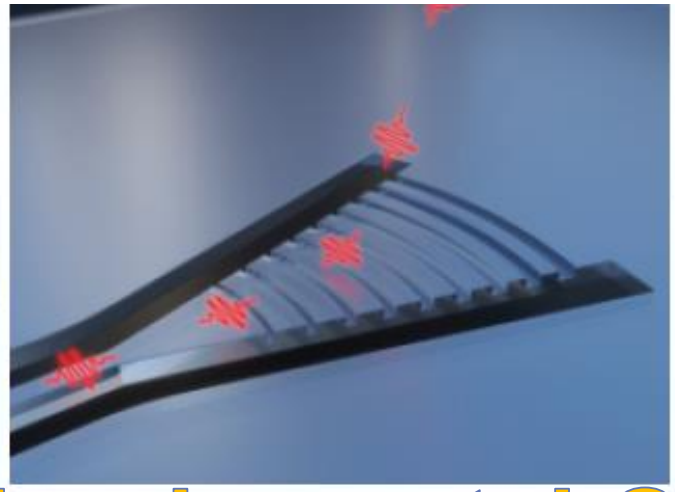


From Fundamental Quantum Physics to Revenue

Peter Lodahl
DNRF Center for Hybrid Quantum Networks Hy-Q
Founder of Sparrow Quantum
Niels Bohr Institute
University of Copenhagen

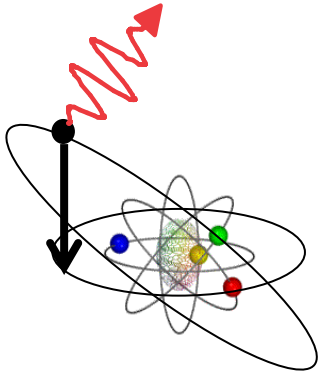
Danmarks Grundforskningsfond
Danish National Research Foundation
DANMARKS FRIE FORSKNINGSFOND
erc
Innovationsfonden
novo nordisk fonden

What is Quantum?

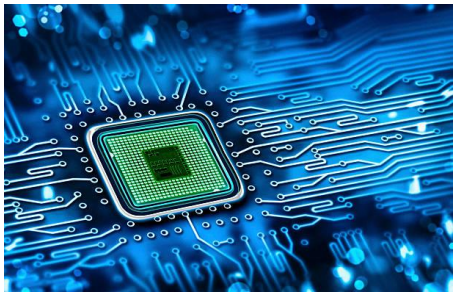
The microscopic world

of atoms and photons

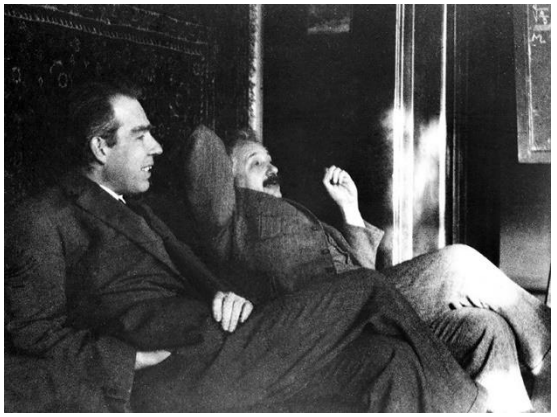
How does light and matter interact?



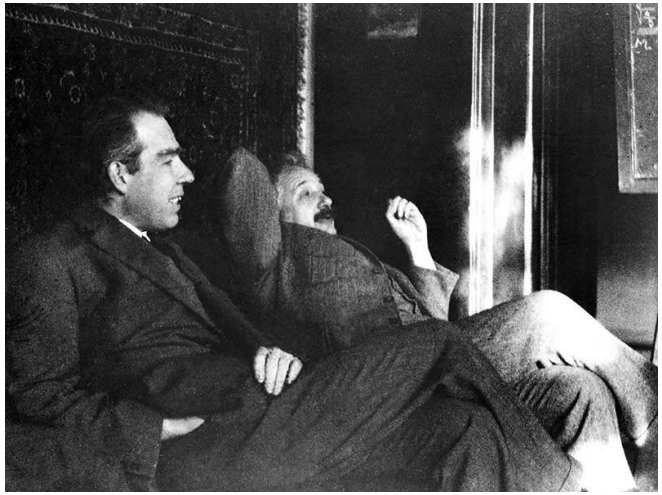
Q-tech 1.0 is responsible for the technology of today: lasers, transistors, computer chip, internet, etc



The *strange* quantum behavior unraveled by Bohr and Einstein holds the potential for Q-tech 2.0



Denmark: The Birthplace of Quantum Mechanics

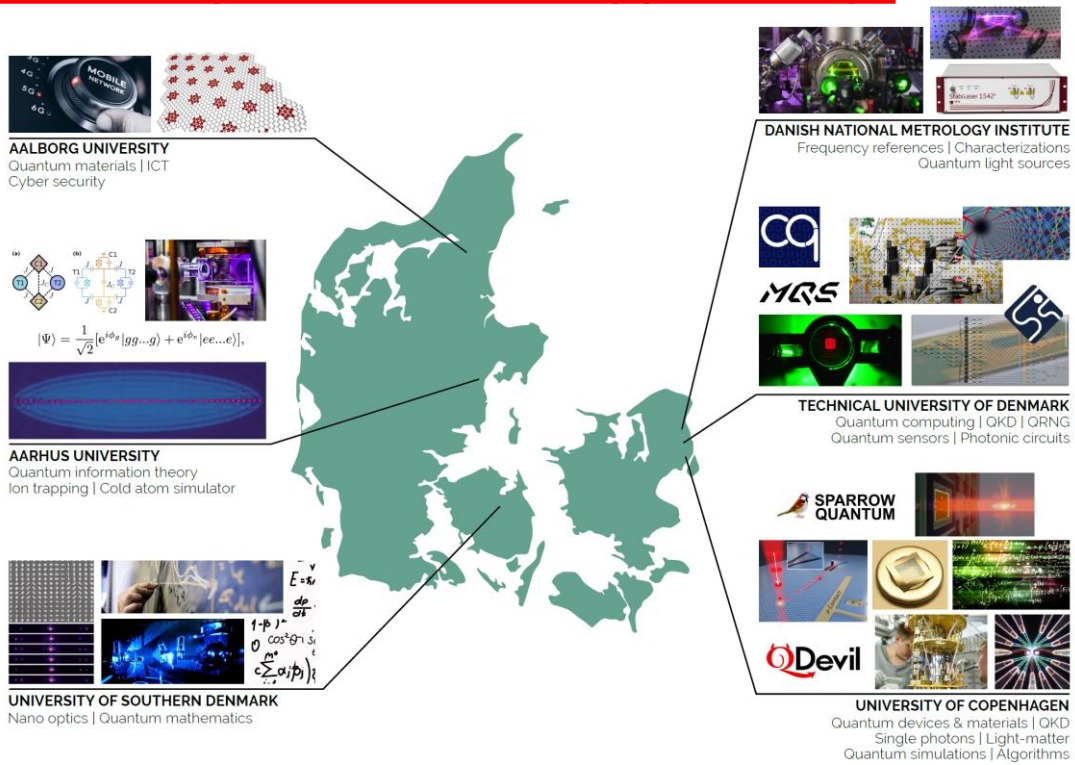


It took a century to take the leap from conceptual idea to emerging technology!

Quantum Denmark Today

World-class research environments in DK

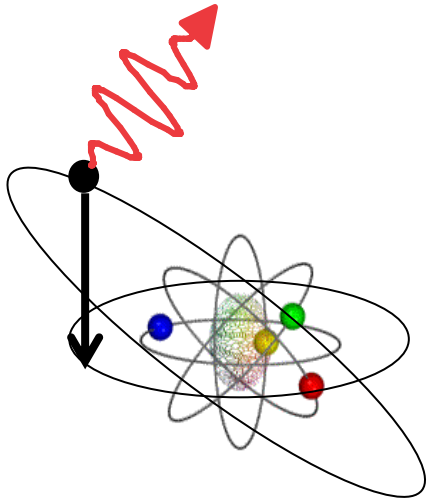
Can we capitalize on this opportunity?



DIANA Quantum Centre DK (NATO), NNF centers for quantum materials and quantum simulators, etc

Fundamentals of Photon Emission

Niels Bohr (1913): an excited atom radiates a single quantum of light – the photon



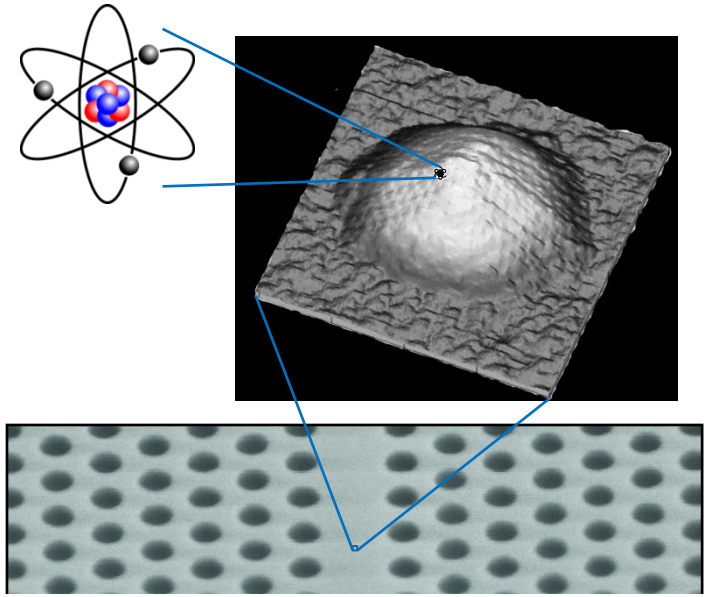
But: the photon is emitted in random directions

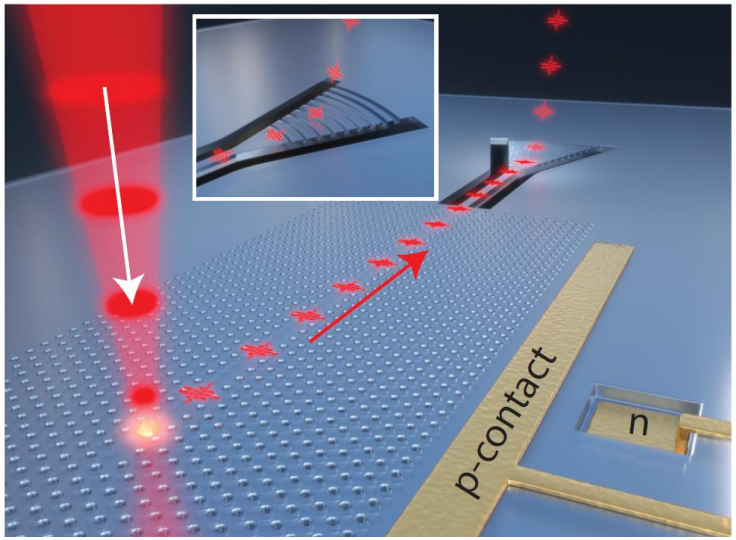
→ We need the ability to control light emission

Answer: modern nanophotonics technology

The Deterministic Single-Photon Source

Quantum dots embedded in photonic cavities or waveguides





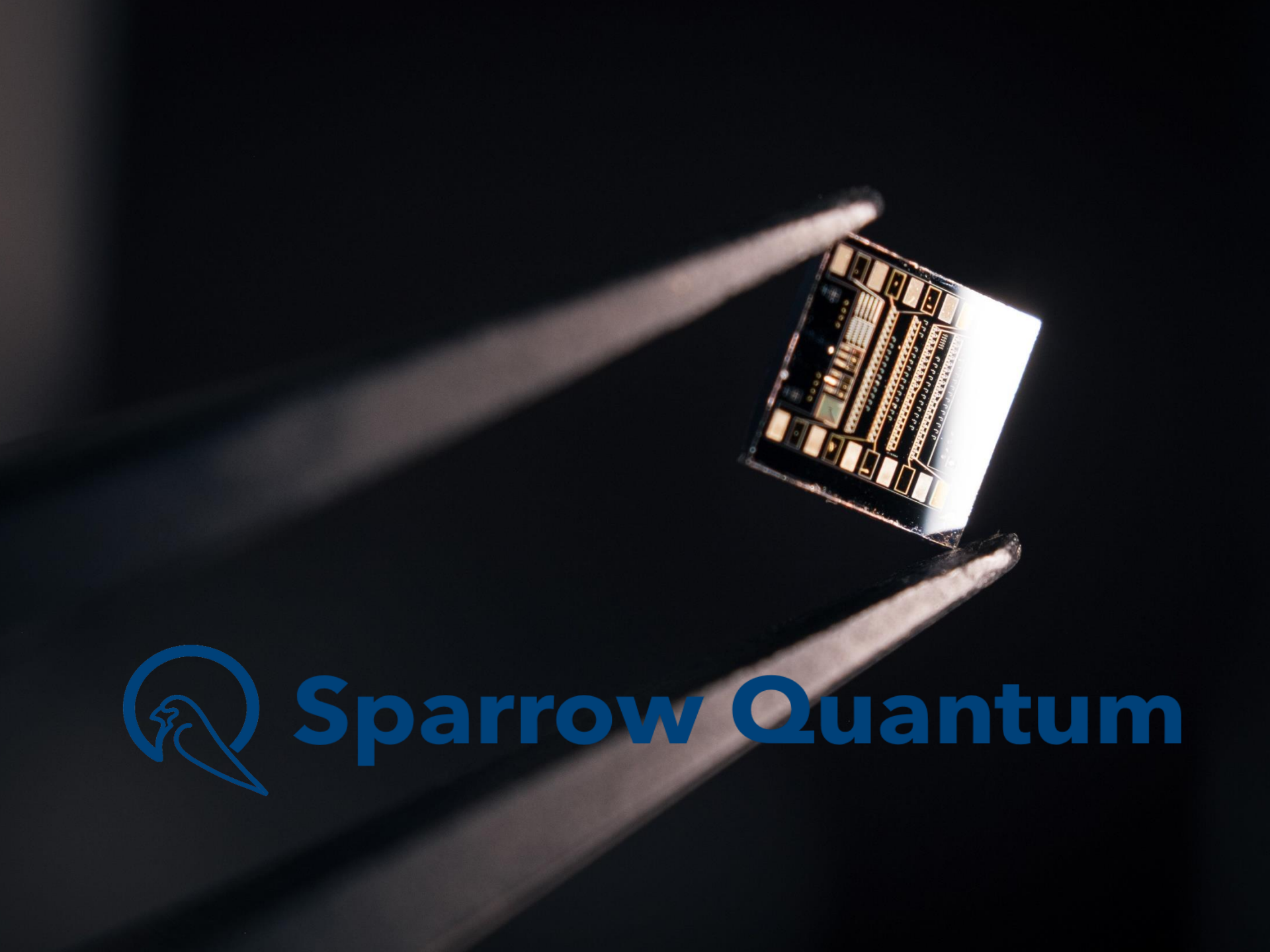
No ”free lunch” in quantum technology

20 years of dedicated fundamental research

Bell Labs was an ivory tower with a factory downstairs **Jon Gertner, The Idea Factory**

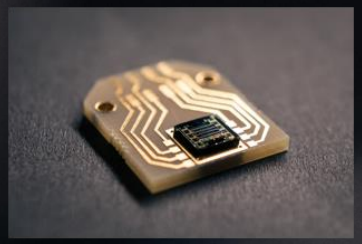
Patented technology at NBI

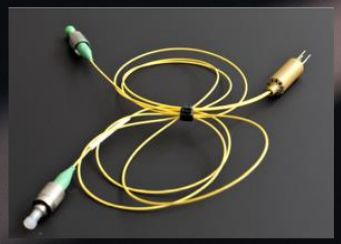
Lodahl, Ludwig and Warburton, Phys. Today 75, 44 (2022).


Sparrow Quantum

Product Road Map

Sparrow Quantum

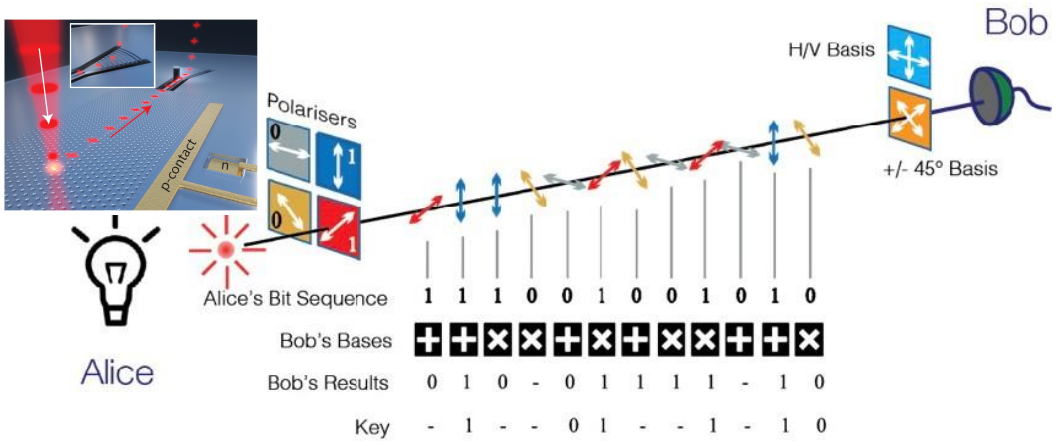




Single photon chip → Fibre-couple assembly → Integrated source → Integrated Telecom source

- SQ closed a seed investment round in April 2023 (largest investment ever in Danish q-tech start-up)
- Strategic planning of the future product development (quantum secure communication, photonic quantum computing, quantum interconnects, etc.)

Secure Quantum Communication



Unbreakable quantum secure communication

'Rolls-Royce' foundational quantum hardware towards fully device independence, quantum internet, etc

November 2022: Live Quantum Link

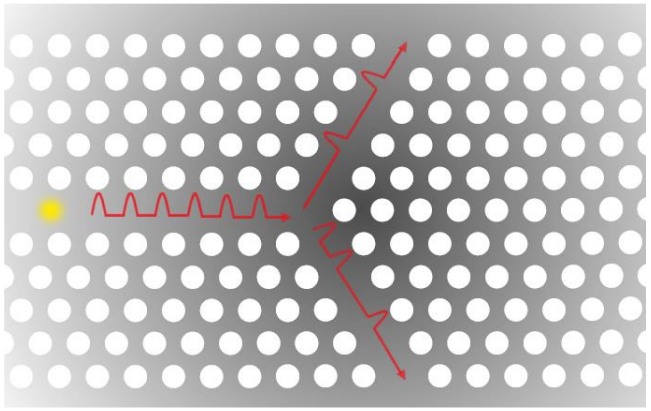
Encrypted video call from NBI to DTU (Prof. Leif Oxenløwe's lab)

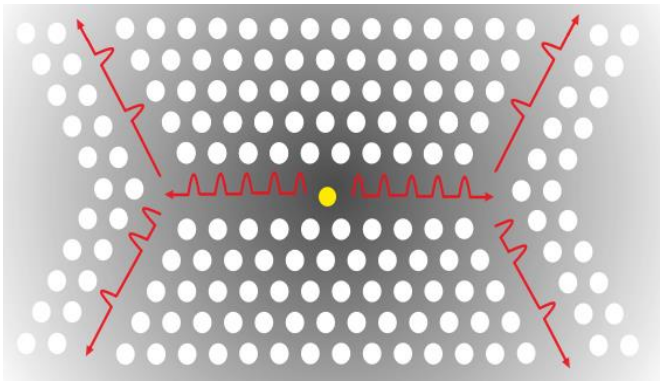
Direct synergy between SPOC and Hy-Q DNRF centers

Possibly world's first live quantum encrypted TV interview

Innovationsfonden

Quantum Strangeness and Complexity

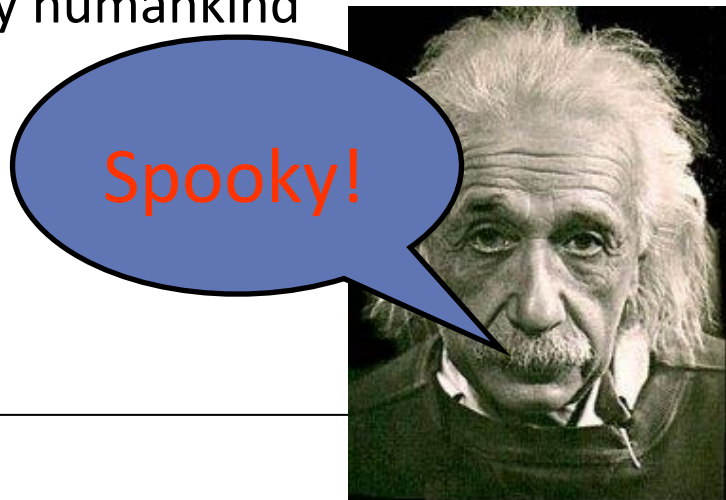




- A photon can be two different places at once: superposition

$$|\Psi\rangle = a\,|\uparrow\rangle + b\,|\downarrow\rangle$$ The qubit

- Two photons can be instantaneously connected: entanglement
- Quantum complexity: Just 100 photons can encode the information capacity ever generated by humankind



Basis of radically new technology

Quantum Computing

Challenge: computers cannot solve quantum problems

Problem: The World is quantum!

Quantum mechanics underpins high-tech

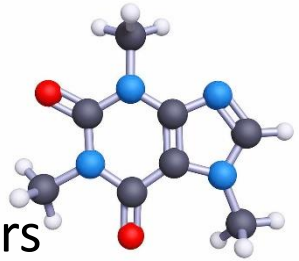
Opportunity: Exploit complexity to build quantum computers

→ engineer new materials (energy)

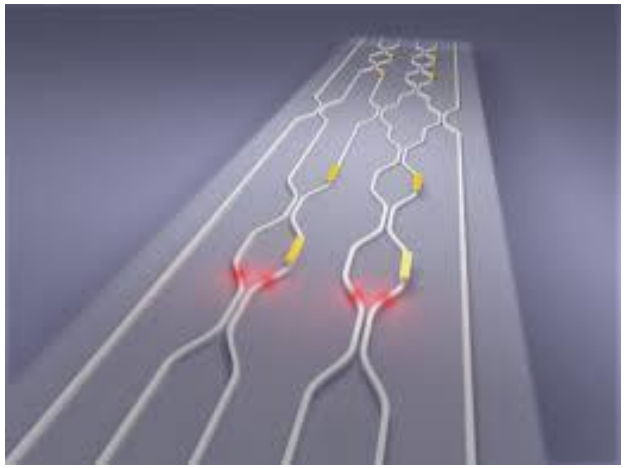
→ drug discovery (health)

→ break encryption systems (security)

→ big data, machine learning etc (e.g., logistics)



Caffeine
$C_8H_{10}N_4O_2$



Nature isn't classical, dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical, and by golly it's a wonderful problem, because it doesn't look so easy.

R.P. Feynman (1982)