

# Hello, Quantum World!

Jules May

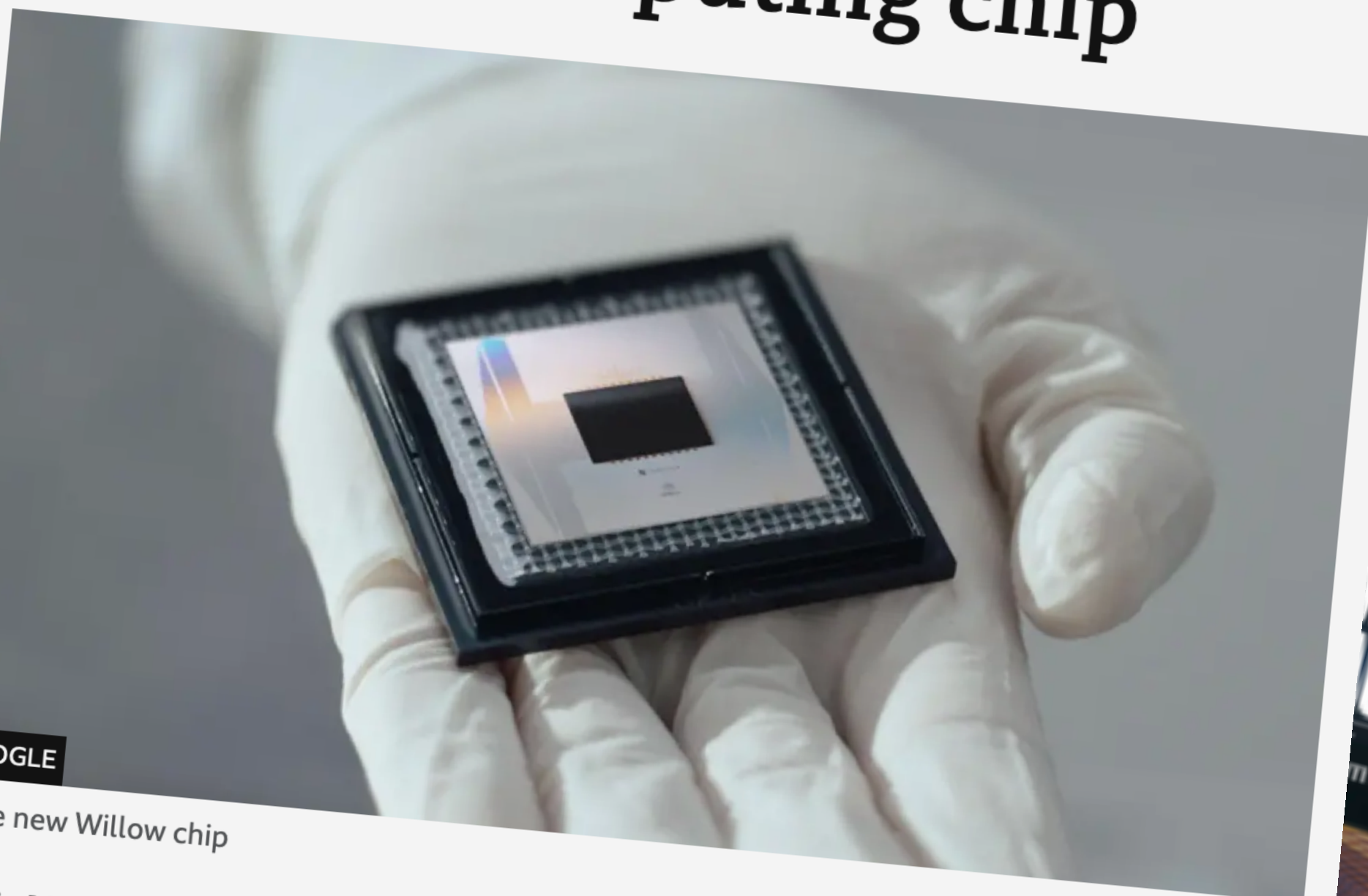


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Technology

# Google unveils 'mind-boggling' quantum computing chip



GOOGLE | The new Willow chip

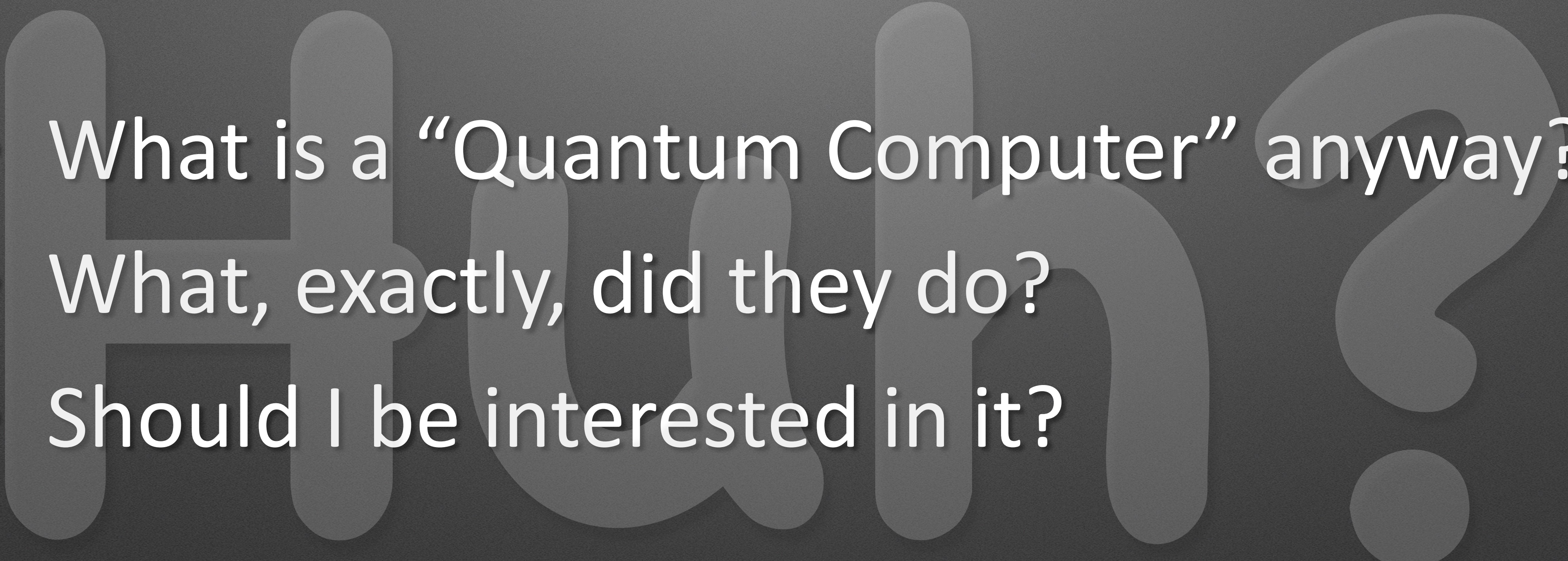
**Chris Vallance**  
Senior Technology Reporter

9 December 2024

Google has unveiled a new chip which it claims takes five minutes to solve a problem that would currently take the world's fastest super computers ten septillion – or 10,000,000,000,000,000,000,000 years – to complete. The chip is the latest development in a field known as quantum computing which is attempting to...

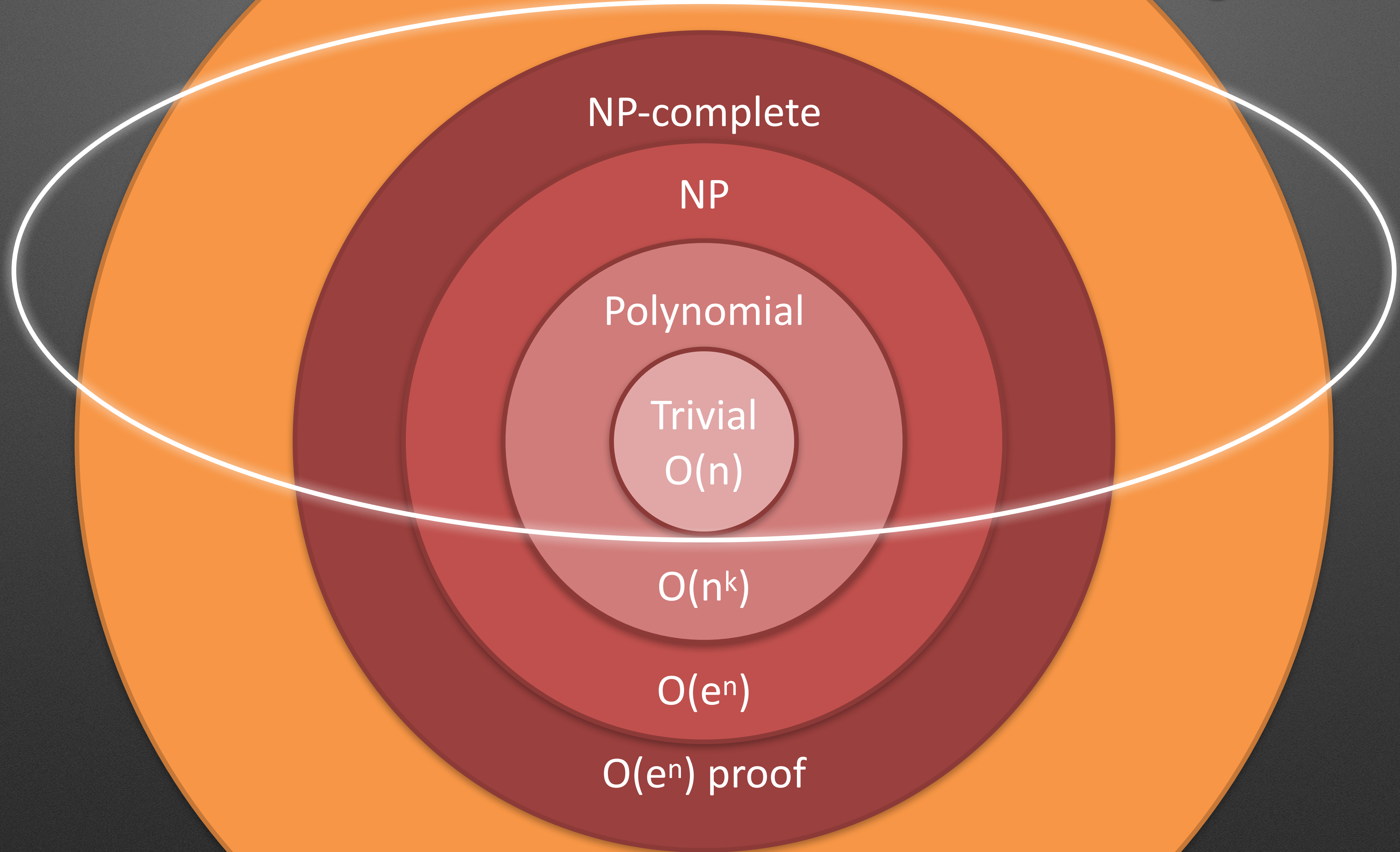


Huh?

- 
- What is a “Quantum Computer” anyway?
  - What, exactly, did they do?
  - Should I be interested in it?

**What's wrong with classical computers?**

# What's wrong with computers?





# A brief history

- 1982: Feynman proposed a quantum computer
- 1985: David Deutsch developed the Universal Quantum Machine (Quantum Turing Machine)
- 1994: Shor's factorisation algorithm
- 1997: Grover's search algorithm
- 2001: First quantum computer (7 bits)

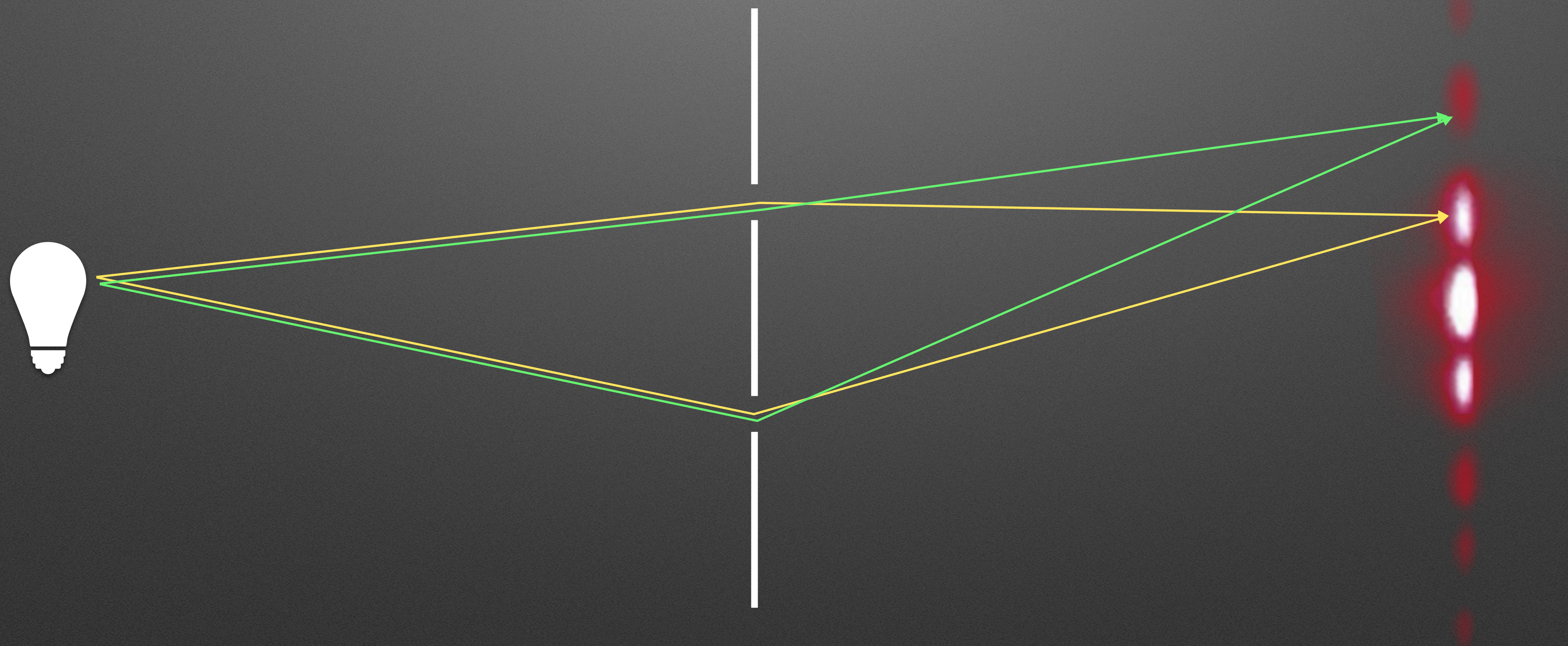




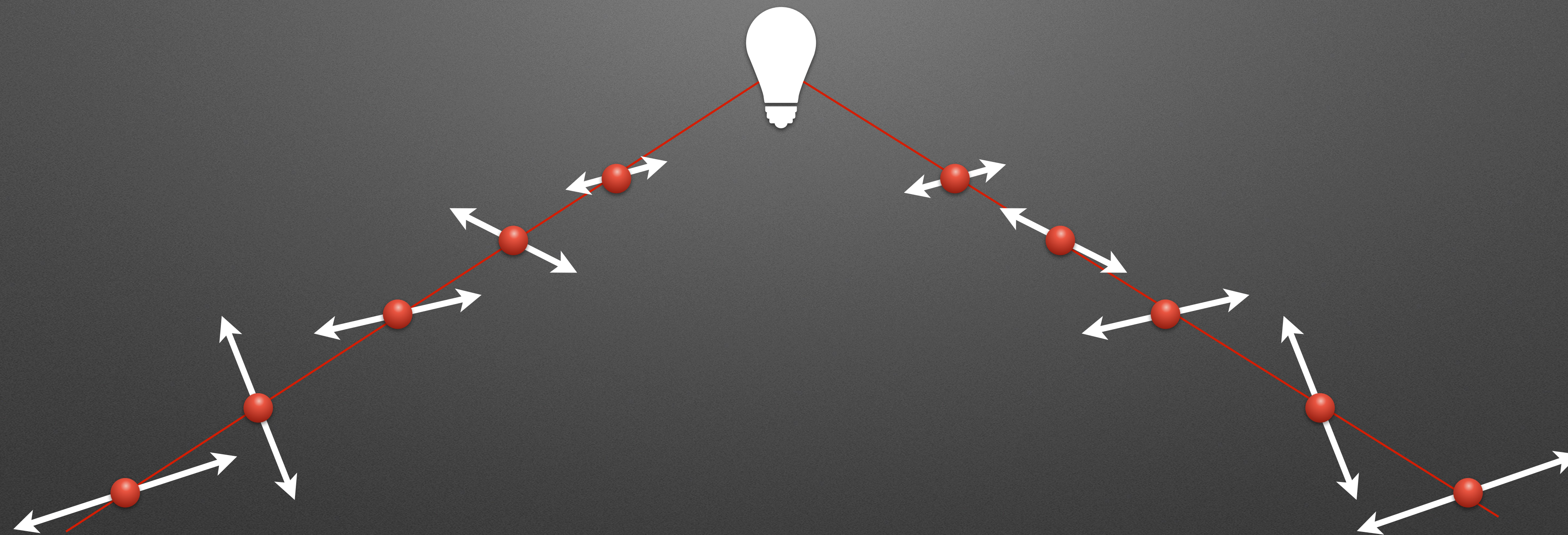
# How is the QC used?



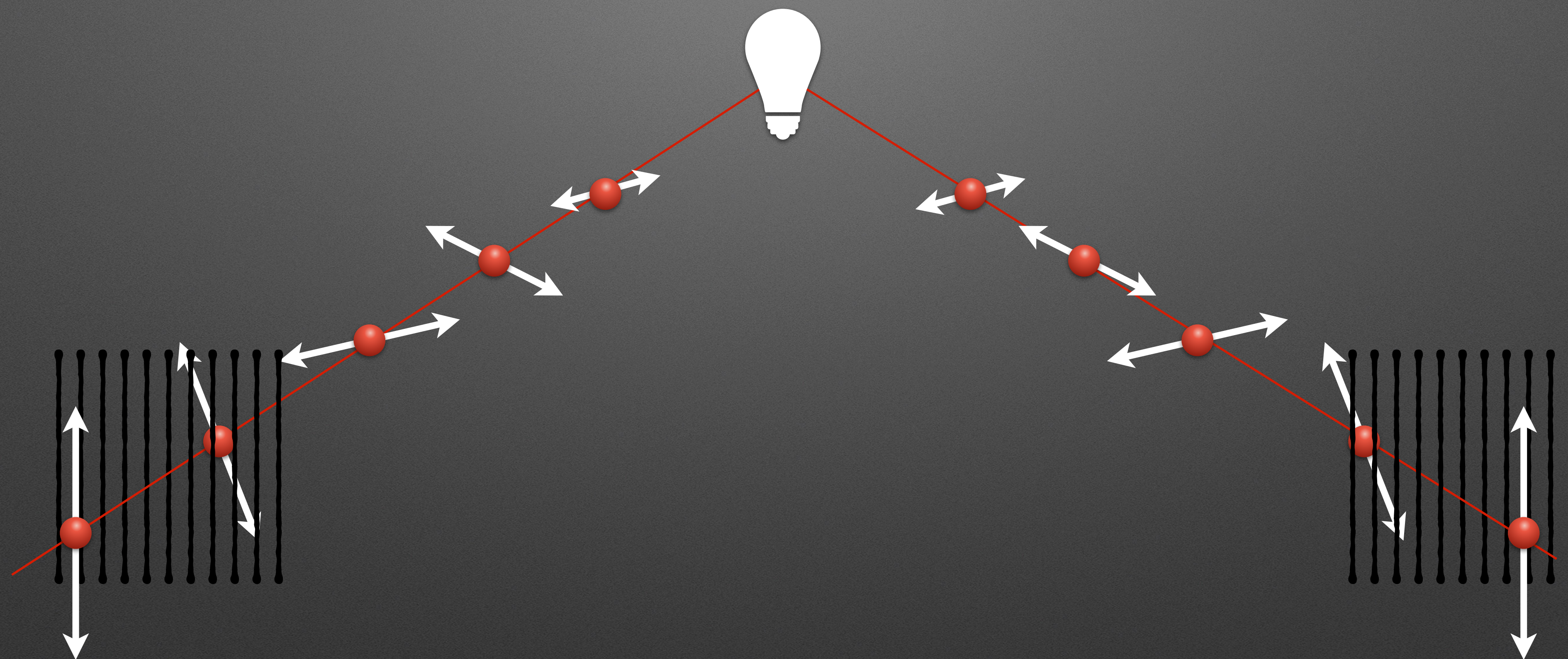
# Superposition and collapse



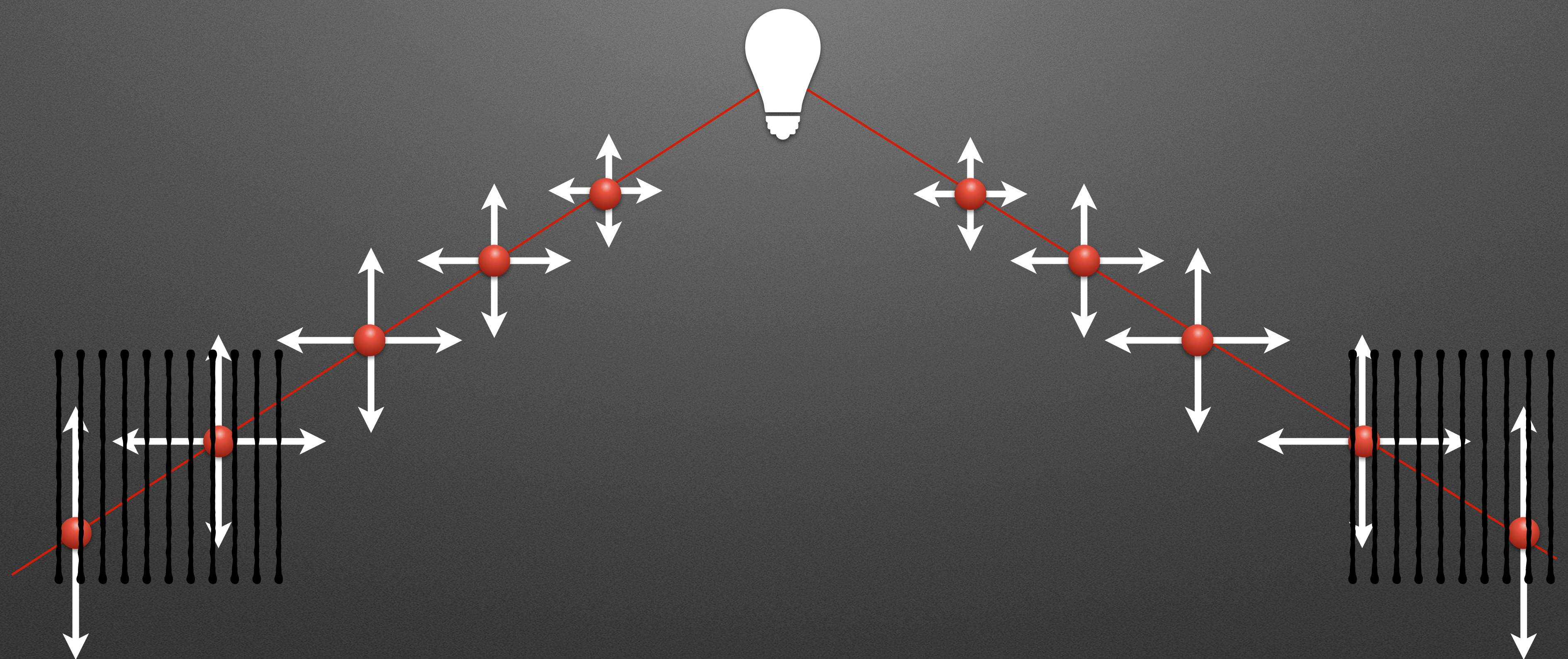
# Entanglement



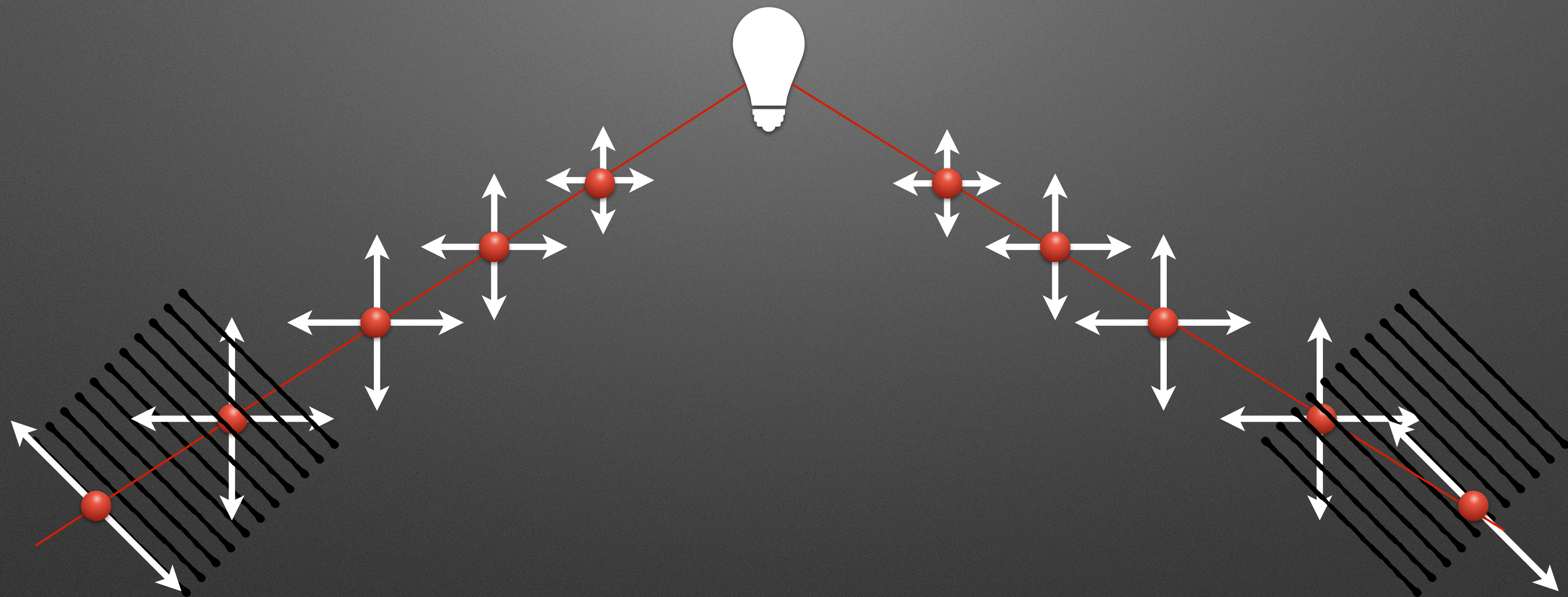
# Entanglement



# Entanglement



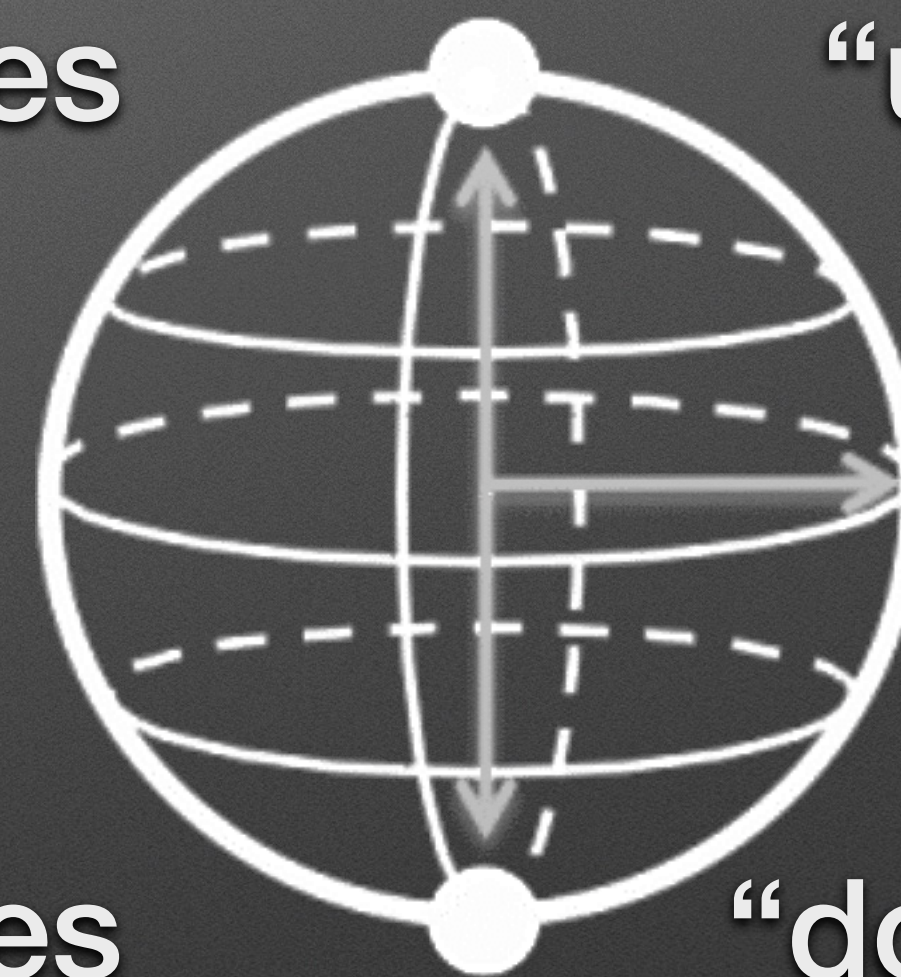
# Entanglement



# Qubits



“1” states



“up”

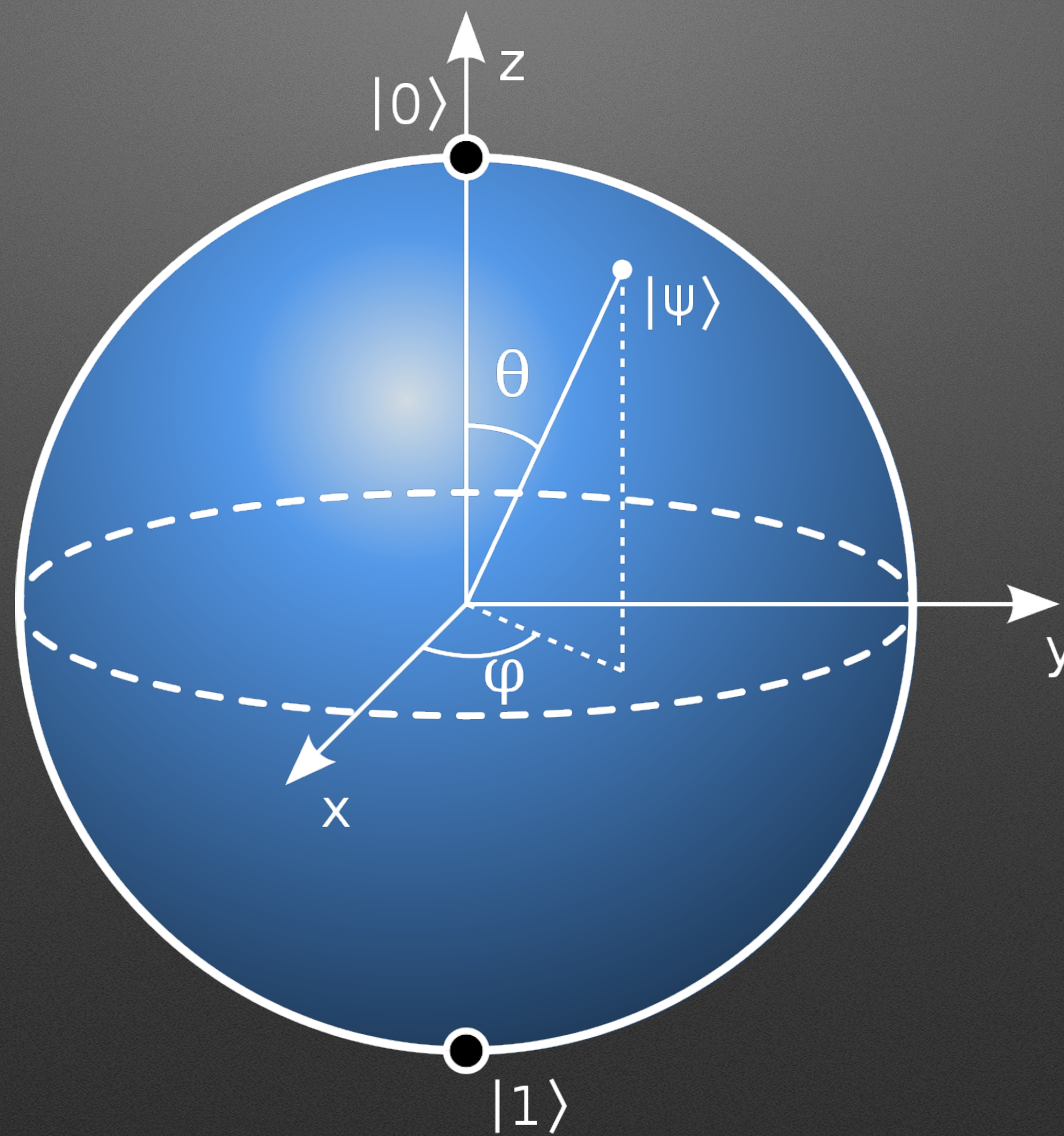
“0” states

“down”



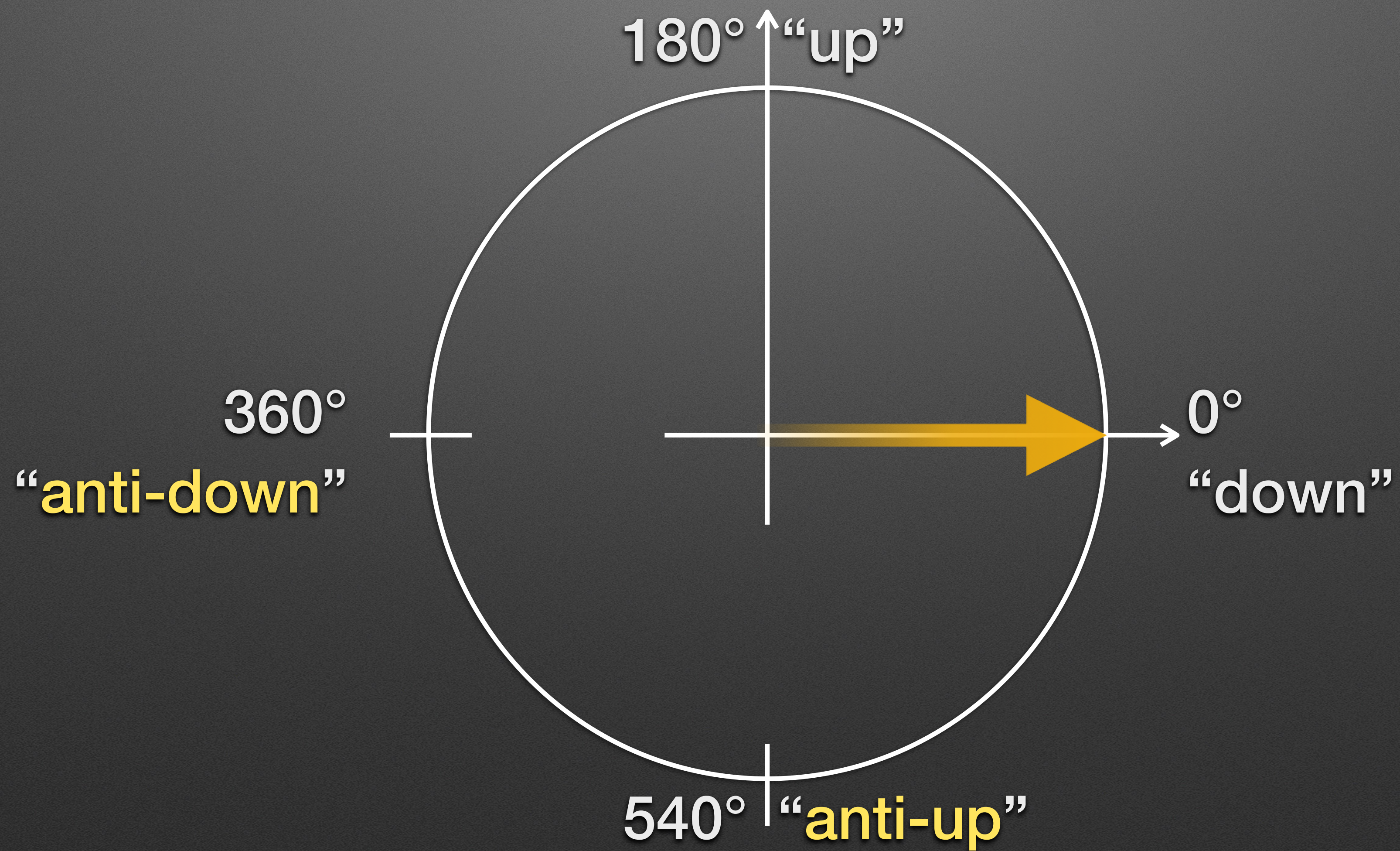
# Qubits

The Bloch sphere

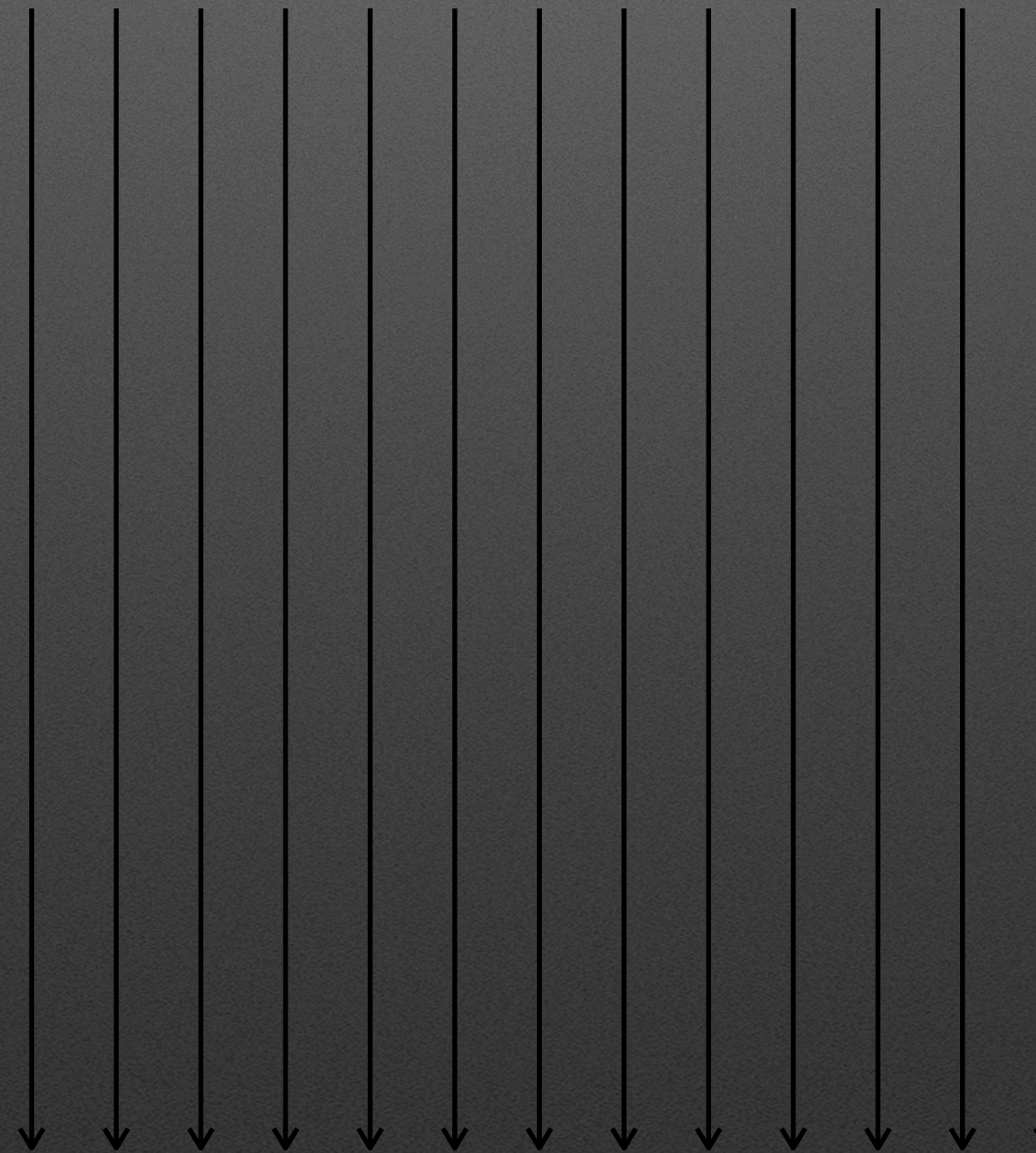
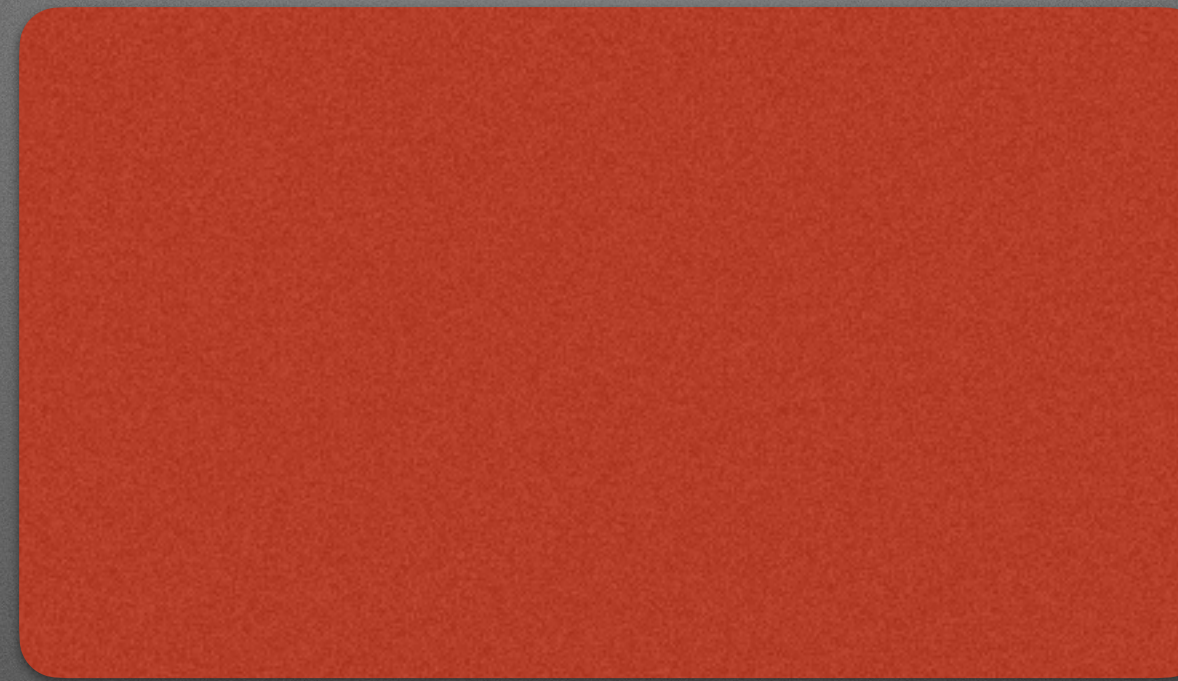
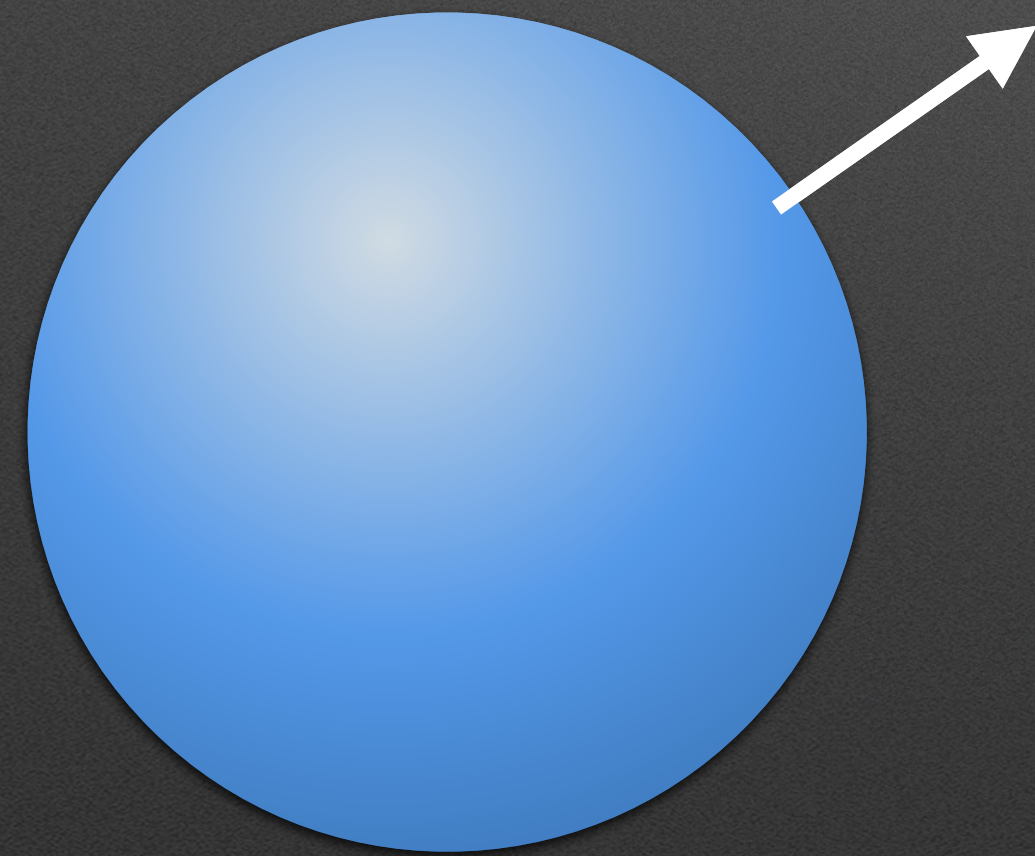


# Qubits

The Lie field



# Collapsing the Qubit



# So, what does a quantum computer do?

- Construct a problem definition by initialising qubits *May be a superposition*
- Transform the problem, using a combination of:
  - rotations
  - entanglements*This is the program*
- Collapse the transformed problem *Generate a possible result*

*Rinse and repeat*

**Demo**

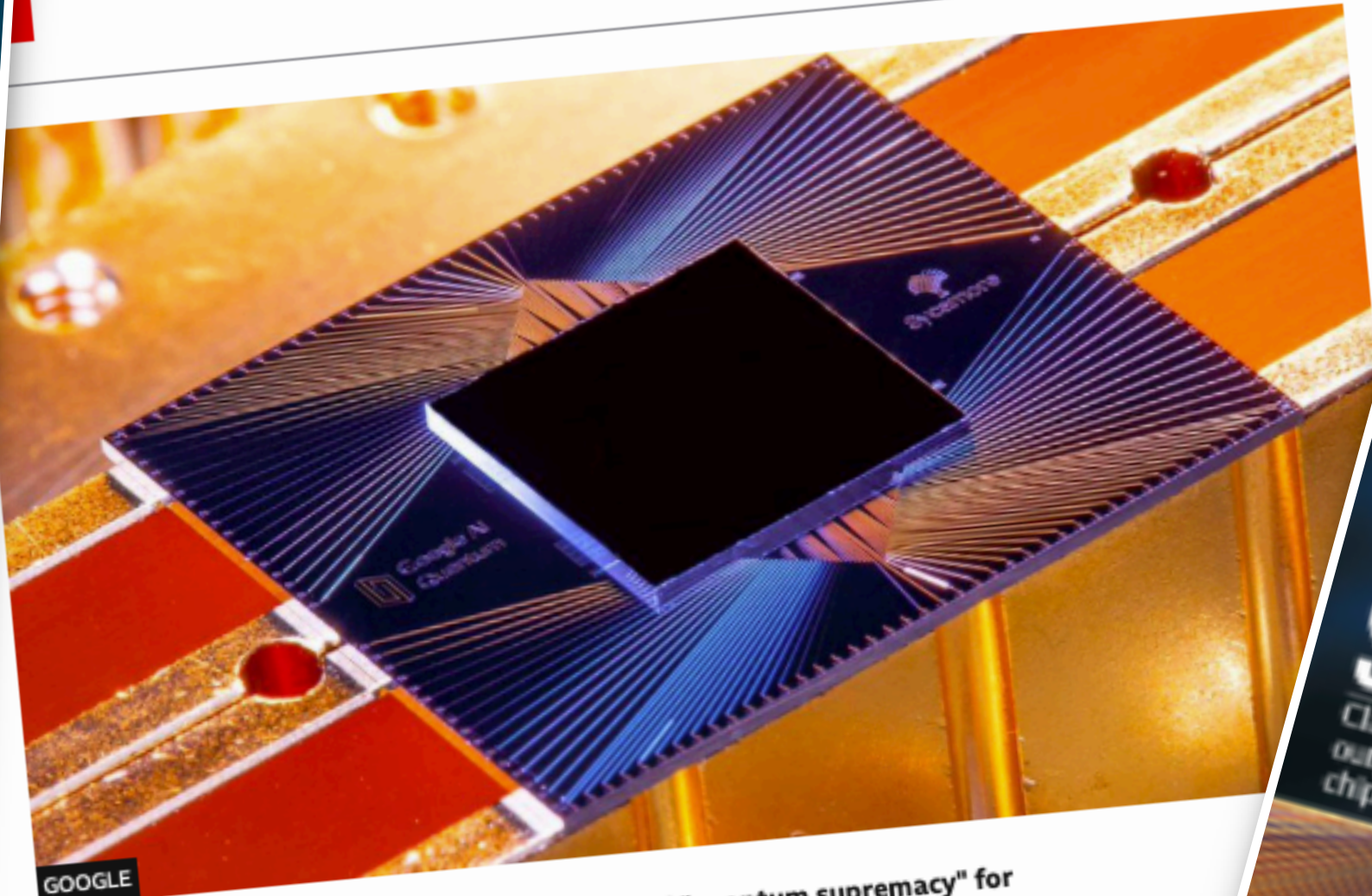


Environment

# Google claims 'quantum supremacy' computer

Rincon  
 editor, BBC News website

October 2019 | Comments



**GOOGLE**

**Google says an advanced computer has achieved "quantum supremacy" for the first time, surpassing the performance of conventional devices.**

The technology giant's Sycamore quantum processor was able to perform a specific task in 200 seconds that would take the world's best supercomputer 10,000 years to complete.

Scientists have been working on quantum computers for decades because they promise much faster speeds.

**The result appears in Nature journal.**

In classical computers, the unit of information is called a "bit" and can have a value of either 1 or 0. But its equivalent in a quantum system - the qubit - can be 1 and 0 at the same time.



### Quantum computer chips demonstrated at the highest temperatures

### IBM is using quantum to generate Minecraft-like worlds

### Honeywell claims it has built the most powerful quantum computer ever

### A quantum computer that measures light has achieved quantum supremacy

### Quantum internet signals beamed between drones a kilometre apart

### First ever quantum chess tournament won by Amazon

### City-wide quantum data network in China is the largest ever built

### Quantum computer helps to design quantum computer

### Google demonstrates victory towards large-scale quantum computers

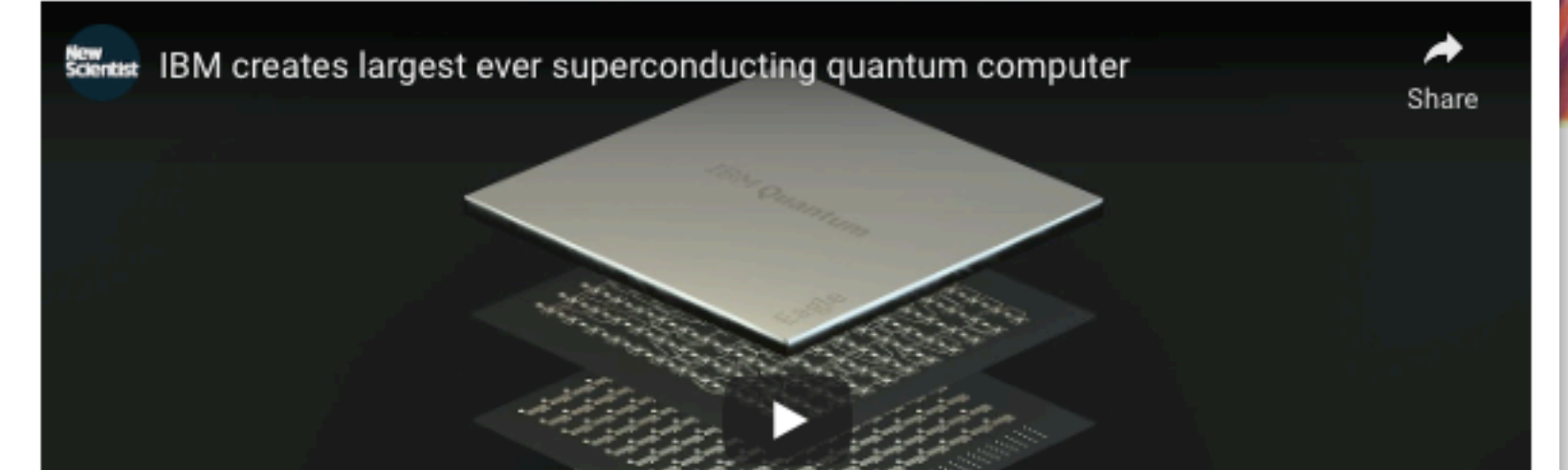
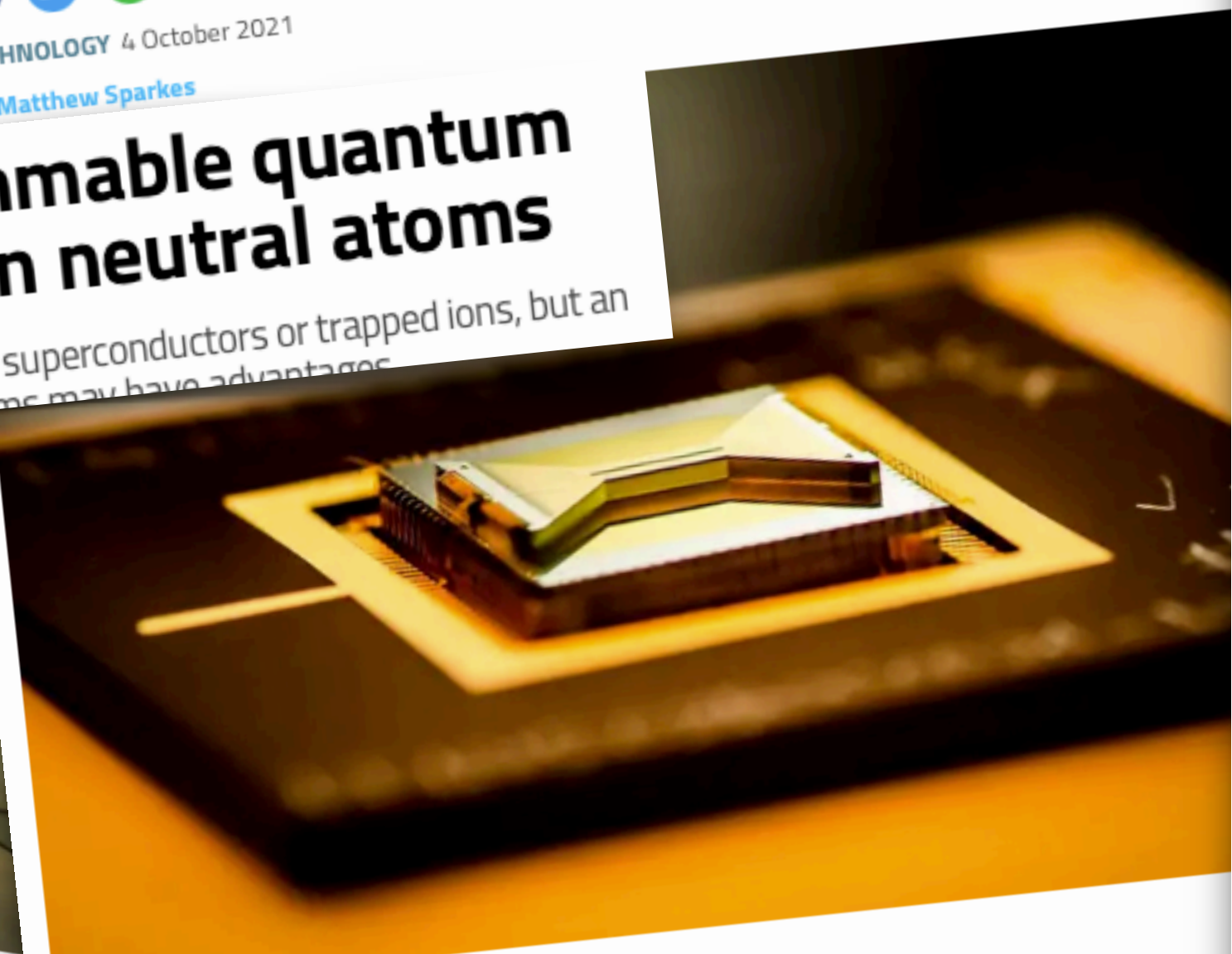
### Quantum computers can now fix their own mistakes without making more

### IBM creates largest ever superconducting quantum computer

### First fully programmable quantum computer based on neutral atoms

Most quantum computers are based on superconductors or trapped ions, but an alternative approach using ordinary atoms may have advantages

IBM has made a 127-qubit quantum computer. This is over double the size of comparable machines made by Google and the University of Science and Technology of China



Google's Sycamore quantum computer  
Rocco Ceselin/Google  
Google has shown that its Sycamore quantum computer is an essential step for large-scale quantum computing because it solves

IBM creates largest ever superconducting quantum computer

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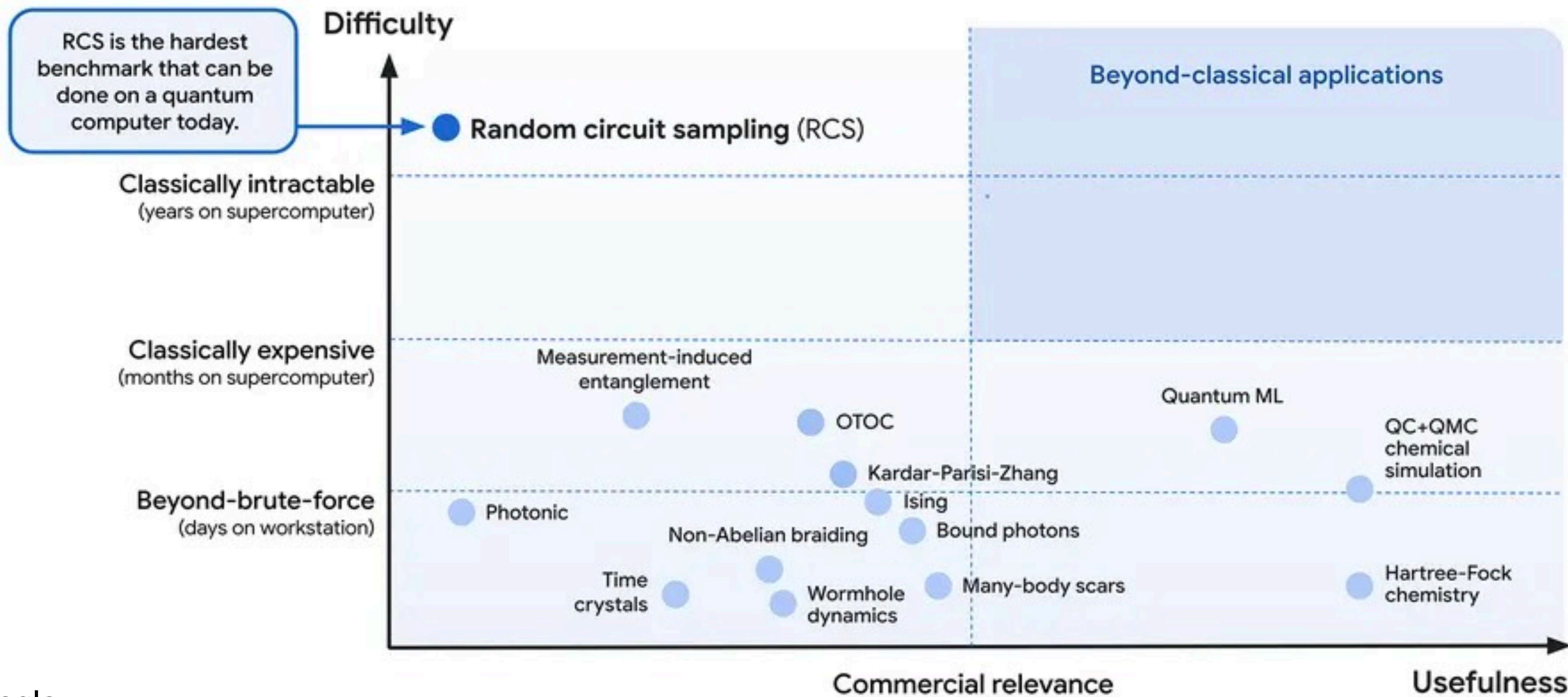




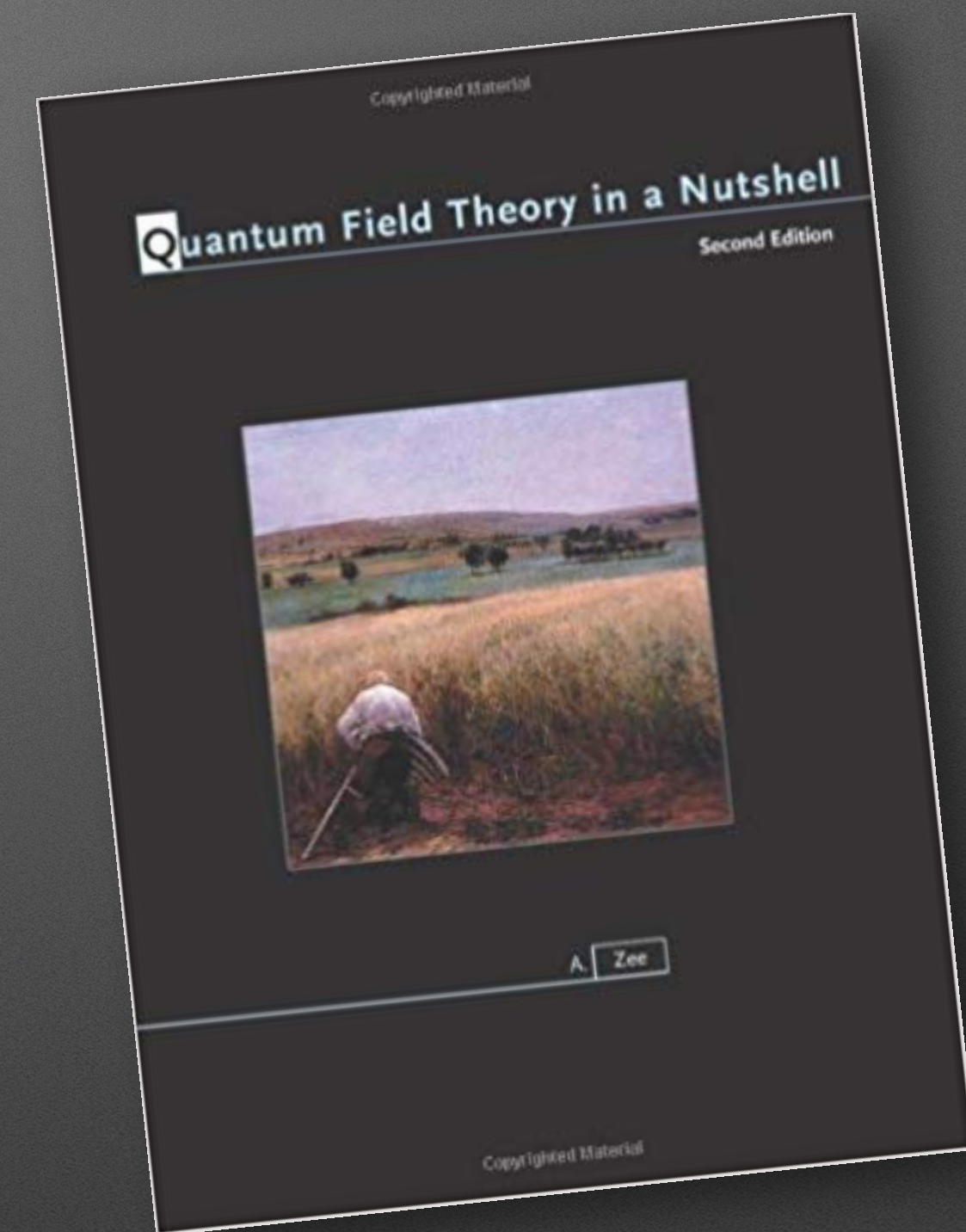
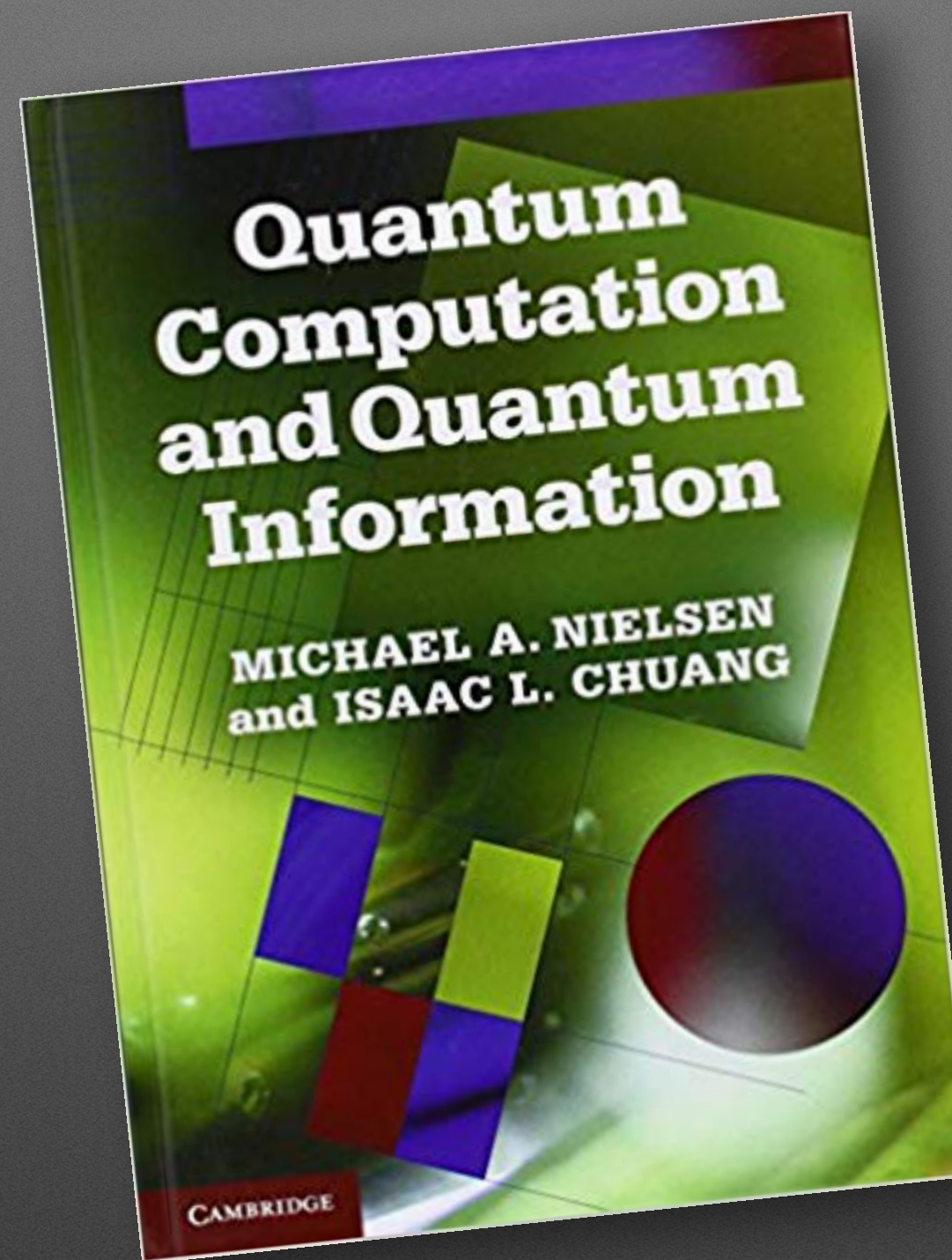
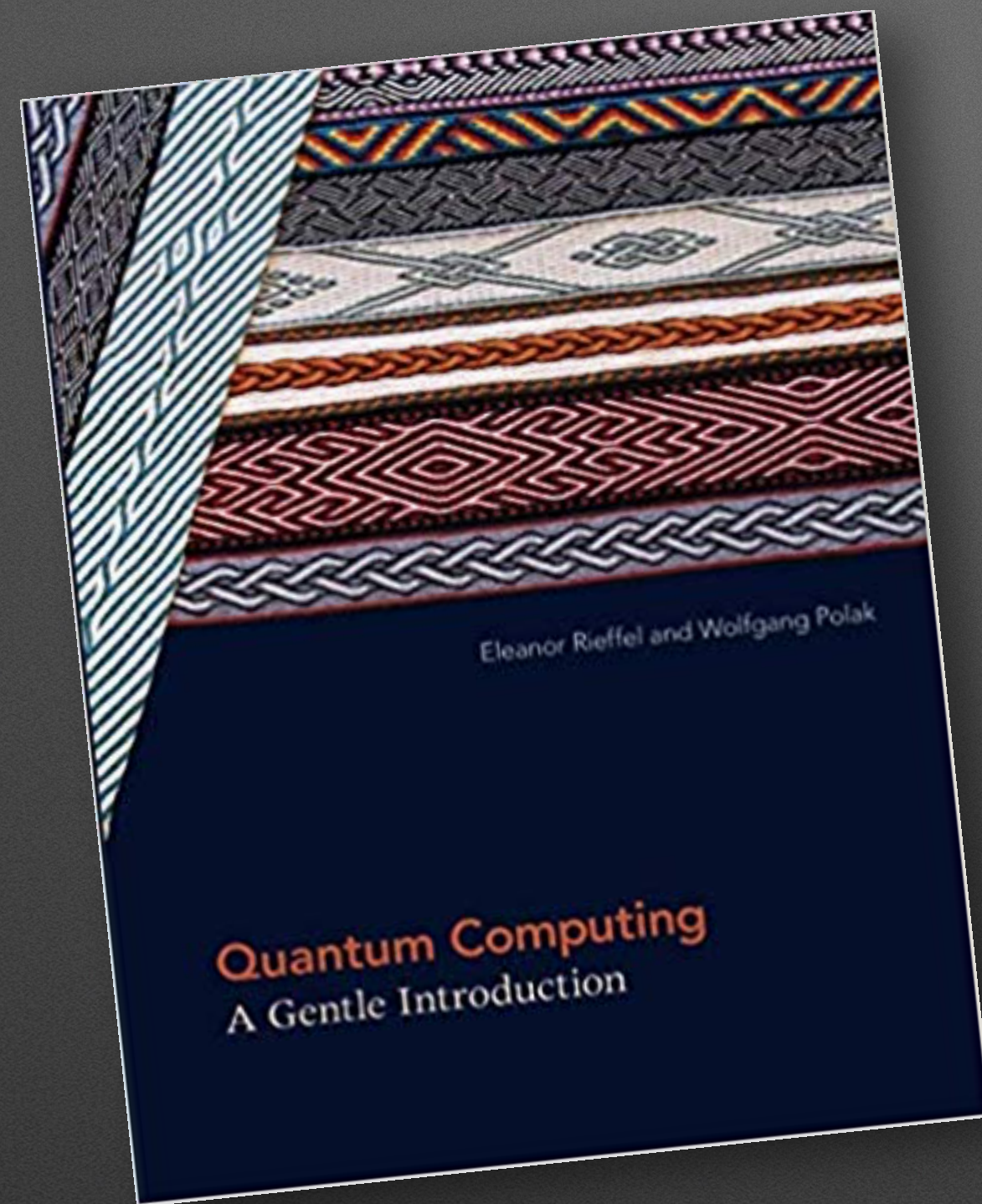
# What's been going on?

- Engineering
  - Scale
  - High temperature
  - Error Correction
- Applications
  - Physical modelling (chemistry, weather, etc)
  - Optimisation
  - Financial
  - AI
- Security
  - Cracking current encryption
  - Quantum-secure classical encryption
  - Quantum communication

# Today



# Resources



<https://quantum.ibm.com/>

[https://en.wikipedia.org/wiki/Quantum\\_computing](https://en.wikipedia.org/wiki/Quantum_computing)

<https://blog.google/technology/research/google-willow-quantum-chip/>