Hi,
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Google Scholar: https://scholar.google.com/citations?user=Furo_uwAAAAJ&hl=en&oi=ao

This is CS4084!

GCR:2c46hhrz

Marks Distribution

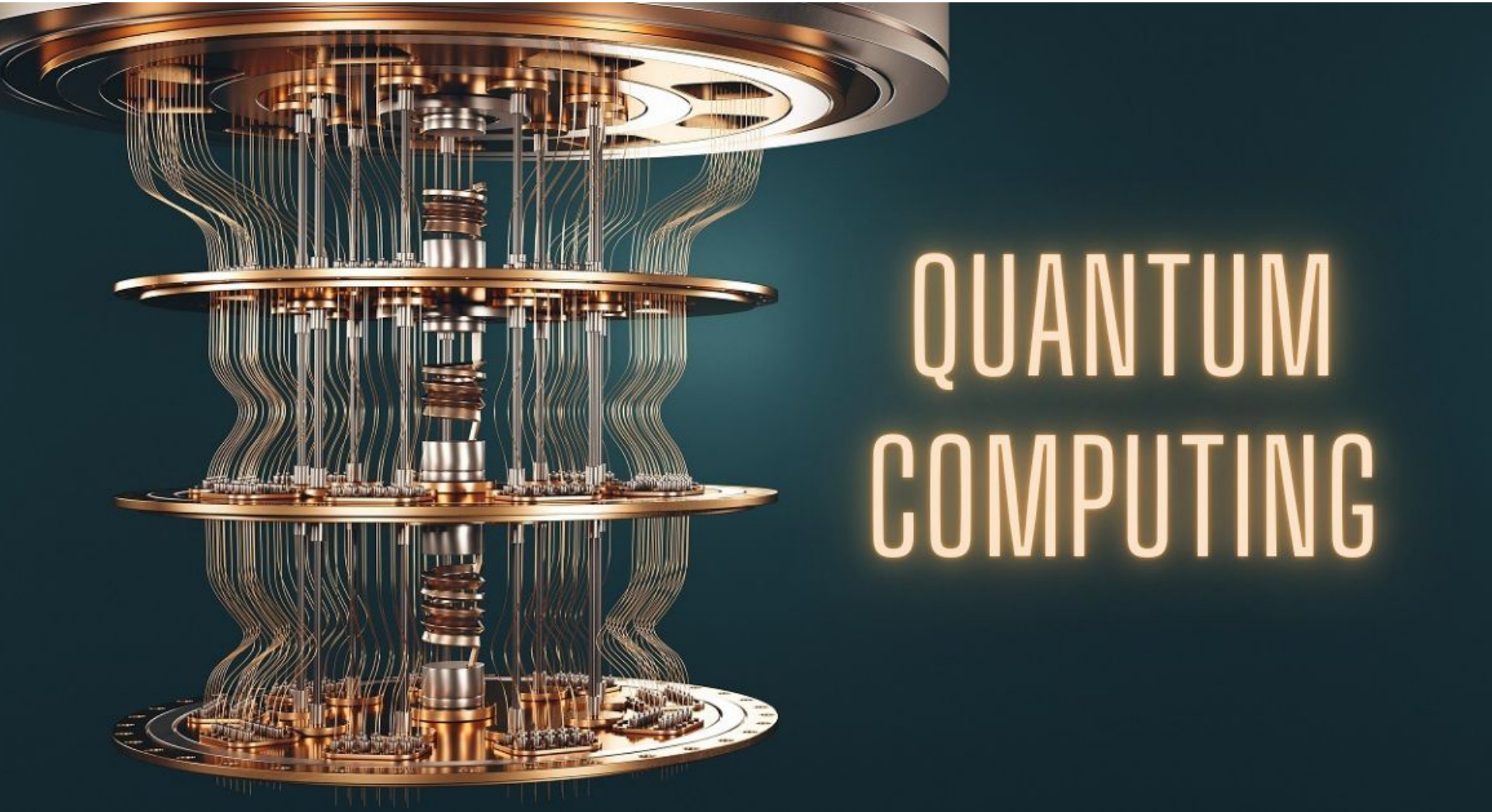
Mid 1 = 15

Mid 2 = 15

Assignments = 10

Project = 10

Final = 50


QUANTUM
COMPUTING

Quantum Computing

Quantum computing is a computing paradigm that exploits quantum mechanical properties (superposition, entanglement, interference...) of matter in order to do calculations

MYTHS

Quantum computers are just very fast normal computers

Quantum computers will replace classical computers

Quantum computers will replace laptops and phones

Quantum computers can solve any problem instantly

Quantum computers always give the correct answer

You must understand quantum physics deeply to use quantum computers

Quantum computers are already practical and stable

Quantum supremacy means quantum computers are superior in everything

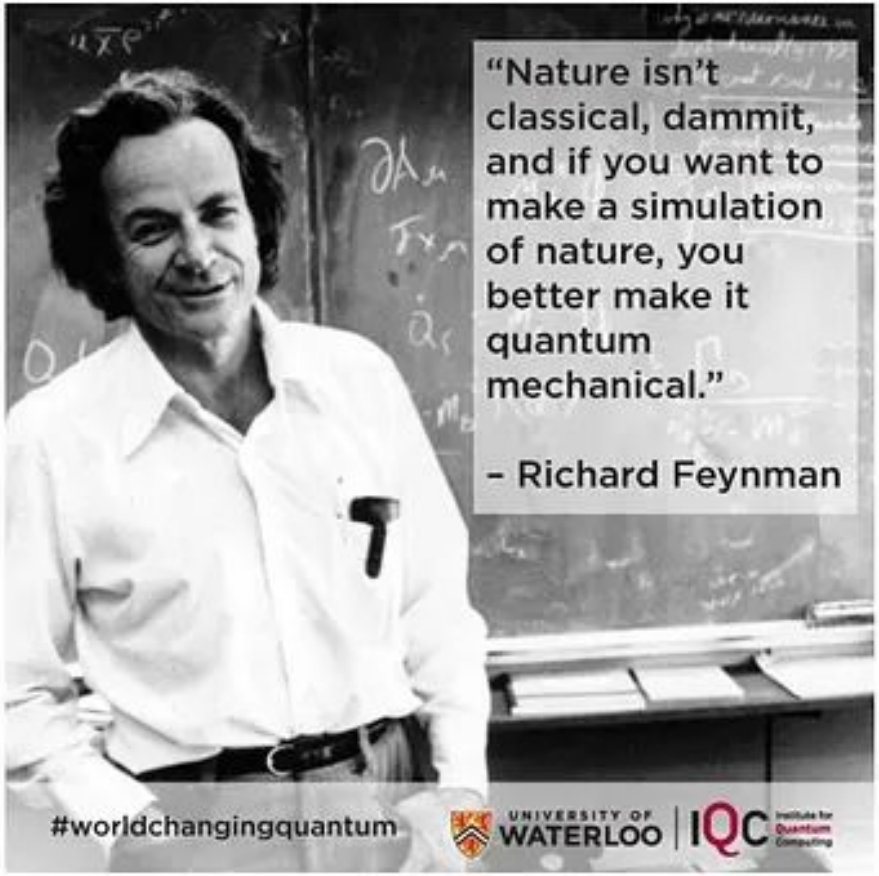
Quantum computing breaks all encryption today

Quantum computing is better than AI

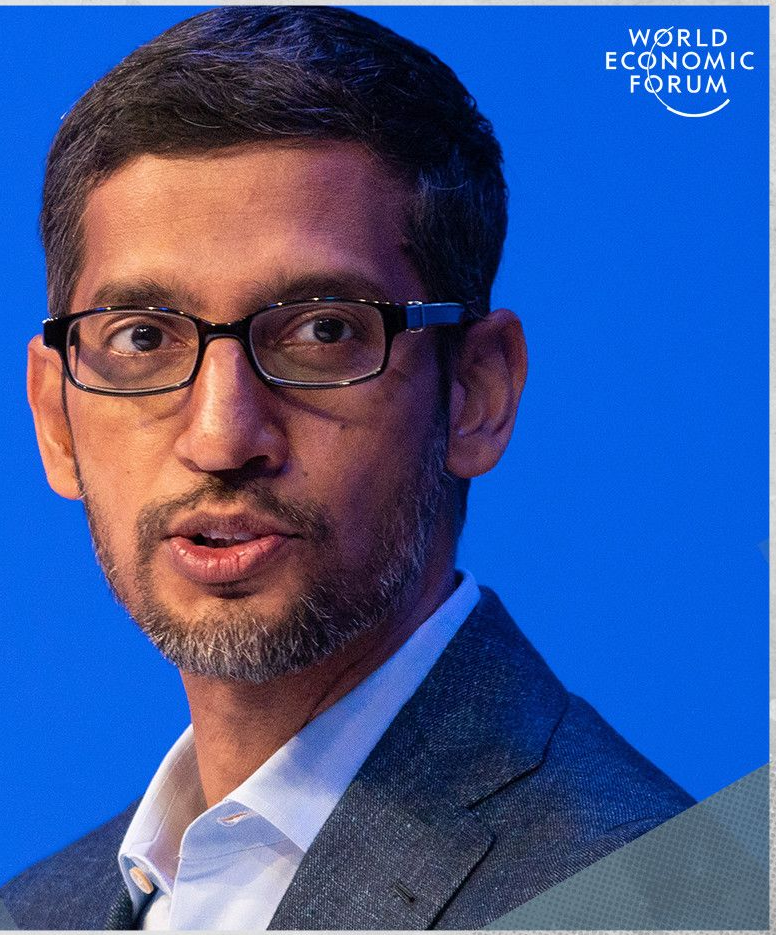
AI will instantly run better on quantum hardware

Businesses must choose between investing in AI or quantum

Motivation


"Nature isn't classical, dammit, and if you want to make a simulation of nature, you better make it quantum mechanical."
– Richard Feynman
#worldchangingquantum
UNIVERSITY OF WATERLOO
IQC Institute for Quantum Computing

“Nature at a fundamental level works in a quantum way.”



Sundar Pichai
CEO, Alphabet

Where Quantum Computing is Actually Helpful?

1. Chemistry & Materials (Most Promising, Most Real)

Molecules are quantum systems themselves.

Classical computers struggle because the complexity grows exponentially.

Real use cases

- Drug discovery (protein-ligand interaction)
- Battery materials (lithium, solid-state batteries)
- Catalysts (fertilizers, green hydrogen)
- New materials (superconductors, polymers)

Where Quantum Computing is Actually Helpful?

2. Optimization Problems (Huge Economic Impact)

Many optimization problems explode combinatorially:

Routing, Scheduling, Resource allocation

Quantum algorithms can explore many possibilities simultaneously.

Real use cases

- Supply chain optimization
- Airline crew scheduling
- Traffic flow optimization
- Portfolio optimization (with caveats)
- Factory layout & planning

Where Quantum Computing is Actually Helpful?

3. Cryptography & Security (Future-Critical)

Shor’s algorithm can theoretically break:

RSA, ECC, Diffie-Hellman

Real use cases

- Driving post-quantum cryptography
- Quantum-safe security planning
- Long-term data protection

Where Quantum Computing is Actually Helpful?

4. Monte Carlo & Risk Simulation (Selective)

Some quantum algorithms offer quadratic speedups for sampling problems.

Real use cases

- Financial risk modeling
- Option pricing (specific models)
- Energy system simulations
- Climate modeling components

Where Quantum Computing is Actually Helpful?

5. Search & Graph Problems

Grover’s algorithm gives quadratic speedup for unstructured search.

Real use cases

- Network analysis
- Fraud detection (niche)
- Database search (very specific scenarios)

Where Quantum Computing is Actually Helpful?

6. Machine Learning (Very Limited , Mostly Hype)

Some quantum algorithms offer quadratic speedups for sampling problems.

Where it might help

- Feature space exploration
- Kernel methods
- Optimization subroutines

Where it doesn’t

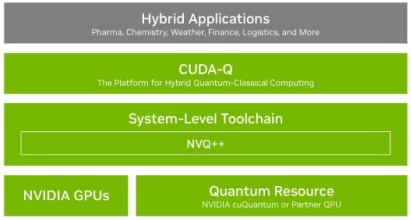
- Training large neural networks
- LLMs
- Computer vision at scale

Big Techs Are Involved

- Google (Alphabet)
- IBM
- Microsoft - Azure Quantum
- AWS - Amazon Braket
- Nvidia
- Xanadu

PennyLane

Tensorflow Quantum



NVIDIA CUDA-Q

Quantum-accelerated applications won't run exclusively on a quantum resource but will be hybrid (quantum and classical) in nature. To transition from algorithm development by quantum physicists to application development by domain scientists, a development platform is needed that delivers high performance, interoperates with today's applications and programming paradigms, and is familiar and approachable to domain scientists.

With a unified programming model, NVIDIA® CUDA-Q is a first-of-its-kind platform for hybrid quantum-classical computers, enabling integration and programming of QPUs, quantum emulation, GPUs, and CPUs in one system. CUDA-Q is built for performance, is open source, and provides high-level language to develop and run hybrid quantum-classical applications.

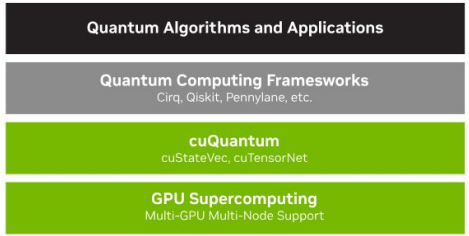
NVIDIA cuQuantum

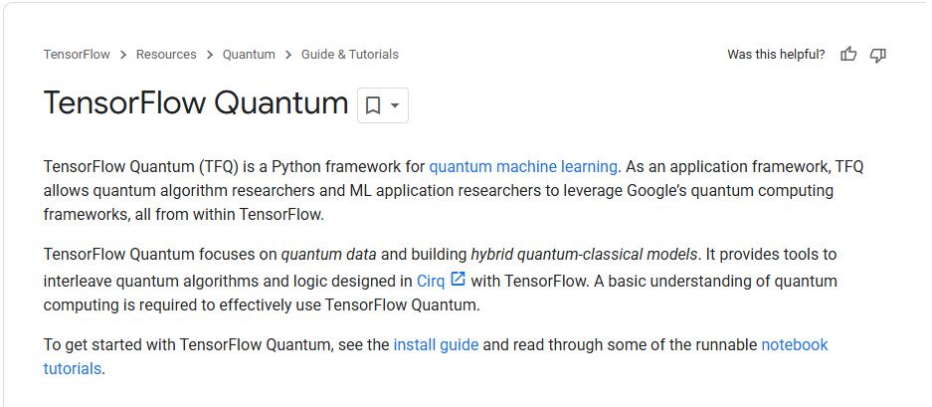
NVIDIA cuQuantum is a set of low-level libraries for accelerating quantum circuit simulation. cuQuantum is primarily used by developers building circuit simulation frameworks and accelerates Cirq, Qiskit, PennyLane, and more.

cuQuantum offers state vector (cuStateVec) and tensor network (cuTensorNet) circuit simulation algorithms with multi-GPU acceleration.

The cuQuantum Appliance is a Docker container consisting of leading community frameworks accelerated by cuQuantum and optimized for the NVIDIA platform.

The NVIDIA cuQuantum Appliance is available in the NVIDIA NGC™ catalog.





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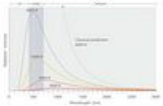
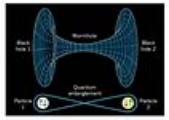
Theoretical Foundations

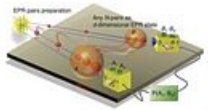
1900 — Planck's Quantum Hypothesis



1935 — The EPR Paradox



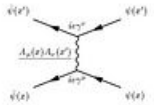
1964 — Bell's Inequality



1970 — Birth of Quantum Information Theory

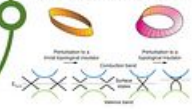
1980 — First Conference on Physics and Computation

1981 — Feynman's Quantum Computer Proposal



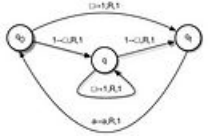
Emergence

1982 — Discovery of Topological Quantum order



Development

1984 — Benioff's Quantum Turing Machine



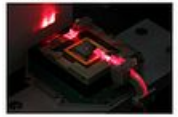
1985 — Deutsch's Universal Quantum Computer

1994 — Shor's Algorithm

1994 — Grover's Algorithm

1996 — DiVincenzo Criteria For Quantum Computer

2000 — First Trap Ion Quantum Computer



Race

2004 — Circuit QED Demo.

2007 — The Transmon Superconducting Qubit

2007 — D-Wave One Quantum Annealer

2013 — Rigetti Computing

2016 — Microsoft Station Q

2019 — Google Quantum Supremacy

2020 — IBM Quantum Roadmap

2021 — Company Booming

IONQ, Honeywell, PsiQuantu, XANADU

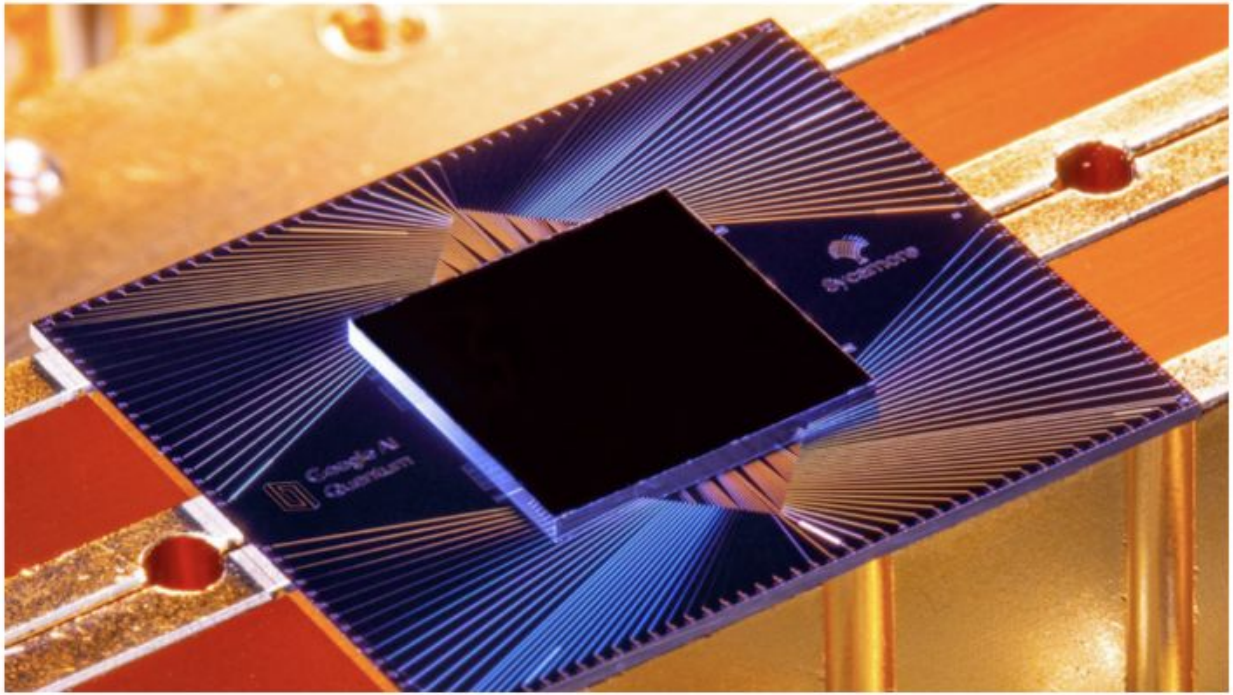
2022 — Quantumpedia's Founding

Ongoing Advancements

NEWS QUANTUM PHYSICS

Google officially lays claim to quantum supremacy

A quantum computer reportedly beat the most powerful supercomputers at one type of calculation



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Article | Published: 23 October 2019

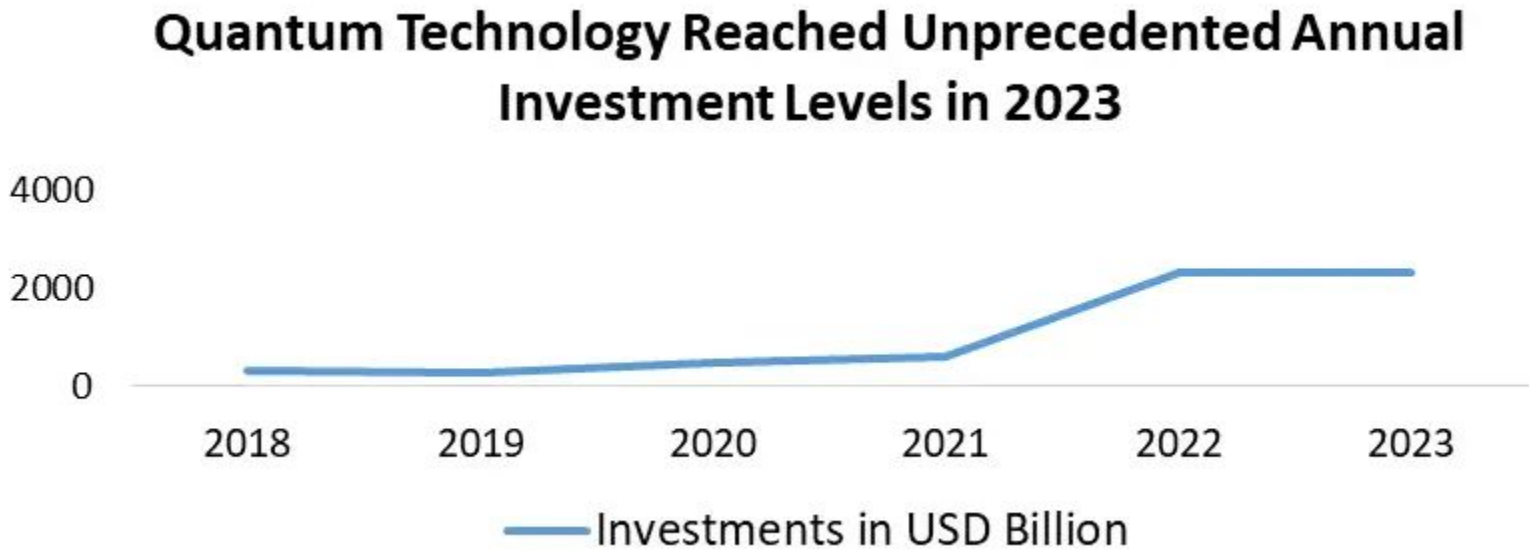
Quantum supremacy using a programmable superconducting processor

Frank Arute, Kunal Arya, Ryan Babbush, Dave Bacon, Joseph C. Bardin, Rami Barends, Rupak Biswas, Sergio Boixo, Fernando G. S. L. Brandao, David A. Buell, Brian Burkett, Yu Chen, Zijun Chen, Ben Chiaro, Roberto Collins, William Courtney, Andrew Dunsworth, Edward Farhi, Brooks Foxen, Austin Fowler, Craig Gidney, Marissa Giustina, Rob Graff, Keith Guerin, ... John M. Martinis ✉ + Show authors

Nature **574**, 505–510 (2019) | Cite this article

Abstract

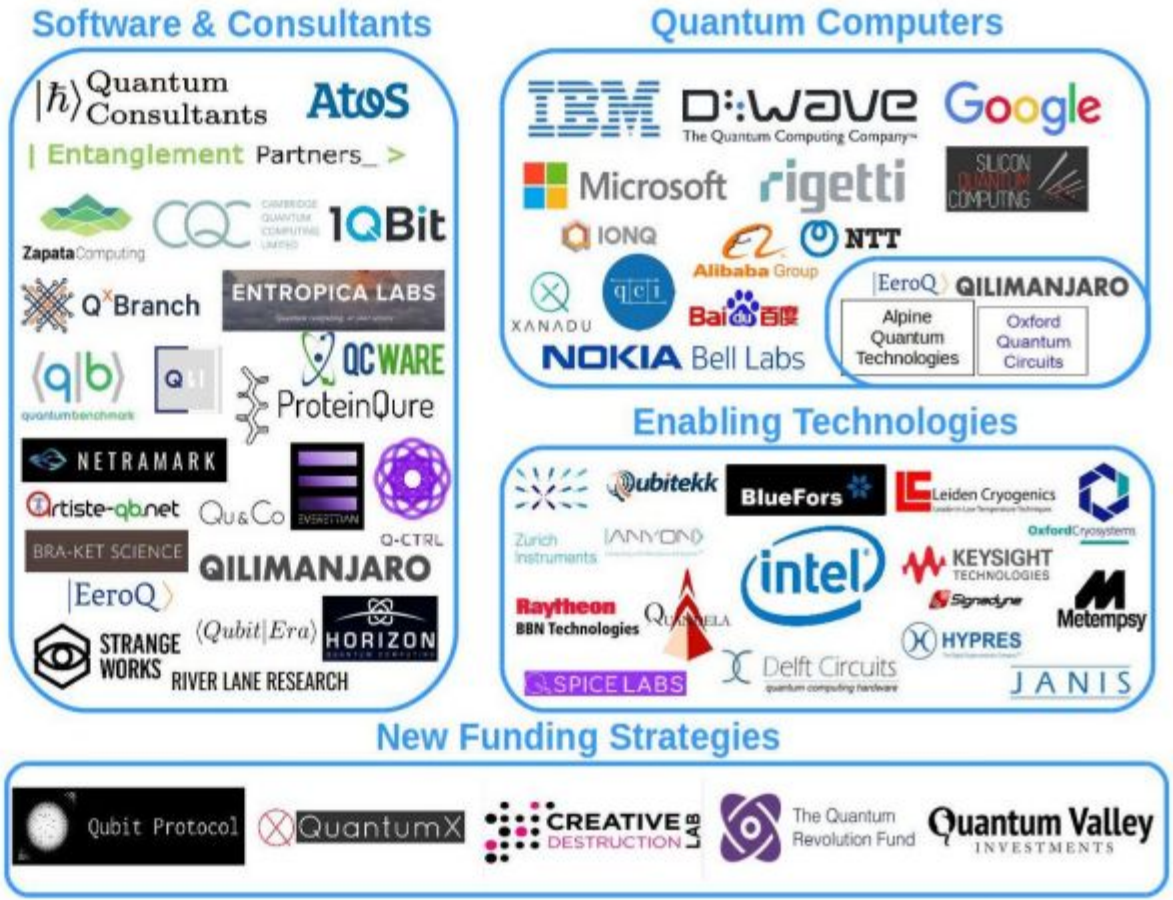
The promise of quantum computers is that certain computational tasks might be executed exponentially faster on a quantum processor than on a classical processor[1]. A fundamental challenge is to build a high-fidelity processor capable of running quantum algorithms in an exponentially large computational space. Here we report the use of a processor with programmable superconducting qubits[2,3,4,5,6,7] to create quantum states on 53 qubits, corresponding to a computational state-space of dimension 2^{53} (about 10^{16}). Measurements from repeated experiments sample the resulting probability distribution, which we verify using classical simulations. Our Sycamore processor takes about 200 seconds to sample one instance of a quantum circuit a million times—our benchmarks currently indicate that the equivalent task for a state-of-the-art classical supercomputer would take approximately 10,000 years. This dramatic increase in speed compared to all known classical algorithms is an experimental realization of quantum supremacy[8,9,10,11,12,13,14] for this specific computational task, heralding a much-anticipated computing paradigm.



https://www.maximizemarketresearch.com/market-report/global-quantum-computing-market/27533/

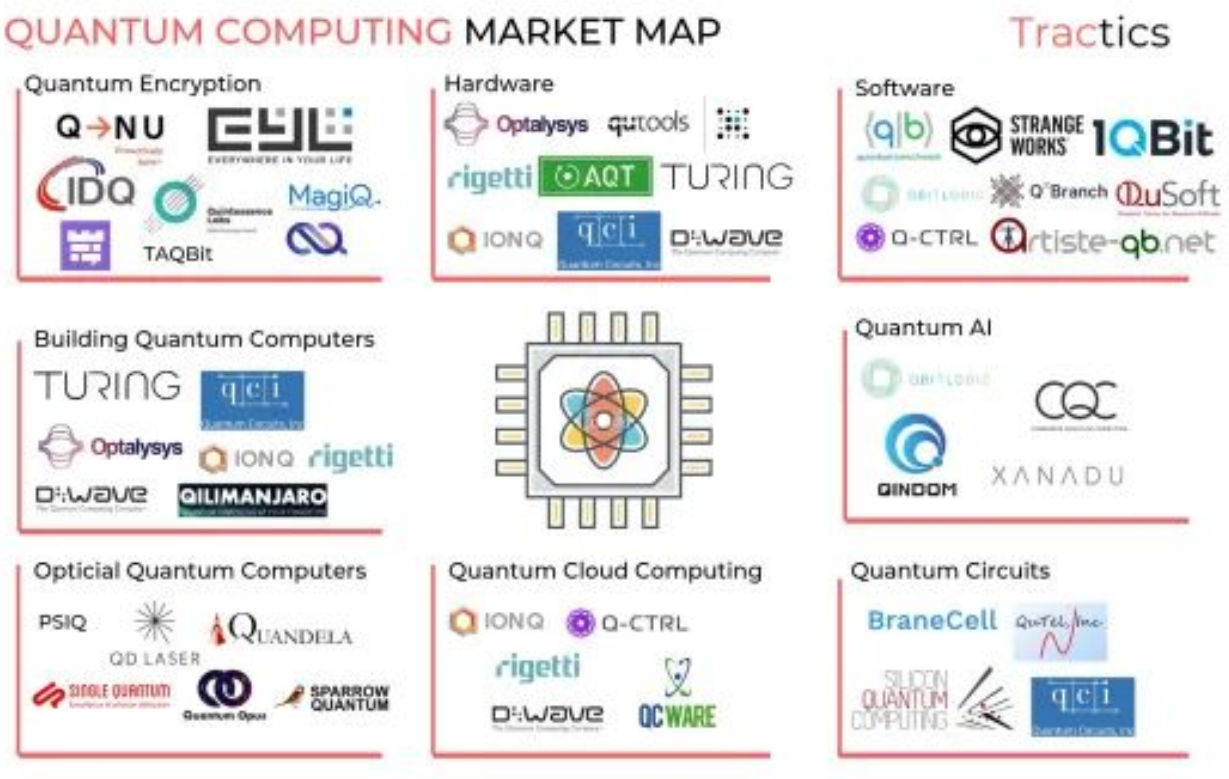
Large Companies are involved

In a growing ecosystem of startups and incumbents



Representative list of players. A very active ecosystem!

QUANTUM WORLD ASSOCIATION



https://research.aimultiple.com/quantum-computing-companies/

This course is:

At the leading edge of a new technology, discipline, and industry

A programming-first approach

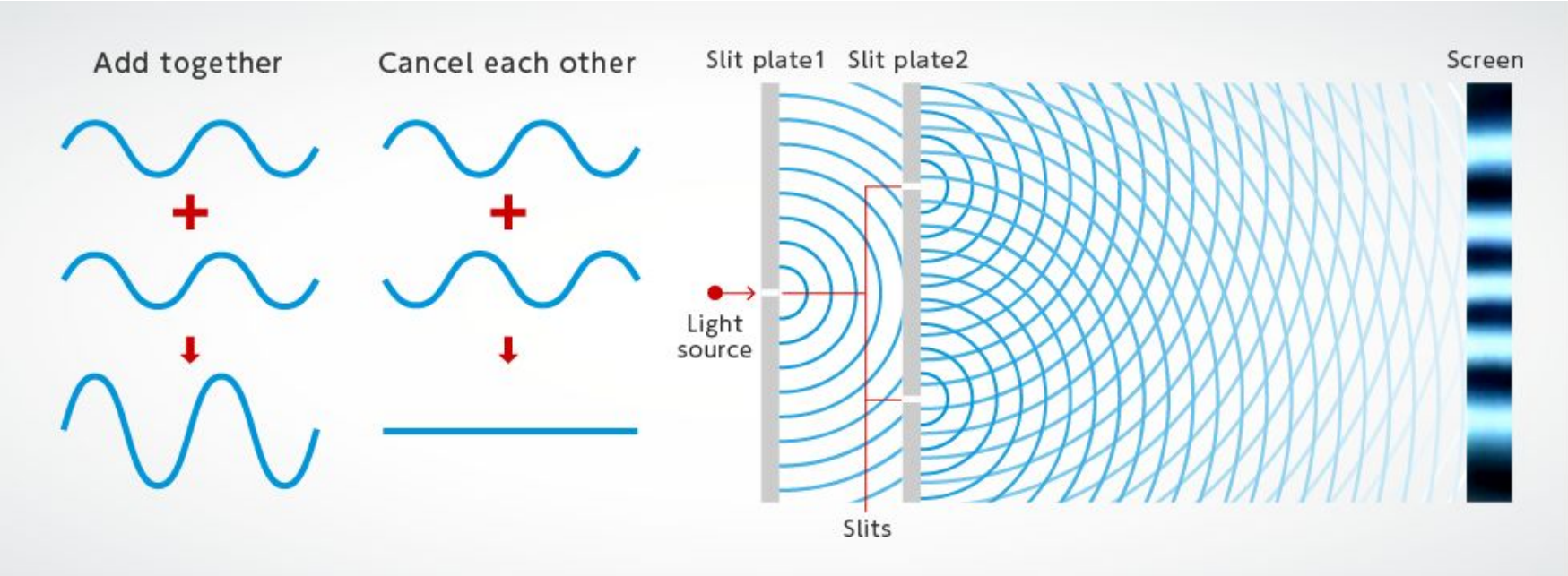
A great way to challenge yourself to think about computation in a totally new way

A way to learn “just enough” quantum physics

An **experiment - where we learn together**!

A dive in history

Is light a wave? - Young's interference experiment



Is light a particle? - Einstein's light quantum hypothesis

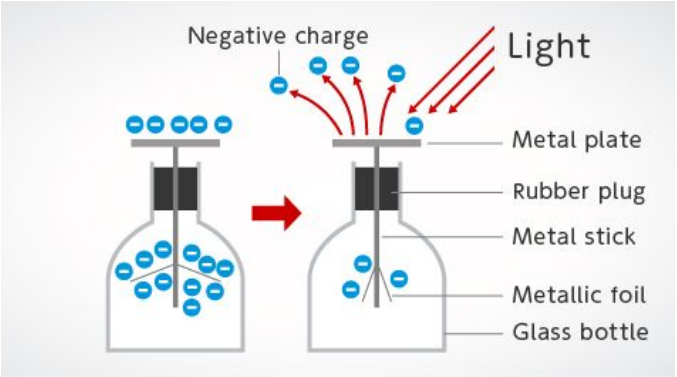
Einstein asserted that light is a particle containing energy corresponding to their wavelength

Photoelectric effect : When light hits a metal, electrons can be knocked out only if the light's frequency is high enough.

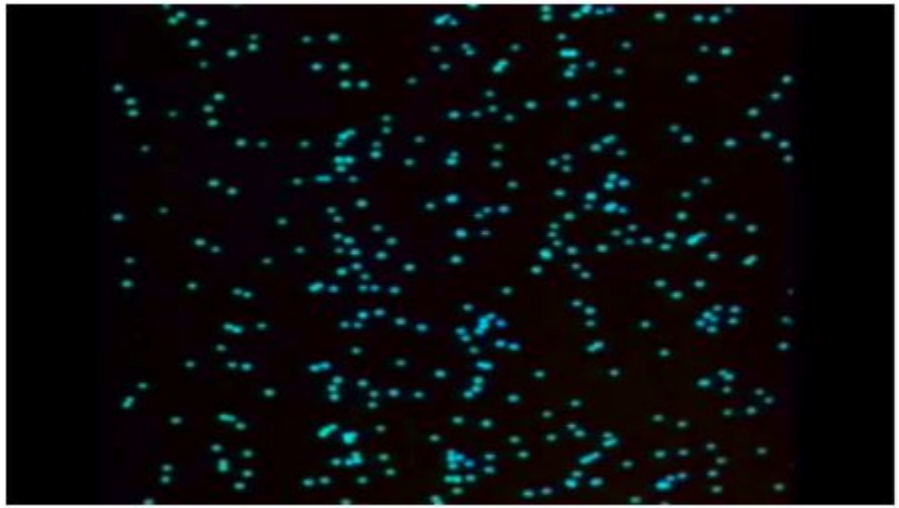
- Blue light has high frequency photons → enough energy to eject electrons
- Red light has low frequency photons → not enough energy, so no electrons are emitted

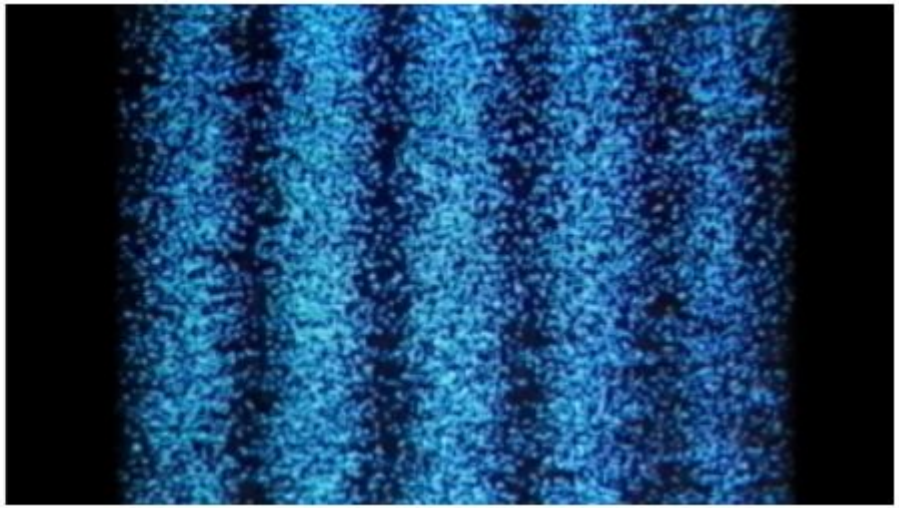
Increasing intensity just adds more low-energy photons; it doesn't help if each photon lacks enough energy.

light = "photons (light quanta)" since it has the properties not only of a wave but also of a particle.



Duality of Photons





Planck's Law

1900

Electromagnetic radiation from heated bodies is not emitted as a continuous flow but is made up of discrete units or quanta of energy, the size of which involves a fundamental physical constant (Planck's constant).

$$E = h\nu$$

$$E = \frac{hc}{\lambda}$$

$E = energy$

$h = Planck's\ constant$

$c = speed\ of\ light$

$\lambda = wavelength$

Einstein's Equation

1905

Einstein's relation connects a particle's energy and mass

Photons have no rest mass, but they carry momentum

The energy of a photon comes entirely from its motion

$$E=mc^2$$

Energy and momentum are directly related; for light, all energy is due to momentum

De Broglie

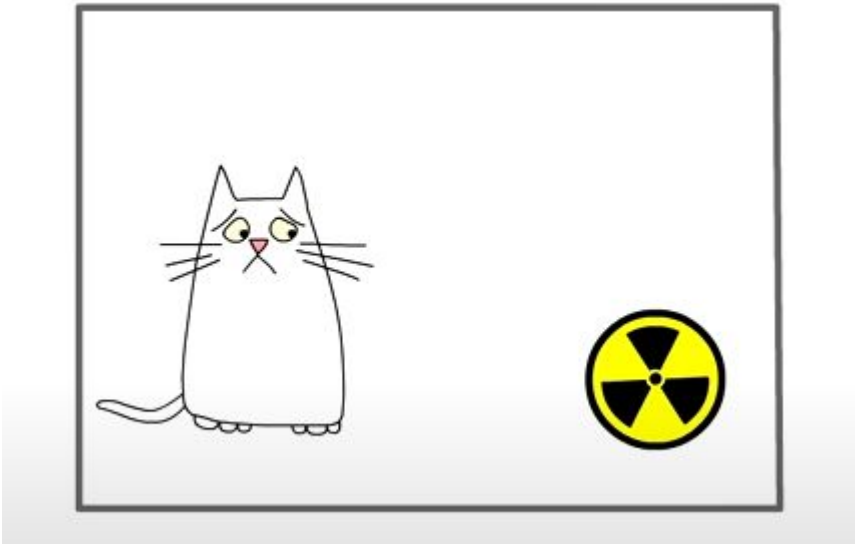
1924

Quantum mechanics assumes matter to be both like a wave as well as a particle at the sub-atomic level.

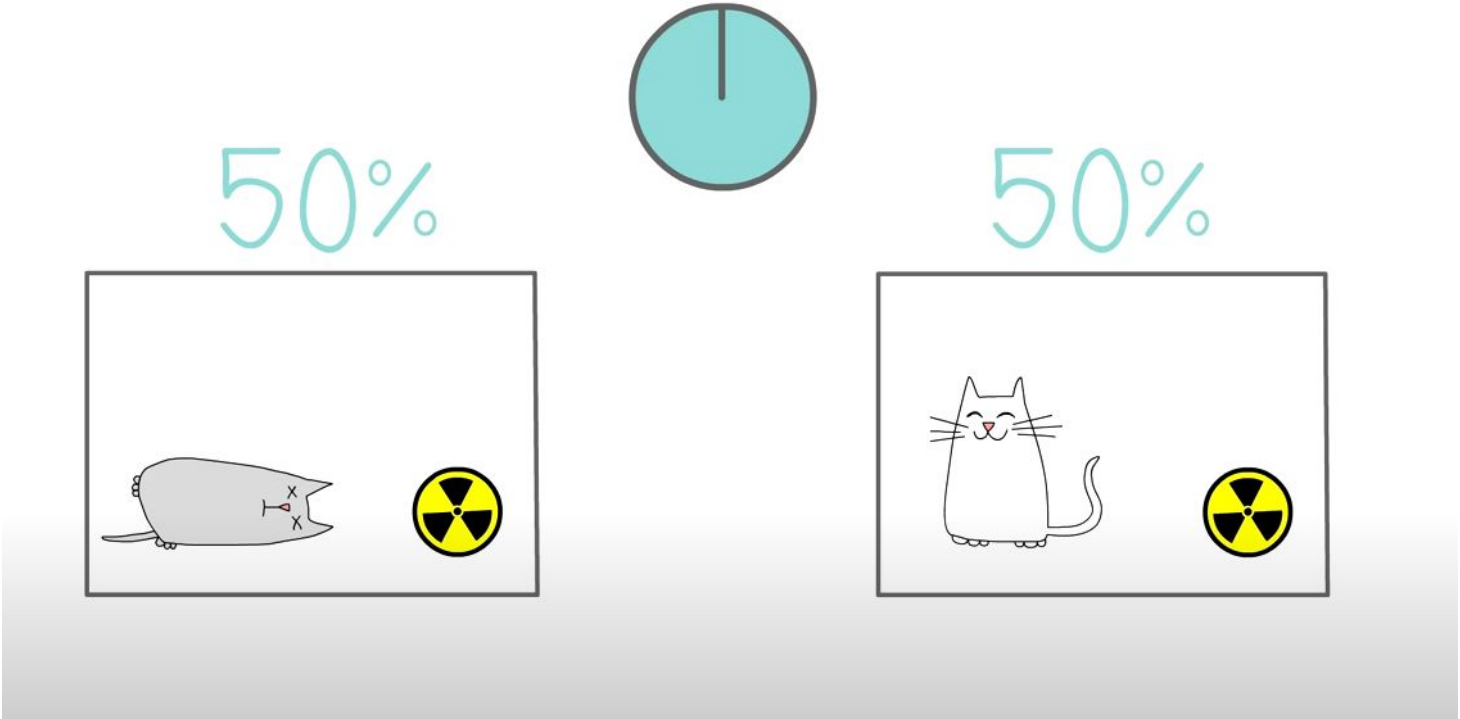
The De Broglie equation states that every particle that moves can sometimes act as a wave, and sometimes as a particle .

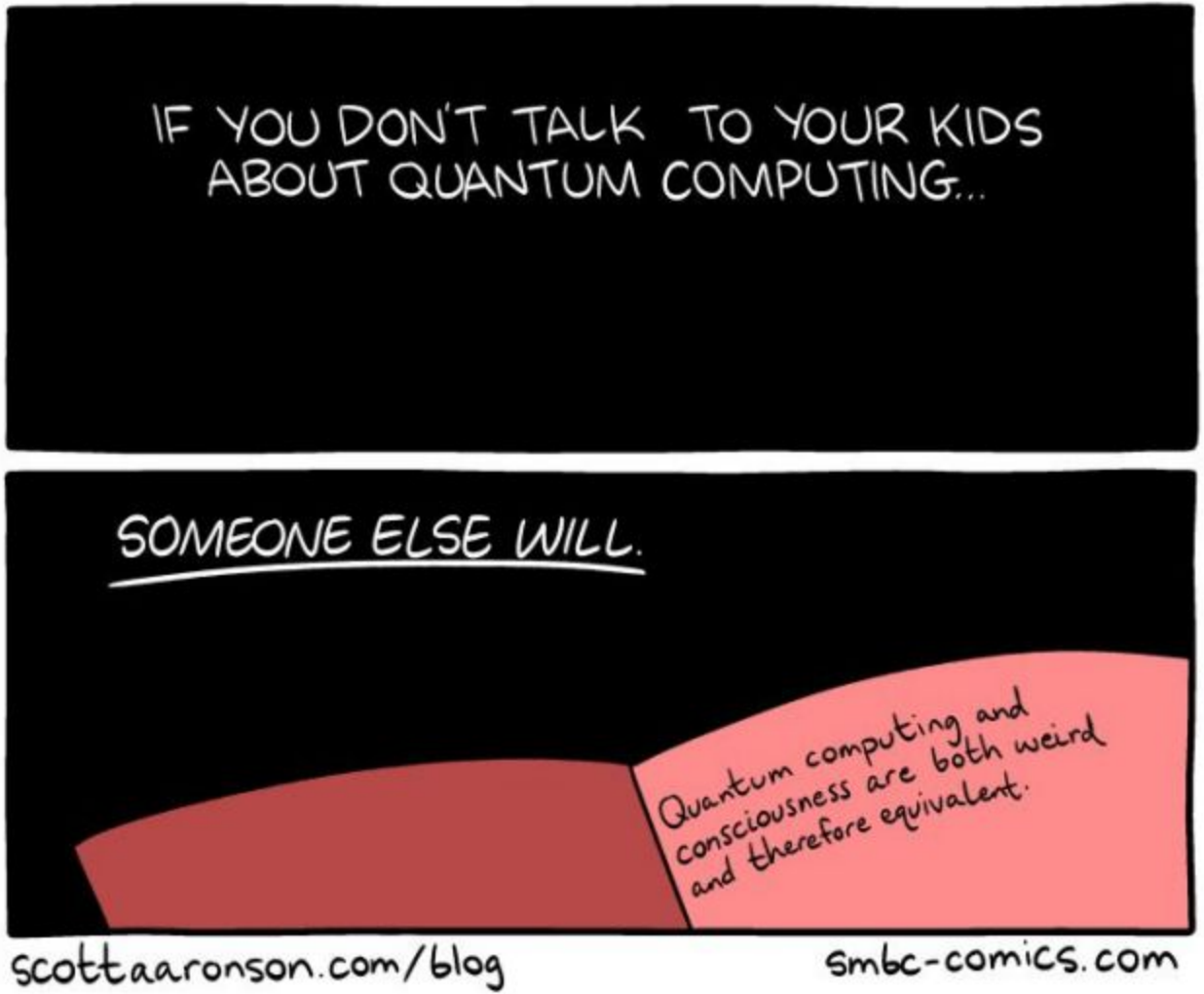
$$\lambda = \frac{h}{mv}$$

Schrödinger's cat Experiment 1935



Schrödinger's cat Experiment




IF YOU DON'T TALK TO YOUR KIDS ABOUT QUANTUM COMPUTING...
SOMEONE ELSE WILL.
Quantum computing and consciousness are both weird and therefore equivalent.
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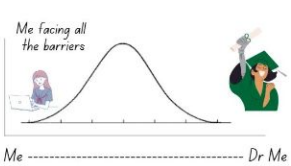

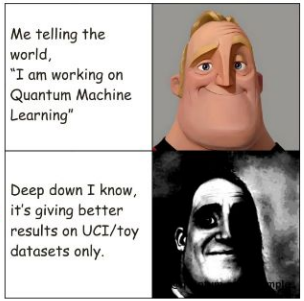

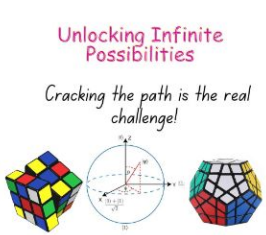

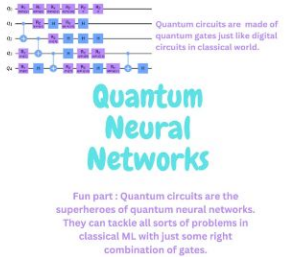

References

https://quantumpedia.uk/a-brief-history-of-quantum-computing-e0bbd05893d0

https://photonterrace.net/en/photon/duality/#:~:text=Einstein%20asserted%20that%20light%20is,intense%20the%20light%20is%20applied.

https://www.youtube.com/watch?v=UjaAxUO6-Uw

https://physicus-minimus.com/en/the-stern-gerlach-experiment/