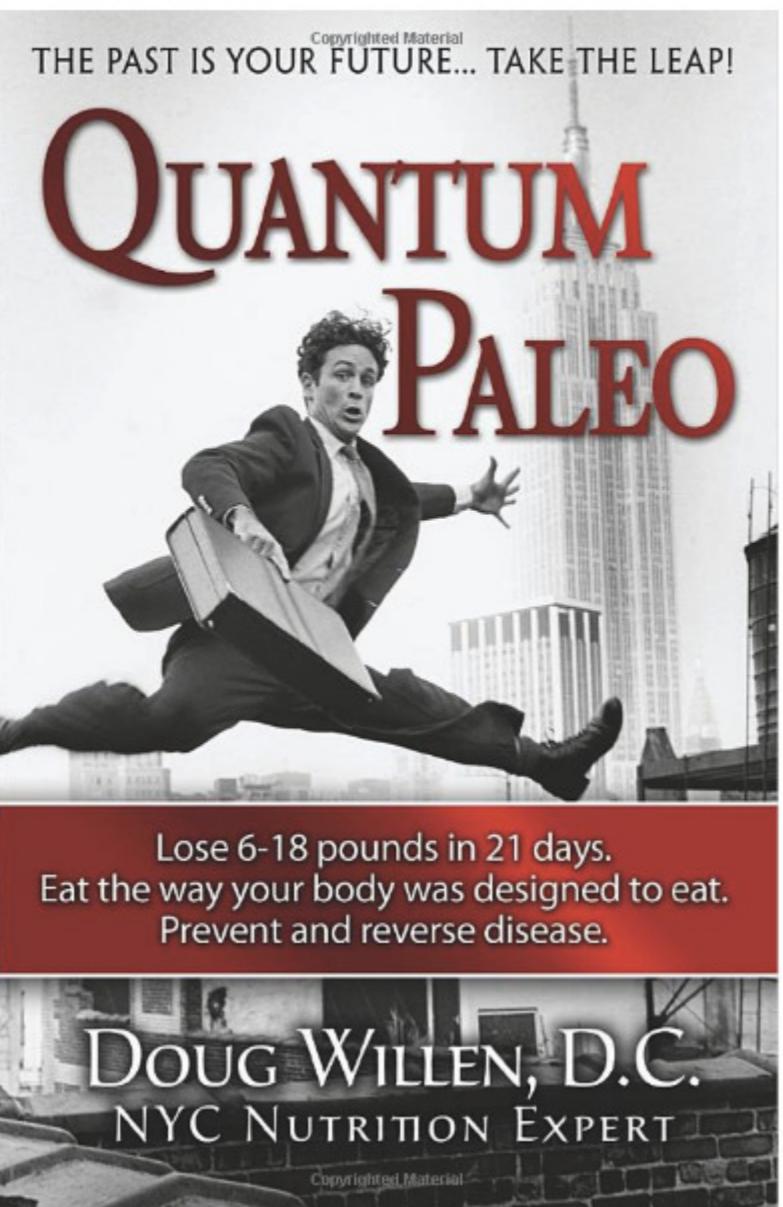
WIKIPEDIA
The Free Encyclopedia

Google



The structure of an atom





**Tragbares Hightech
mit messbaren Effekten auf Zellebene**

QiOne® 2 Pro

4.7 ★★★★☆

Mehr als 7.000 zufriedene Kunden

Erfahre jetzt die Vorteile der
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Zellebene

- 💡 Persönliches Wachstum
- ⚡ Schutz vor E-Smog & 5G
- 🌟 Gesteigerte Anbindung zum
Quantenfeld

✓ **Wirkung in Zellstudien bestätigt**

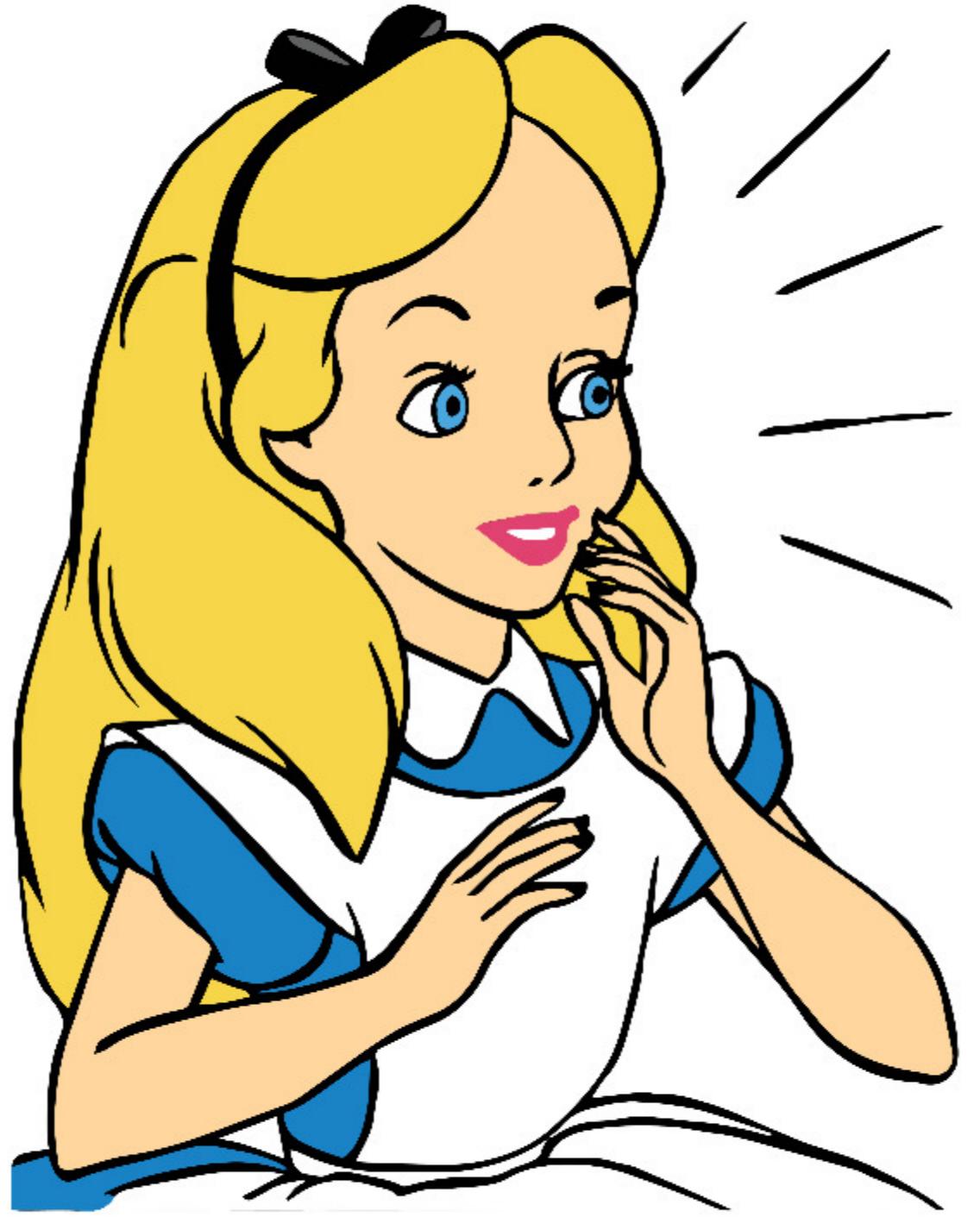
Vernetze jetzt **100 000 000 000**
000 Signale.

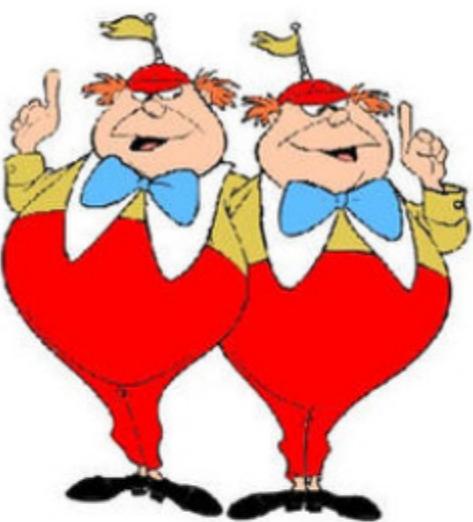
929,- € 999,- € **Angebot**

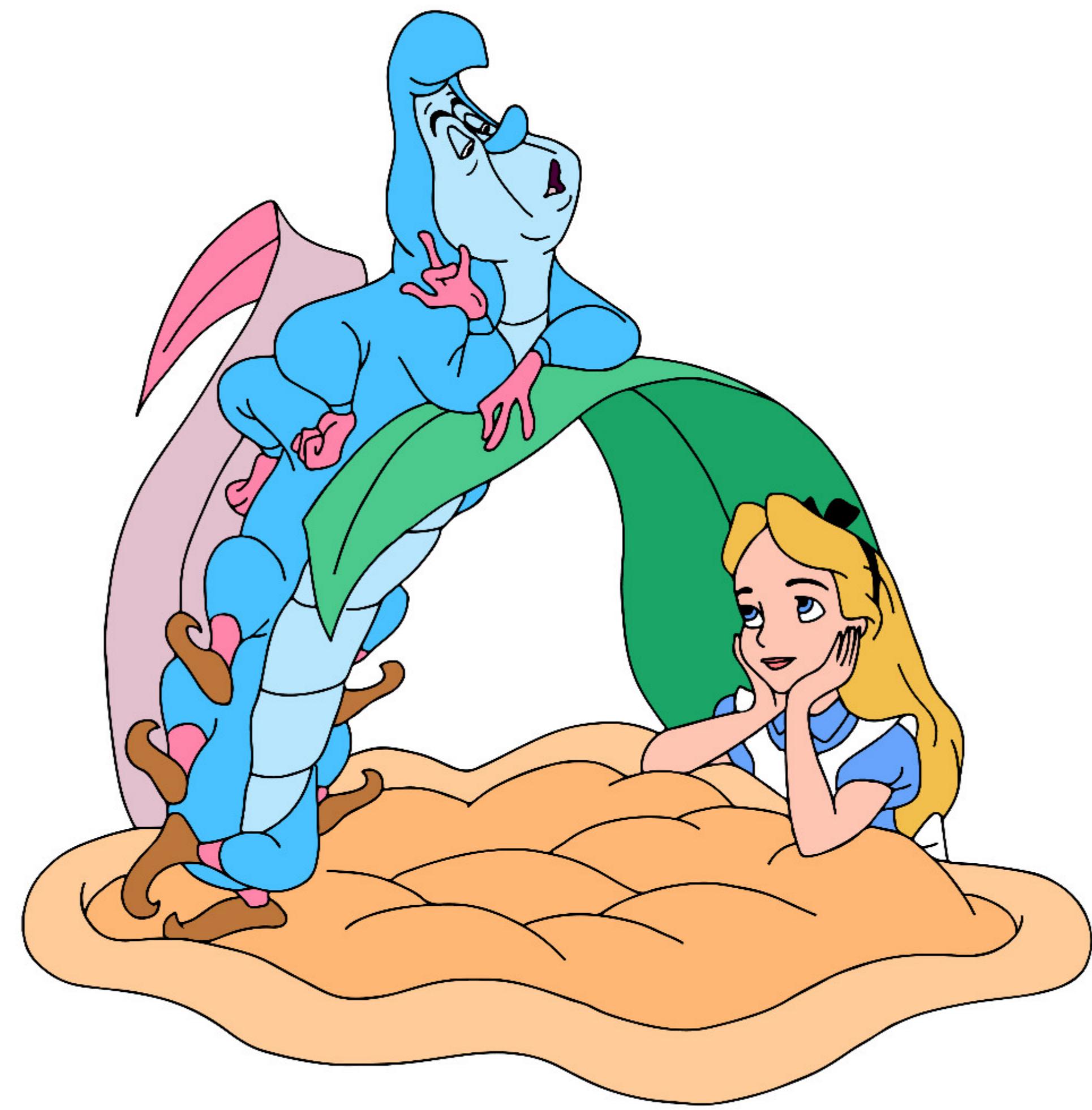
Finanzierung ab **75€/ Monat mit Klarna.** ⓘ











Quantum Falsehood 4



**Quantum computers
are the only
application of
quantum technology.**

Quantum technologies

Sensing

Enhanced precision and sensitivity

- Atomic clocks
- Magnetometers for cavity detection
- MRI for brain scanners
- Quantum gravity-sensors for GPS assistance

Communication

Secure communication

- Random number generator
- Quantum Teleportation aka Quantum Internet
- Key distribution

Computing

Solving specific problems

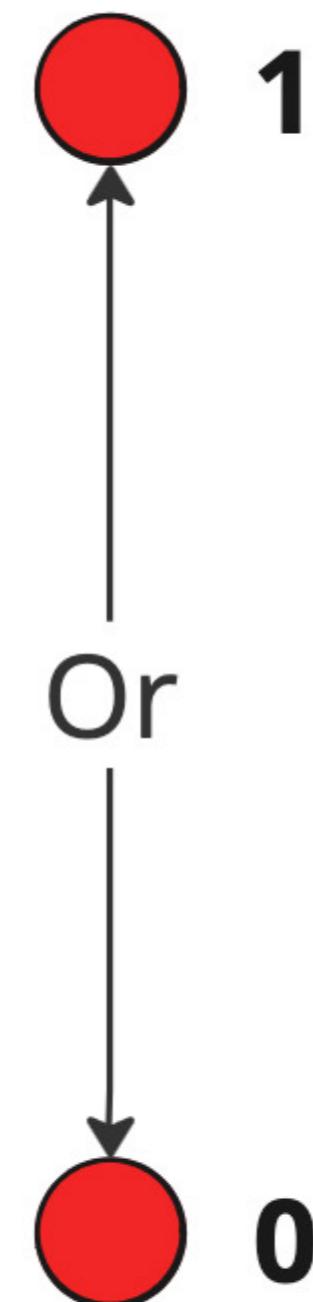
- Qubits
- solving optimization problems like logistics, delivery routes (TSP)
- quantum machine learning
- material science
- drug discovery



**Qubits are in state 0
and 1 at the same
time.**

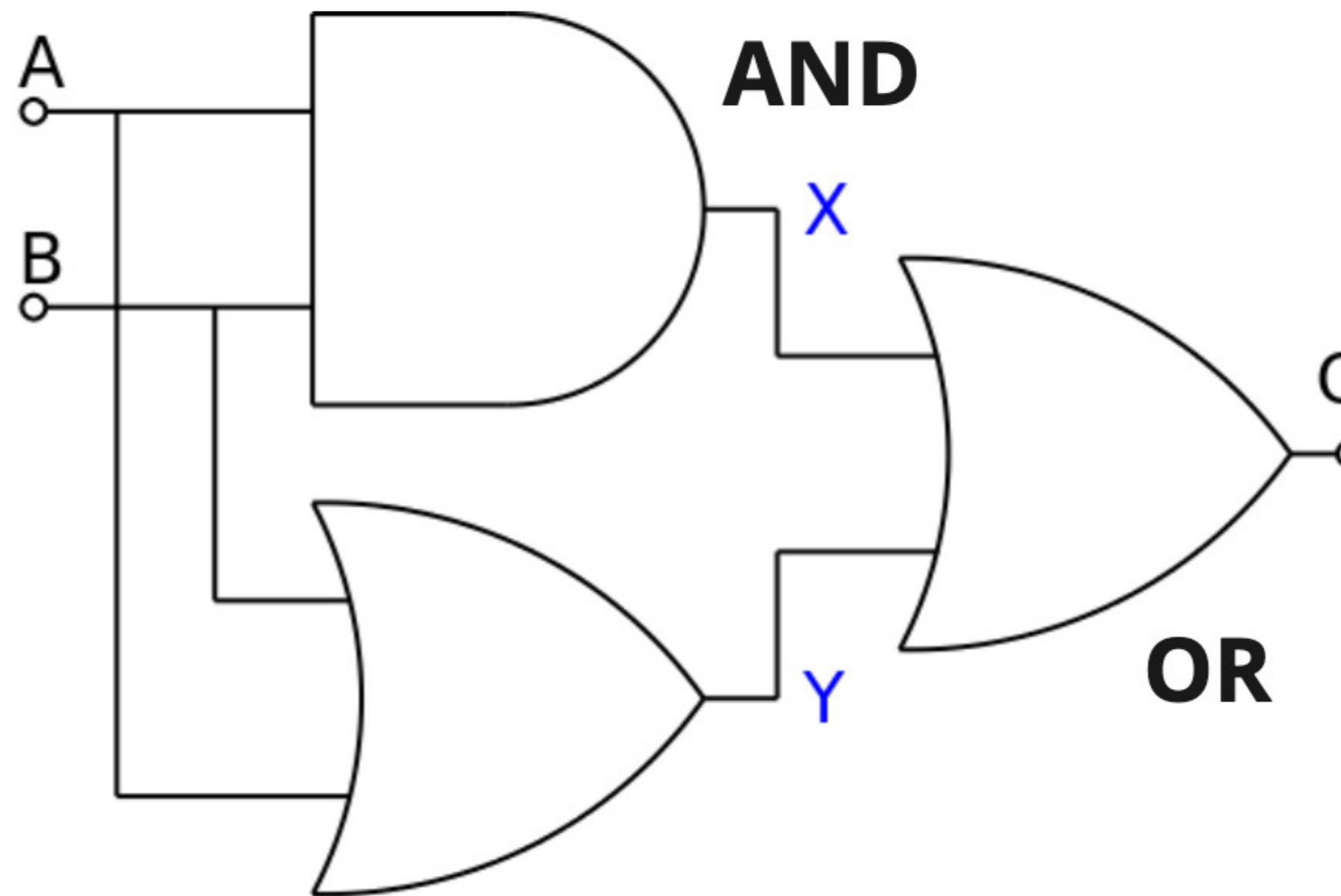
Classical Computing

- The fundamental unit of information is the "bit".
- All classical computation is modifying bit sequences.
 - 1-bit operations like *set* and *not*
 - 2-bit operations like *and*, *or*, *xor*



Classical Bit

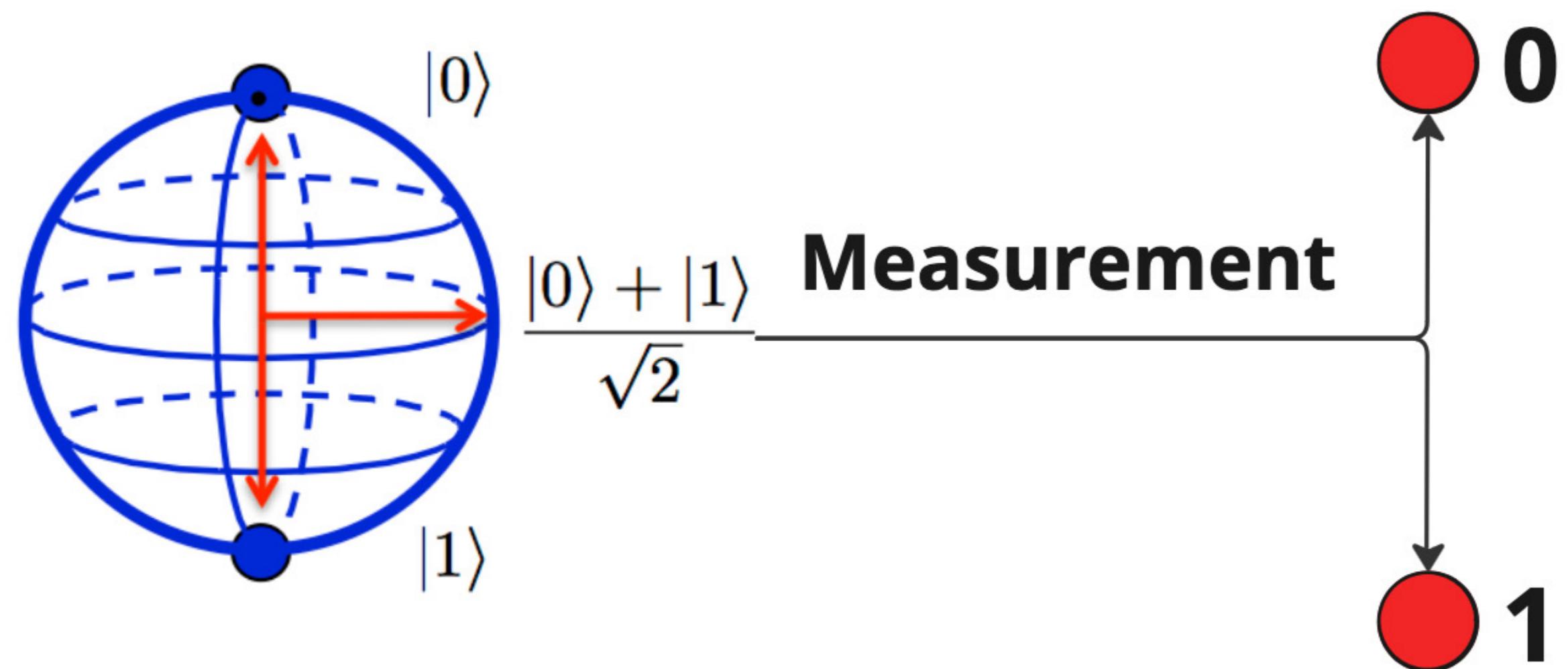
Classical Circuits



A	B	X	Y	Q
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	1

Quantum Computing

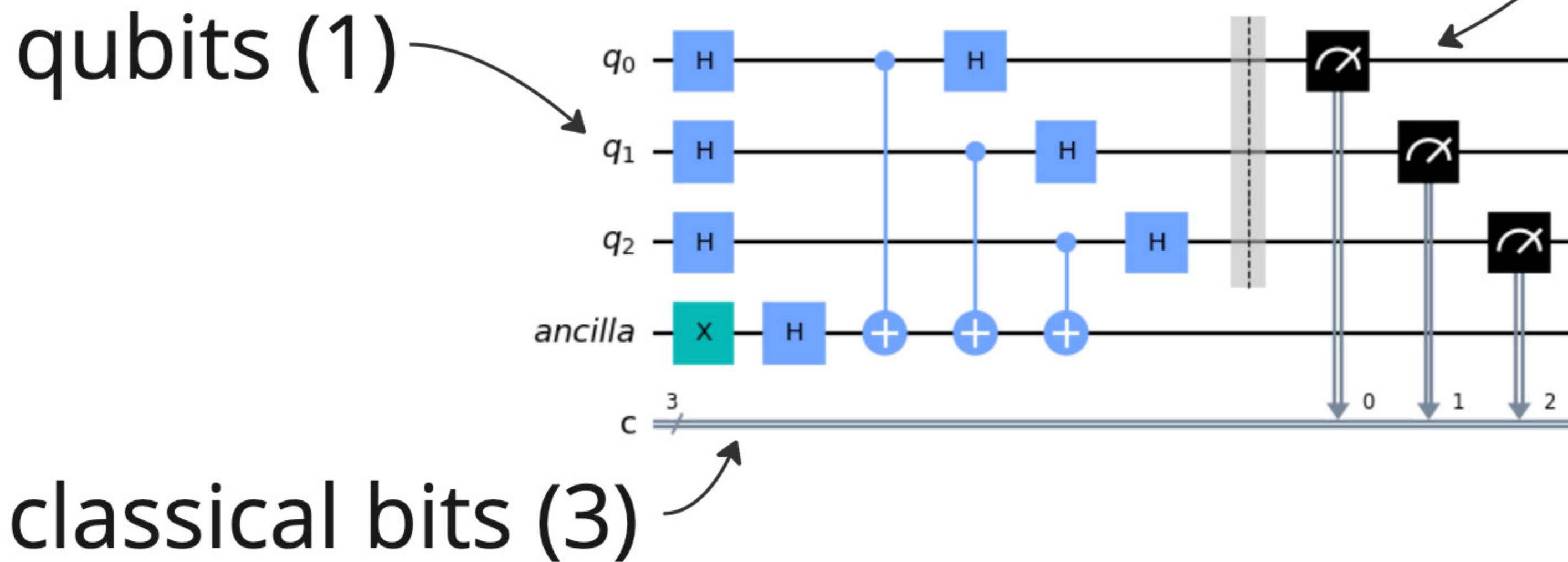
- The fundamental unit of information is the "qubit".
- Qubits are in a **superposition** of $a |0\rangle + b |1\rangle$
- Observing (**measuring**) a qubit turns it into a classical 0 or 1.



Quantum Circuits

- All computation is modifying qbit sequences aka "circuits"
- 1-qubit operations like "H", "X", "Y", and "Z"
- 2-qubit operations like "CNOT" or "SWAP"

measurement (2)



Number of Bits/Qubits

Bit

Qubit

n states per n bit

1	1	
2	2	
3	3	
4	4	
8	8	
16	16	

Number of Bits/Qubits

Bit

Qubit

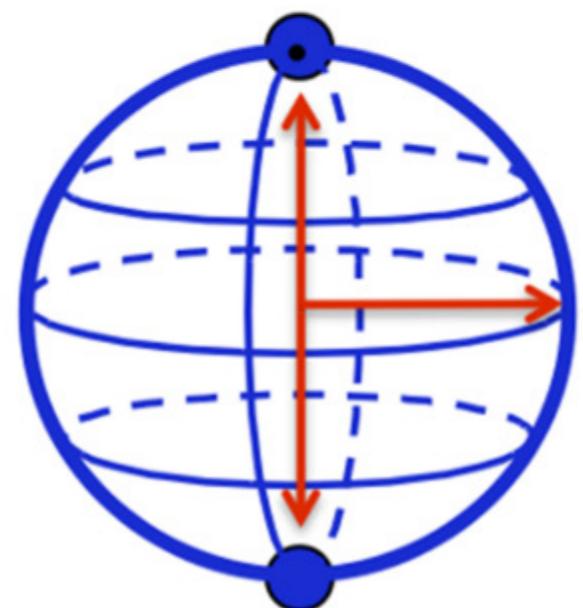
Number of Bits/Qubits	n states per n bit	2^n states per n qubits
1	1	2
2	2	4
3	3	8
4	4	16
8	8	256
16	16	65.536



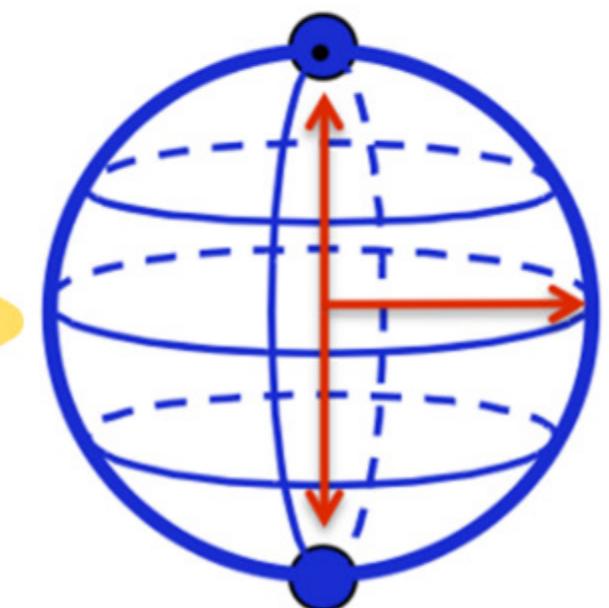
**With entangled
qubits you can
send information...**

**... faster than the
speed of light.**

Entanglement



Entanglement



Anika



Ben

Entangled particles communicate across long distances faster than the speed of light

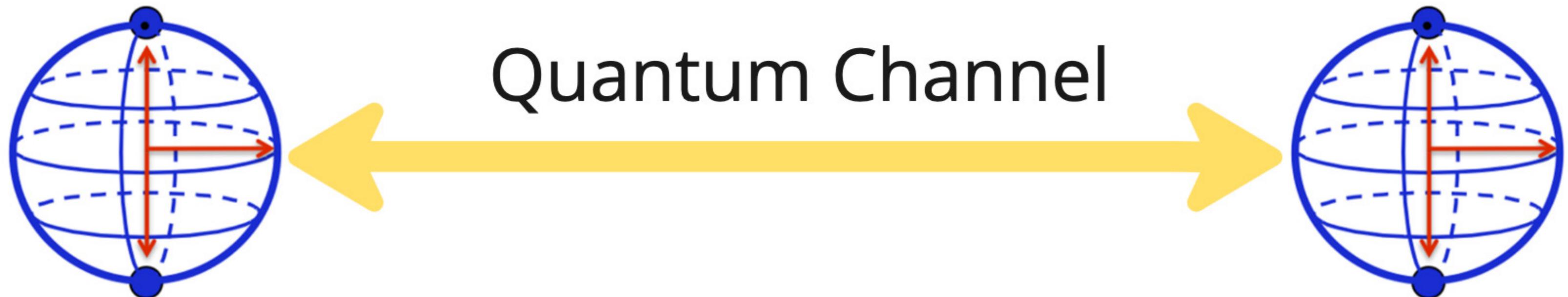
WANNA GET PIZZA?



YOU READ MY MIND



Entanglement

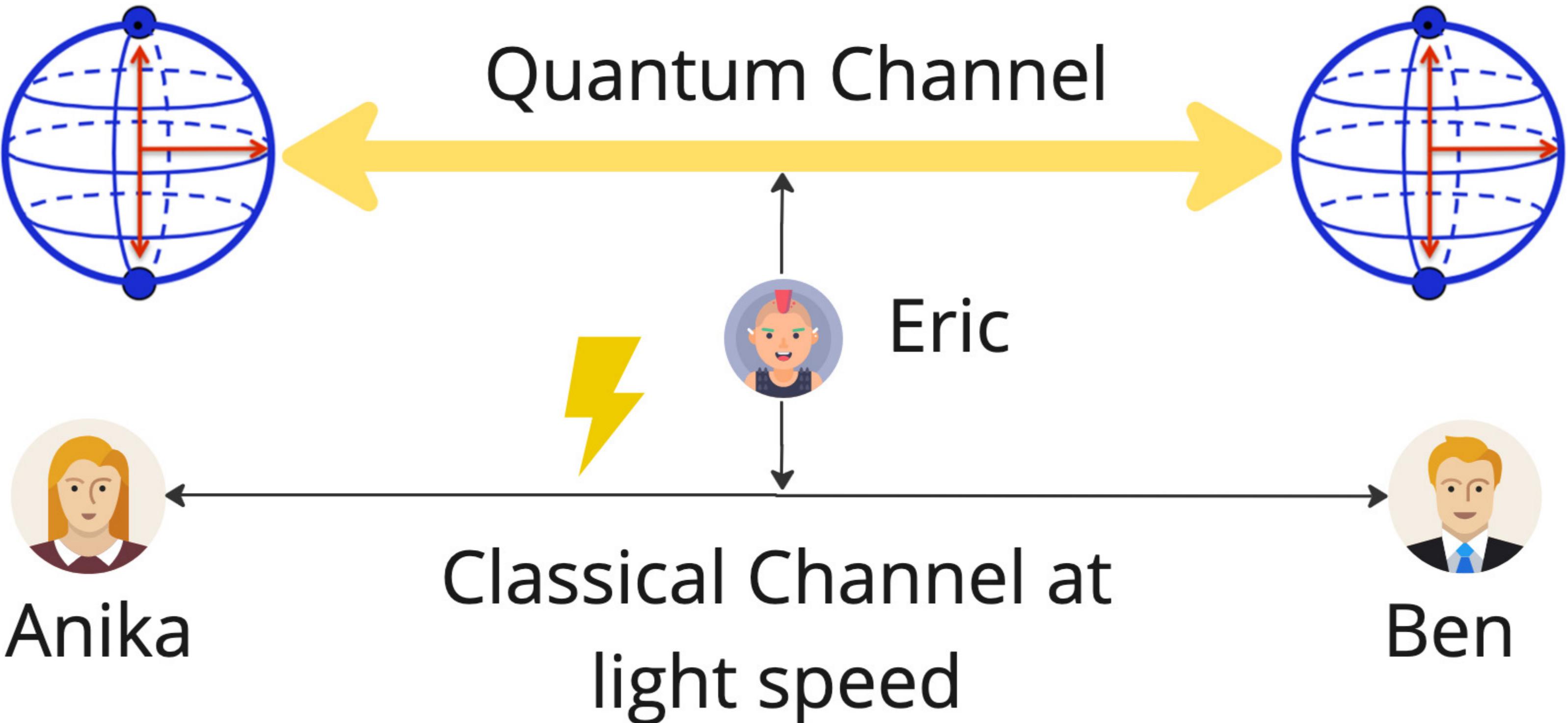


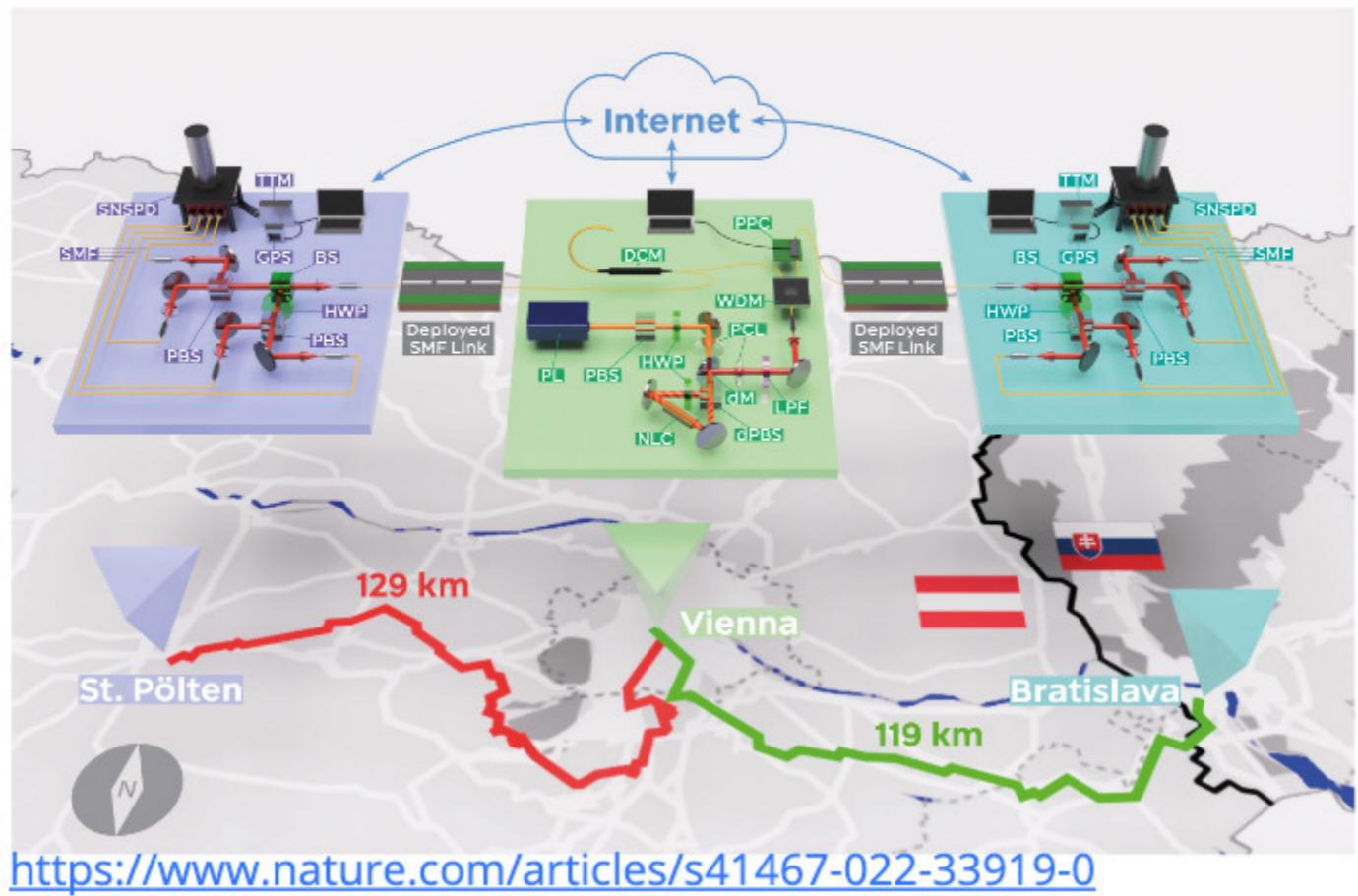
Anika

Classical Channel at
light speed

Ben

Quantum Key Distribution

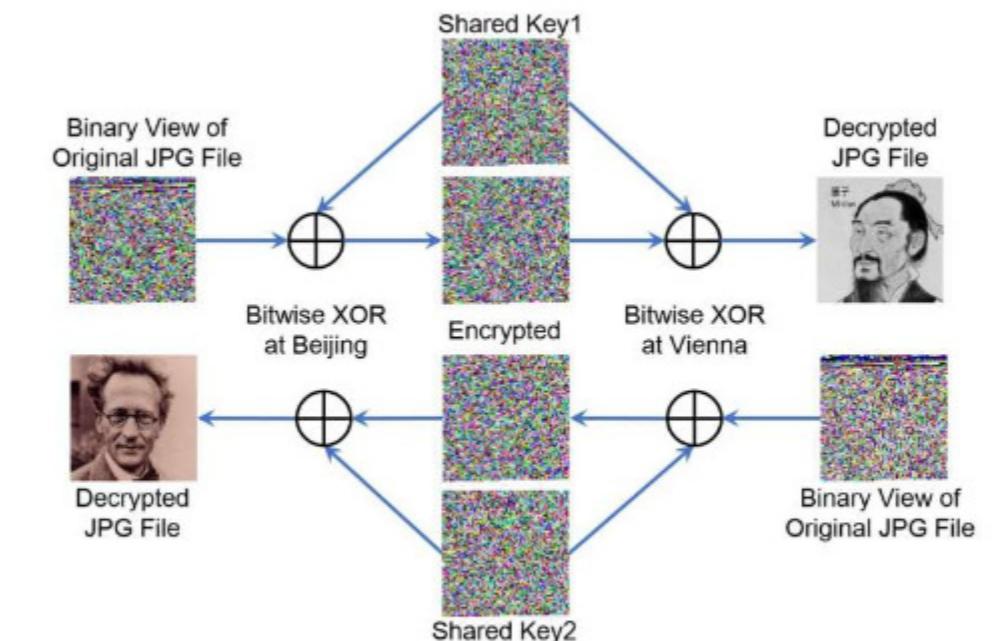




<https://www.nature.com/articles/s41467-022-33919-0>



<https://phys.org/news/2018-01-real-world-intercontinental-quantum-enabled-micius.html>

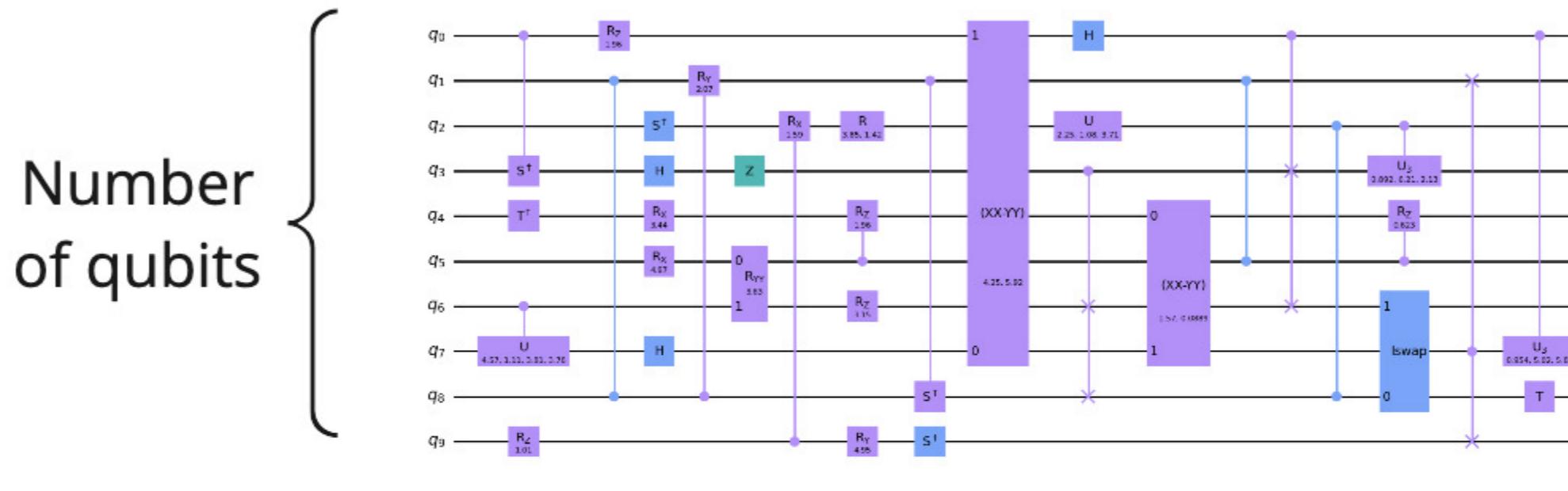


Quantum Falsehood 27



**Bigger quantum
computers with
more qubits is all you
need.**

Simple approach



**Performance =
number of qubits**



Quantum Volume

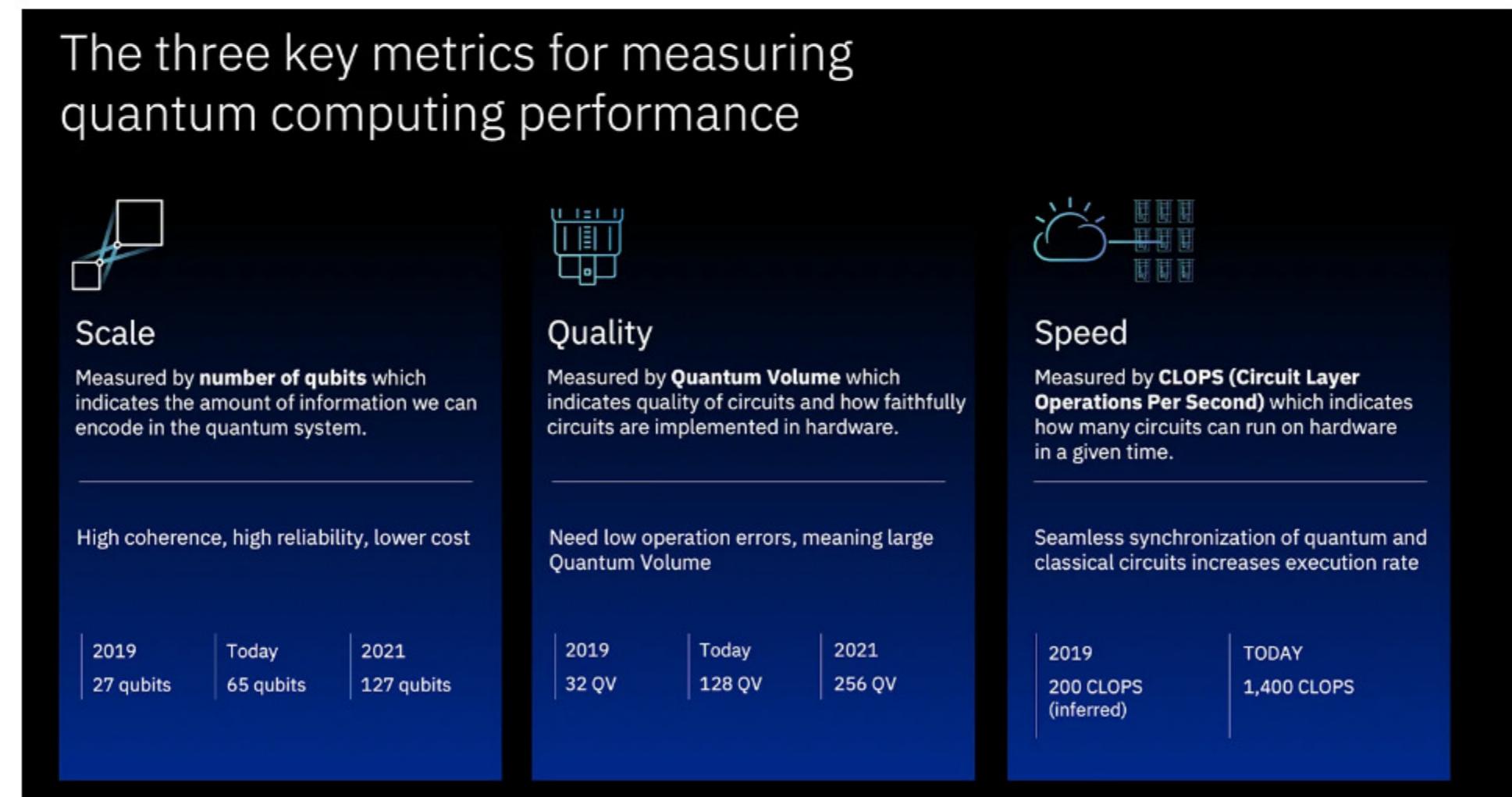
- Quantum Volume is a metric used to measure a quantum computer's power and complexity.
- crucial factors such as
 - qubit count,
 - qubit quality,
 - qubit interaction (connectivity), and
 - error rates

Achievement history [edit]

Date	Quantum volume ^[a]	Manufacturer	Notes
2023, February	$2^7 = 128$	Alpine Quantum Technologies	"Compact Ion-Trap Quantum Computing Demonstrator" (24 qubits) [25]
2023, February	$2^{15} = 32,768$	Quantinuum	"Quantinuum System Model H1-1" (20 qubits) [26]
2023, May	$2^{16} = 65,536$	Quantinuum	"Quantinuum System Model H2" (32 qubits) [27]
2023, June	$2^{19} = 524,288$	Quantinuum	"Quantinuum System Model H1-1" (20 qubits) [1]

CLOPS

- Circuit Layer Operations Per Second by IBM
- Machine dependent
- Considers Scale, Quality & Speed of the machine
- Speed...
 - Repetition rate of QPU
 - Gate speed
 - Runtime compilation
 - Data transfer rate



127 Qubits 1.400 CLOPS,
433 Qubits 15.000 CLOPS

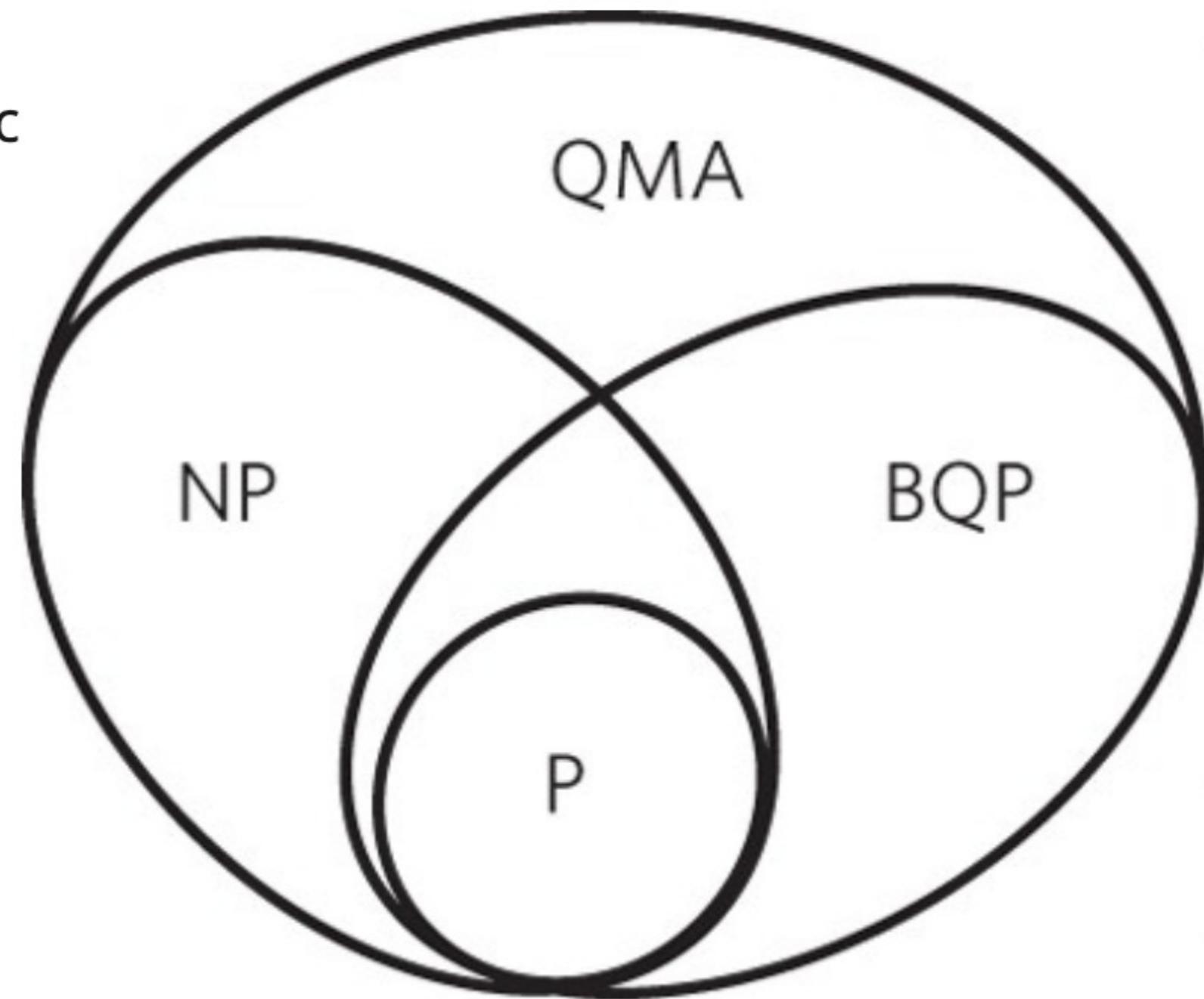


**Quantum computers
promise infinite
speedup for any
computation.**

Computational complexity

NP: non-deterministic in polynomial time (knapsack problem, travelling sales man problem)

P: deterministic in polynomial time (e.g. sorting)



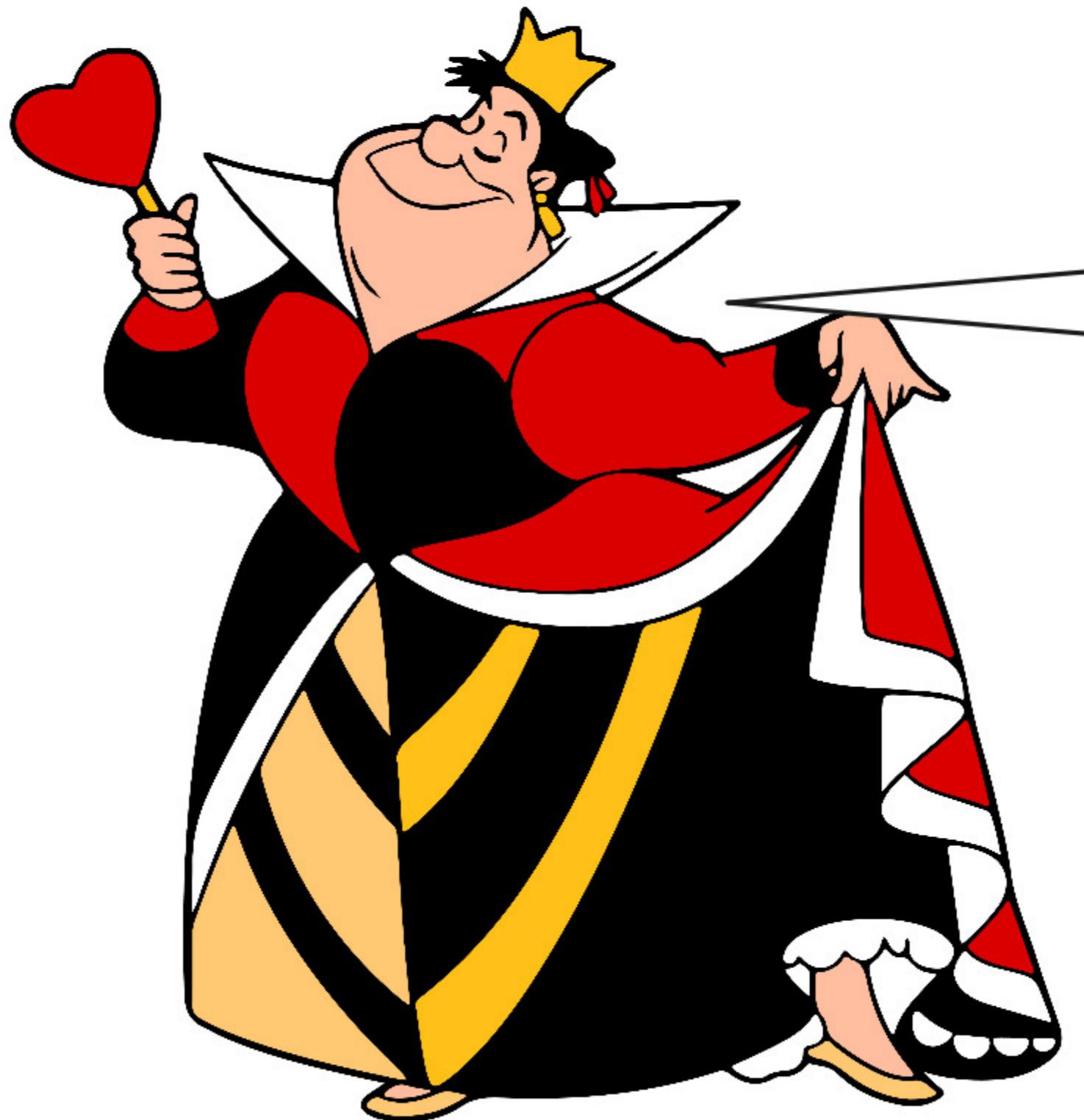
QMA: quantum equivalent of NP

BQP: solvable by a quantum computer in polynomial time (integer factorization, simulation of quantum systems)

Quantum Algorithms for BQP

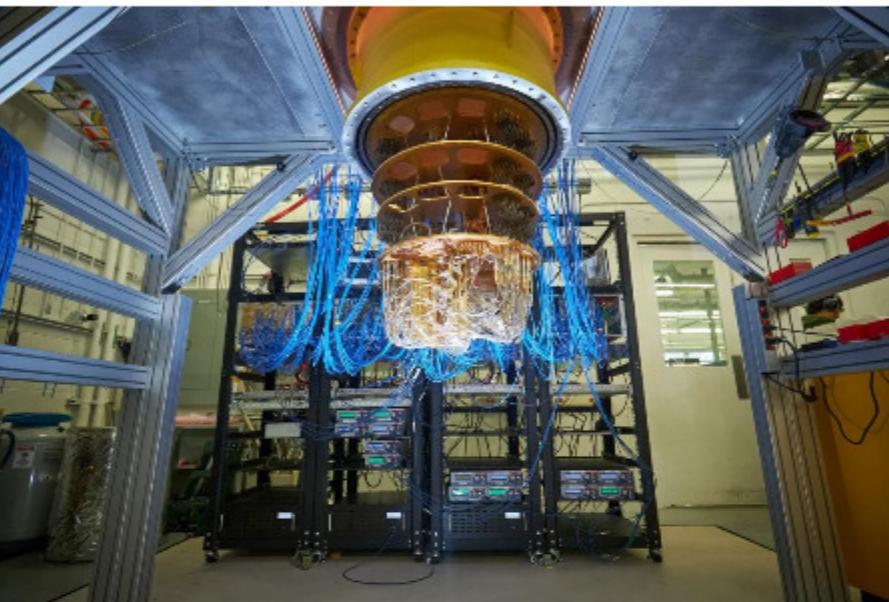
- Deutsch-Jozsa algorithm
- Shor's factorization algorithm
- Grover's search algorithm
- QAOA - Quantum Approximate Optimization Algorithm
- VQE - Variational Quantum Eigen-solver
- QUBO - Quadratic unconstrained binary optimization

Quantum Falsehood 12



Access to quantum computers is limited to rich people.

On-prem access



On-prem access



Cloud Access

- IBM: <https://quantum-computing.ibm.com/>
- Google: <https://quantumai.google/>
- Amazon: <https://aws.amazon.com/braket/>
 - IONQ, OQC, Rigetti, QuEra
- D-Wave: <https://www.dwavesys.com>
- Xanadu: <https://xanadu.ai/>
- Pennylane: <https://pennylane.ai/>

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- Xanadu: <https://xanadu.ai/>
- Pennylane: <https://pennylane.ai/>



**FREE
TIER**



I have to learn
strange and new
programming
languages before I
can use quantum
computers.

Quantum Computing Stack

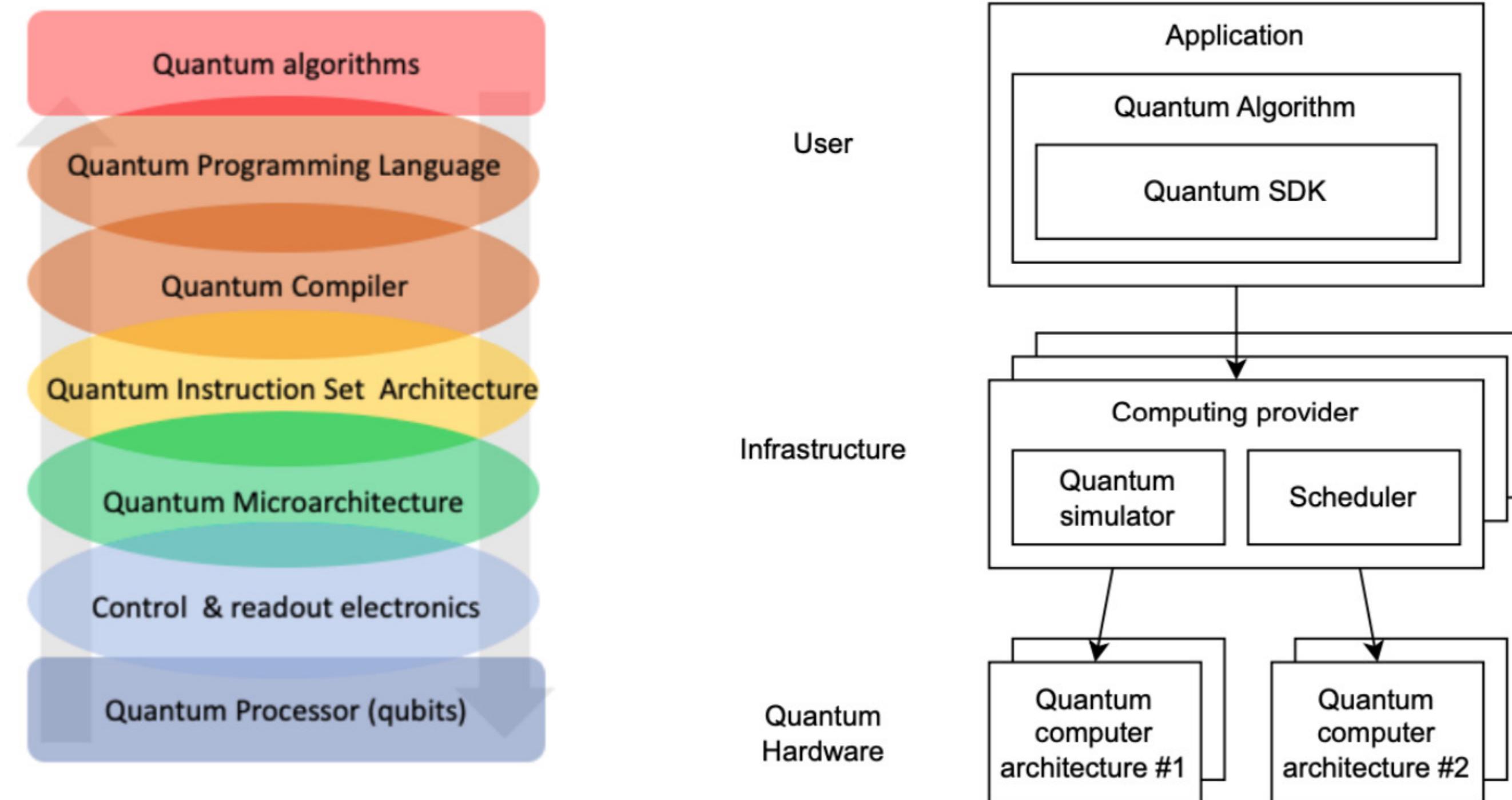
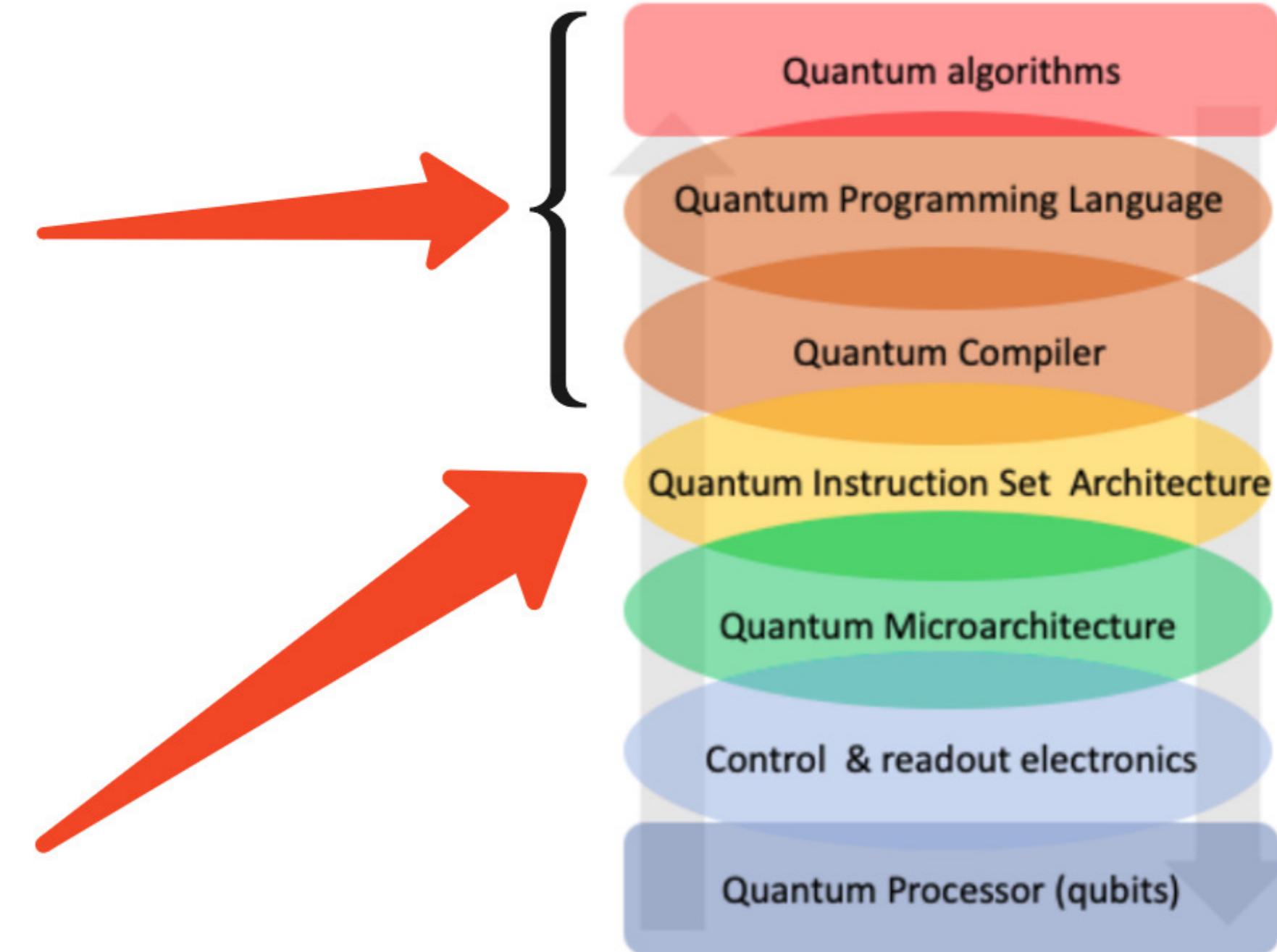


Fig. 3. Ecosystem layers and relationships between stakeholders

Platforms & Languages

- [Qiskit](#) - IBM
 - [pyQuil](#) - rigetti
 - [TKET](#) - quantinuum
 - [Cirq](#) - Google
 - [Q#](#) - Microsoft
-
- [OpenQASM](#)



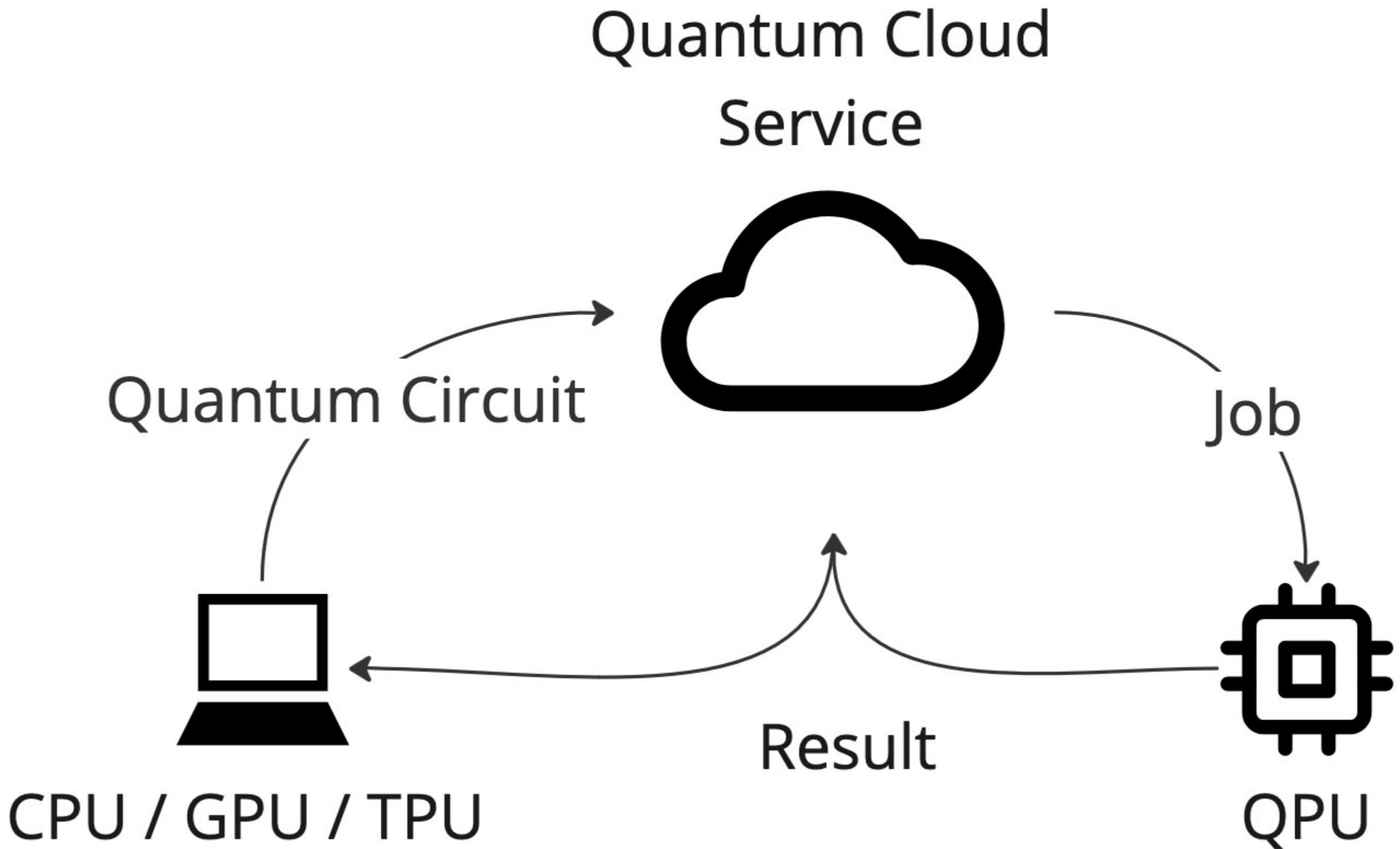
Quantum Falsehood 7



**Quantum computers
will replace all
classical computers.**

Hybrid approach

- CPU
- GPU
- TPU
- **QPU**





**Austria is a too
small country to
make good
quantum tech.**

QUANTEN ECO SYSTEM AUSTRIA

*Interessenten,
Kunden u. Anwender*



QT Hersteller



*Lieferkette, Vertrieb,
Systemintegratoren*



*Forschung und
Entwicklung*





gottfriedszing



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