



Quantum Computing & Data Security: *Hype vs Reality*



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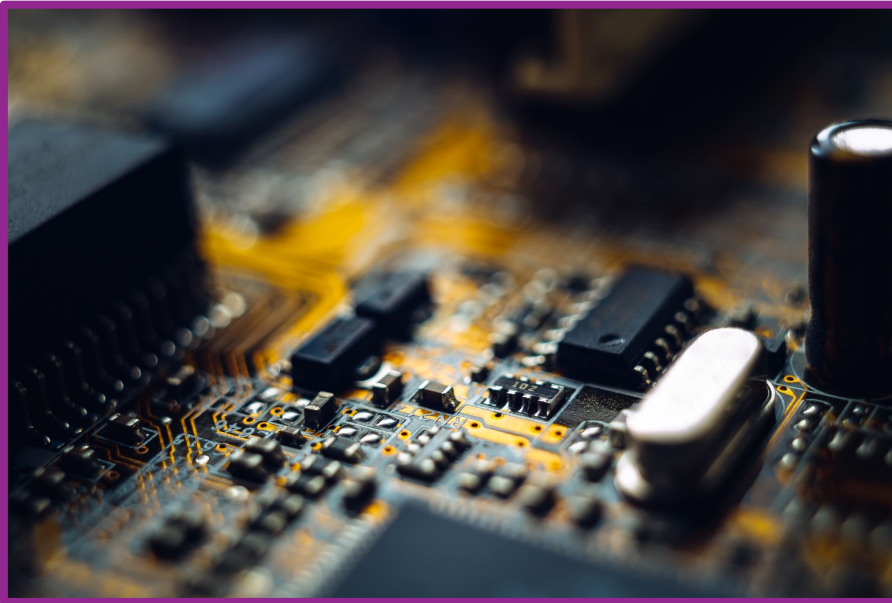
Katanya B. Kuntz, PhD
Founder & CEO

12 November 2025

What is the 2nd Quantum Revolution?

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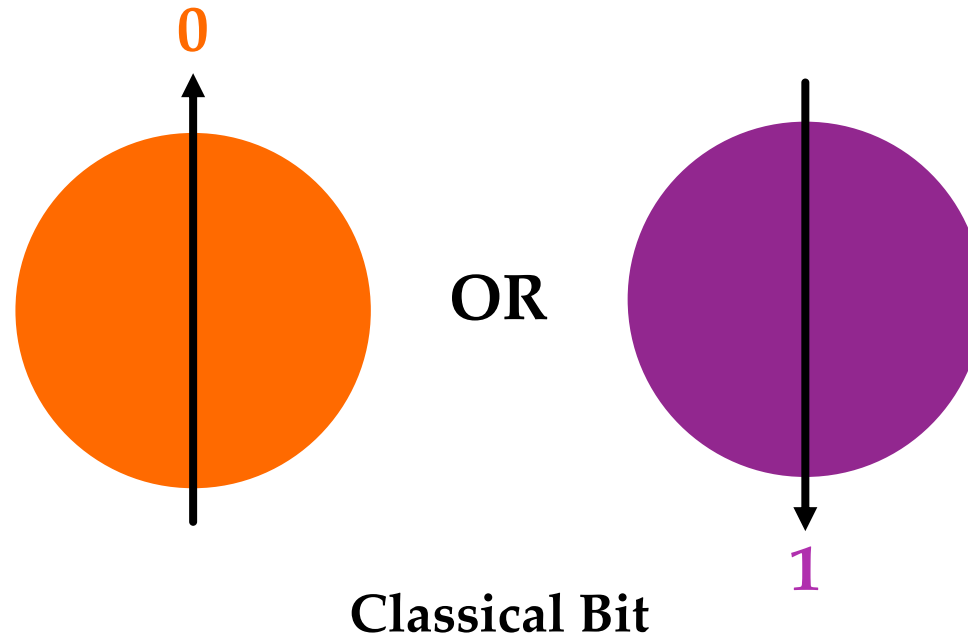
- ❏ Wait... What do you mean the **second** Quantum Revolution? When was the 1st revolution?!
- ❏ The **modern electronics** (TVs, computers, cellphones, solar cells, electric cars, LEDs, lasers, ...) we use in every day life were created thanks to the **first Quantum Revolution**.
- ❏ The **Second Quantum Revolution** is using quantum elements/devices (like atoms, photons, superconducting circuits, ...) to **do** the Computing, Sensing, Memory, Communication,



Myth: AI is Quantum...

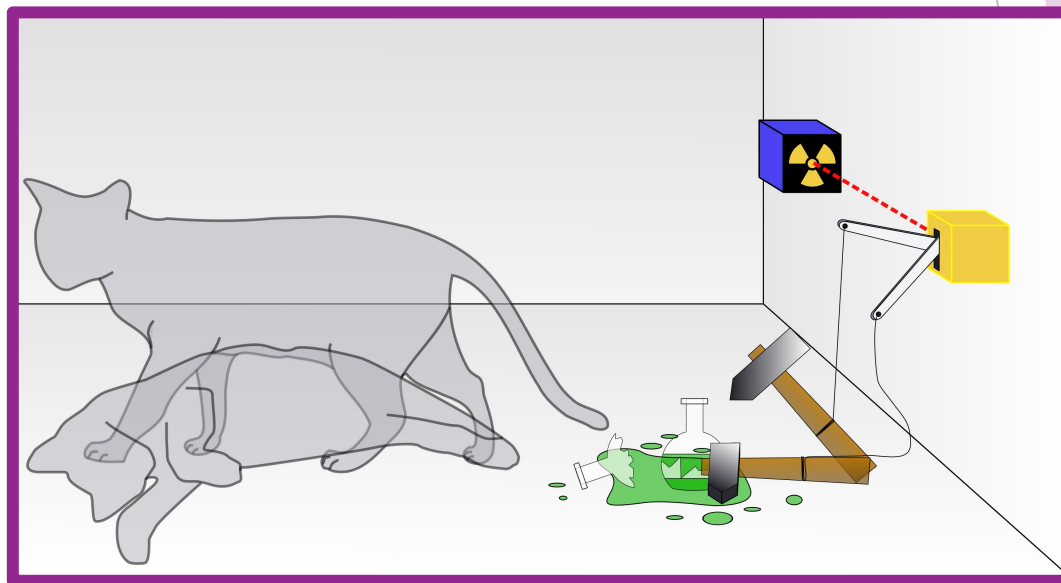
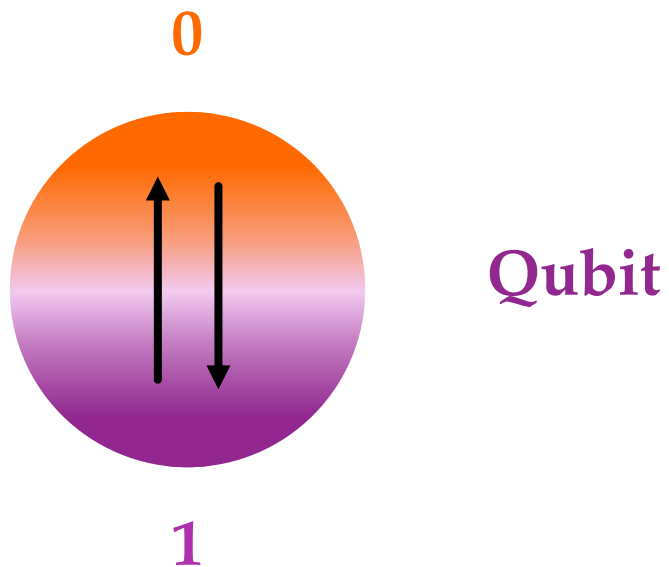
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- ❑ AI is **NOT** a Quantum Technology!
 - ❑ AI is a collection of Classical (traditional) Computers working together
 - ❑ Information is stored & processed as Bits (0 or 1)



Myth: AI is Quantum...

- ❏ Whereas a **Quantum Computer** uses **Quantum Bits (qubits)** to store & process information
 - ❏ Qubits exist in a **combination (superposition)** state of 0 and 1
 - ❏ Qubits can be individual atoms, spin of an electron, particles of light (photons), superconducting circuits, NV-centres, ...

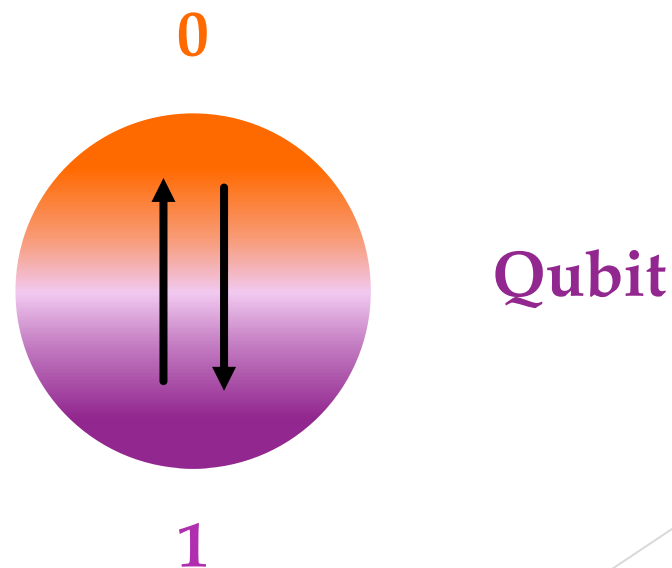
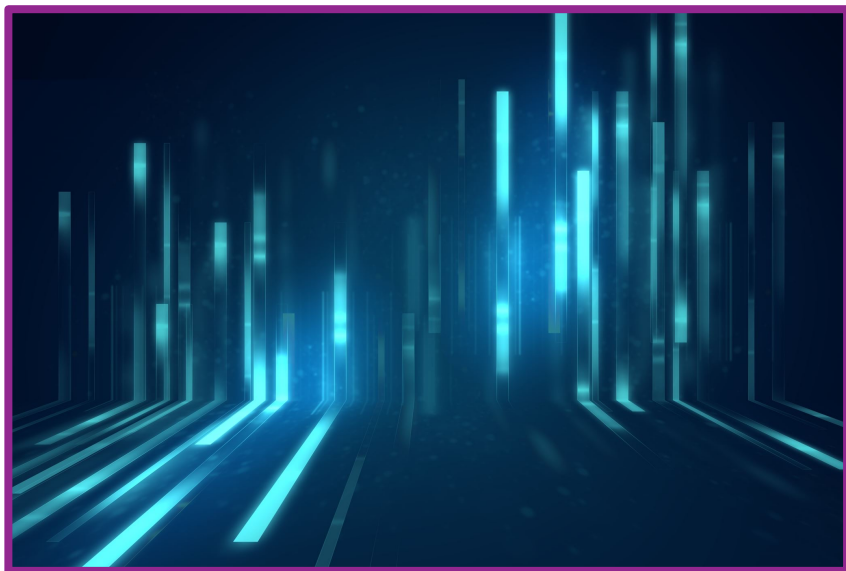


By Dhatfield - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=4279886>



What is a Quantum Computer?

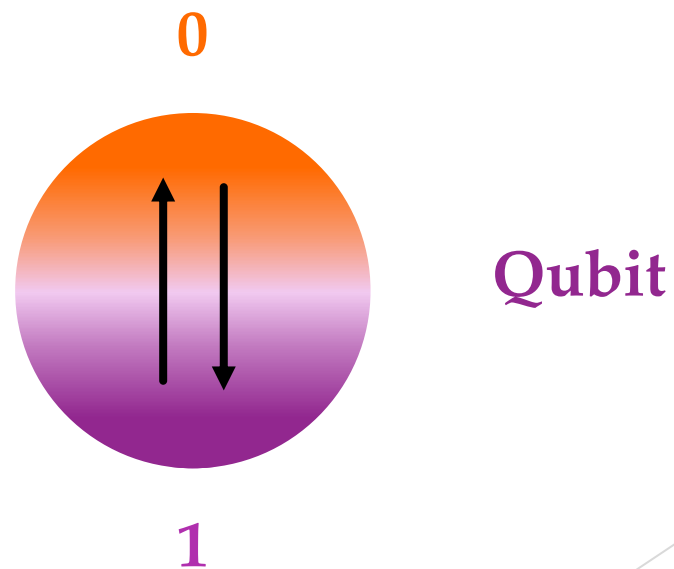
- Special quantum properties allow a **Quantum Computer** to potentially have **significantly more computational power** compared to a classical computer
- Quantum computers may be able to **solve some problems faster and more efficiently** (i.e. **Shor's algorithm, Grover Search**, etc.)



What is a Quantum Computer?

❏ The Quantum Threat: Harvest Now, Decrypt Later (HNDL)

- ❏ A Quantum Computer could potentially be able to hack some current Public Key encryption methods (RSA, elliptical curve, ...).
- ❏ **Quantum-safe encryption:** Post-Quantum Cryptography (PQC), Quantum Key Distribution (QKD)



What is a Quantum Computer?

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- ❏ Lots of people think this is **Quantum Computer...**
- ❏ But this is actually the *FRIDGE* to run a certain type of Quantum Computer!

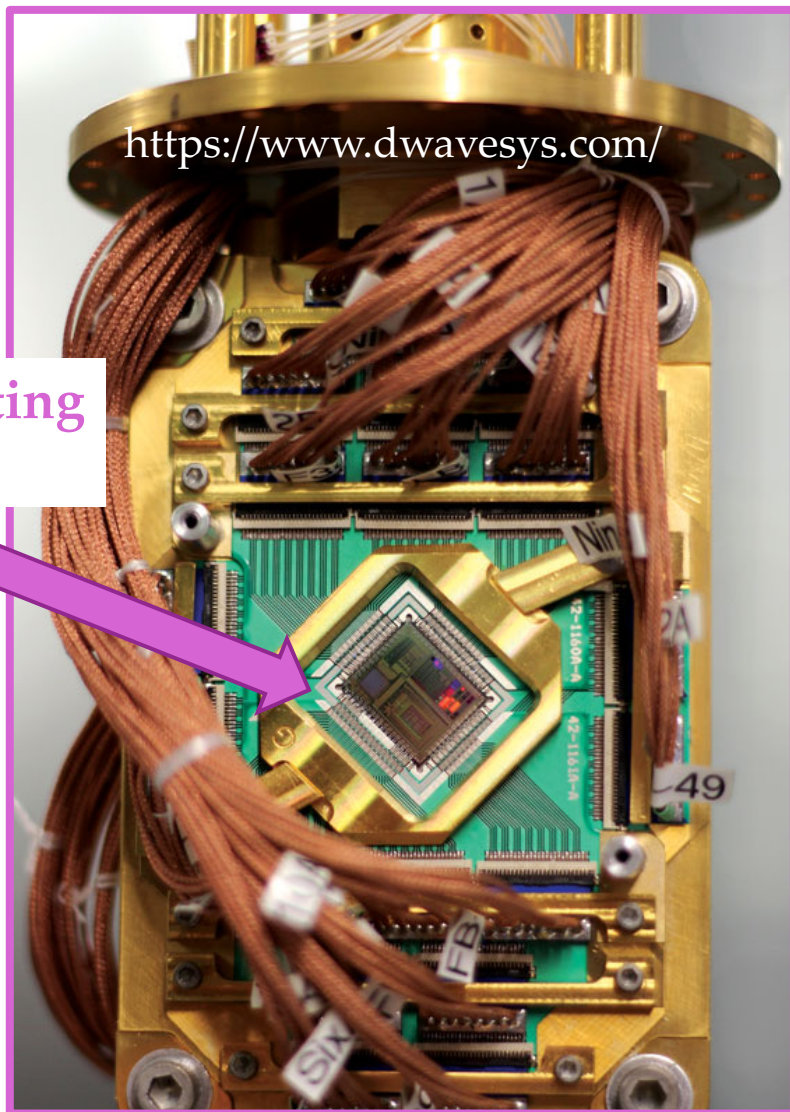


Cryogenic Fridge!

<https://www.forbes.com/sites/karlfreund/2023/06/14/ibm-achieves-breakthrough-in-quantum-computing/>



What is a Quantum Computer?



Superconducting
Circuit



Cryogenic Fridge

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Quantum Computing with Superconducting Qubits

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❏ Companies like **Zero Point Cryogenics** (ZPC) (Edmonton, Alberta) build cryogenic fridges for Quantum Technologies like

- ❏ Quantum Computers
- ❏ Quantum Memories
- ❏ Quantum Sensors...



**ZERO POINT
CRYOGENICS**

<https://www.zpcryo.com/>



What is a Quantum Sensor?

- ❏ **Quantum Sensing** is when a measurement is done that is enhanced (**better sensitivity**) due to **quantum properties**
 - ❏ Using **quantum objects** like atoms, photons, electron spin, superconducting circuits, etc., to do the measurement.
 - ❏ Or exploiting quantum properties like **entanglement, superposition, quantum tunneling, ...**



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- ❏ **Examples of properties that Quantum Sensors can detect:**
 - ❏ Gravity fields
 - ❏ Magnetic/Electric fields
 - ❏ Single photons – detectors like an Avalanche Photodiode (APD) or Superconducting Nanowire Single Photon Detector (SNSPD)
 - ❏ Hidden objects
 - ❏ Time – more precise atomic clocks, GPS
 - ❏ Temperature
 - ❏ Movement – Accelerometers
 - ❏ Gases





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Quantum Optimization:

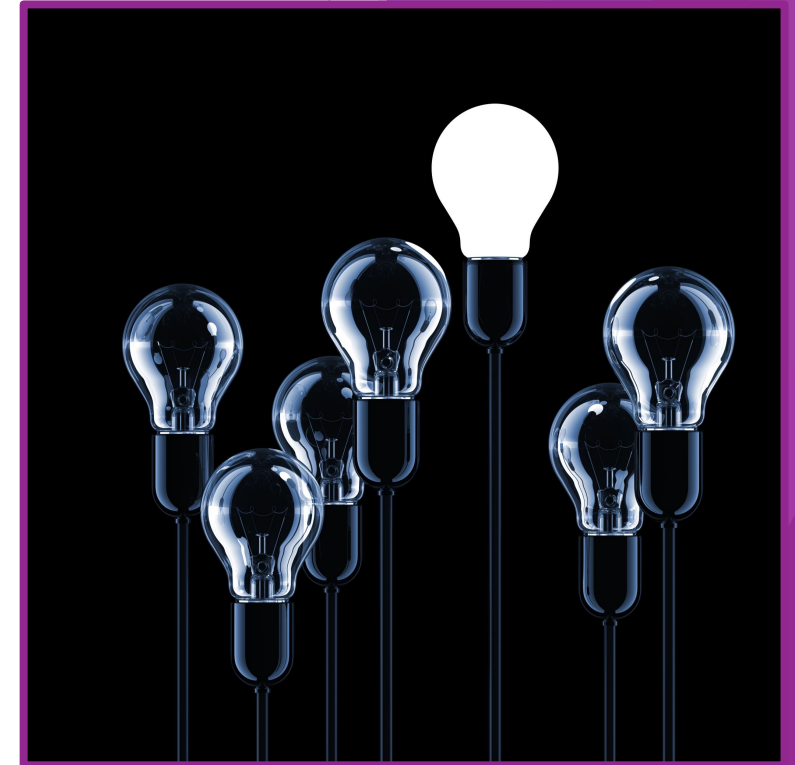
Energy Use Cases



Civil Engineering Use Cases – *Energy*

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- ❏ **Quantum Optimization & Simulation** have the potential to improve efficiencies in:
- ❏ **Decentralized energy generation & transmission:** Navigating complex dynamic changes in both supply & demand by **Load scheduling using dynamic pricing**
 - ❏ **Grid demands:** increasing energy use with new data centres, AI infrastructure; changing customer usage with electric vehicles, smart homes.



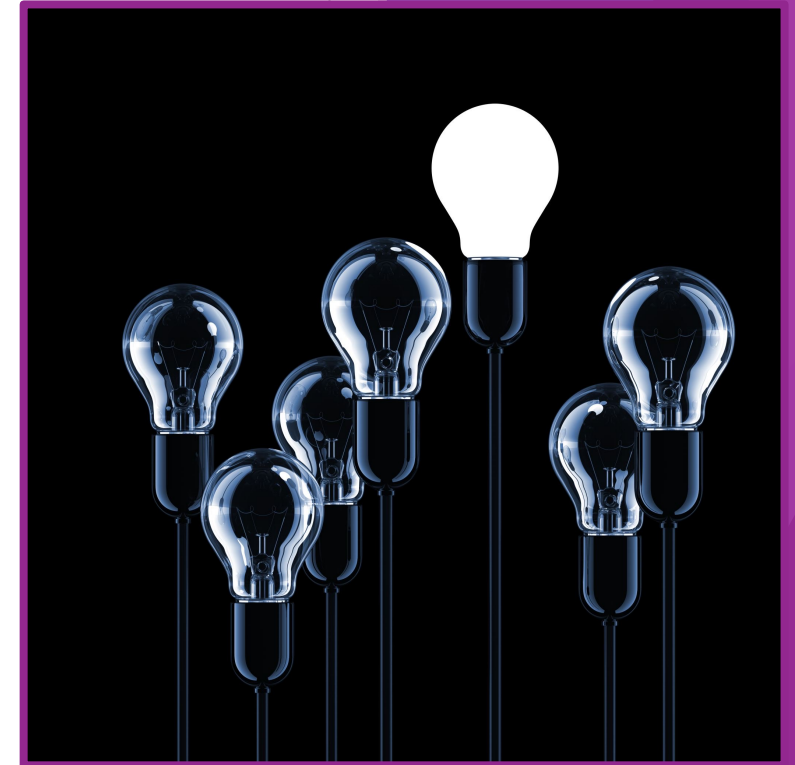
Civil Engineering Use Cases – *Energy*

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- ❏ **Grid demands:** increasing energy use with new data centres, AI infrastructure; changing customer usage with electric vehicles, smart homes.
- ❏ **Energy sources:** transitioning from traditional power plants (steady/predictable) to wind/solar/hydro (dynamic)
- ❏ **Climate change:** sudden heat wave or cold snap can significantly affect demand
- ❏ **Novel energy transportation & exchange methods:** Peer-2-Peer energy trading, microgrids



Civil Engineering Use Cases – *Energy*

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- ❏ It *was* straightforward to calculate the future cost to generate a megawatt made from traditional fuel sources...
- ❏ Now this calculation is **so complex that today's supercomputers struggle** to create accurate pricing models
- ❏ **Quantum computers** can handle **larger data sets & more parameters** to run complex optimization modelling



Civil Engineering Use Cases – *Energy*

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- ❏ Organizations like **E.ON** (one of Europe's largest energy companies) have to provide electricity at a fixed price, despite dynamic consumption rates & delivery costs
- ❏ Often there's a mismatch between the amount of energy bought in advance & the actual real-time demand, which is traded as **energy derivatives**
 - ❏ Pricing those derivatives requires **complex simulations**



Energy Case Study

- In the **Q-Grid project**, **Aqarios & E.ON** are investigating how **quantum computing** can be applied to problems in the energy section, including
- **Grid optimization** with multiple local sources & customers
 - **Dynamic Pricing**
 - **Microgrid Balancing** to maximize efficiency



AQARIOS

<https://aqarios.com/projects/>



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 - ❏ **Microgrid Balancing** to maximize efficiency
- ❏ **Quantum Solutions:**
 - ❏ **Advanced pre- & post-processing techniques** to boost optimization accuracy.
 - ❏ **Next-gen Novel quantum Pipeline** for highly efficient energy distribution.



AQARIOS

<https://aqarios.com/projects/>



Energy Case Study

- ❏ Project will systematically **evaluate quantum algorithms against classical optimization** algorithms to look for a “**quantum advantage.**”
- ❏ **Quantum Results:**
 - ❏ **87x speed improvement** over standard quantum/AI approaches.
 - ❏ **Future-proof Grid management** with novel quantum methods.



AQARIOS

<https://aqarios.com/projects/>





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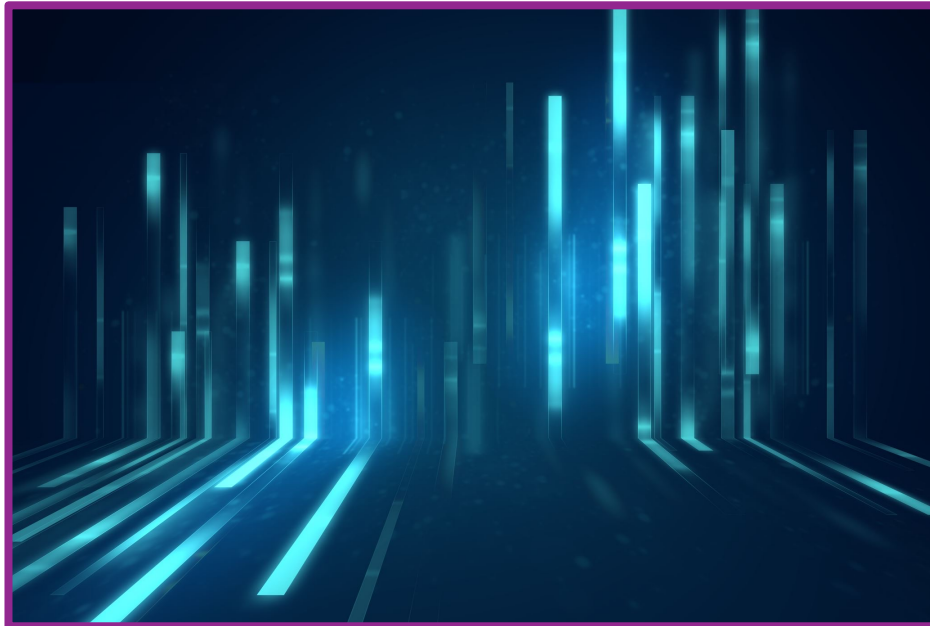
Quantum Key Distribution:

Introduction to Quantum Communication



What is the Quantum Threat?

- ❏ A **Quantum Computer** may be able to solve some problems faster and more efficiently than a classical (traditional) computer.
 - ❏ i.e. **Shor's algorithm**, **Grover Search**, etc.
- ❏ Special quantum properties allow a Quantum Computer to *potentially* be able to hack some current Public Key encryption methods (RSA, elliptical curve, ...).
- ❏ However, *quantum computers aren't better at everything...* Some operations are harder with qubits compared to classical bits (i.e. **Post-Quantum Cryptography (PQC)**).



What is the Quantum Solution?

- ❏ **Quantum Key Distribution (QKD)** is a quantum solution to the encryption threat.
- ❏ QKD is the *real-time generation* of an encryption key between two parties, usually called **Alice** (sender) and **Bob** (receiver), using particles of light (**single photons**).



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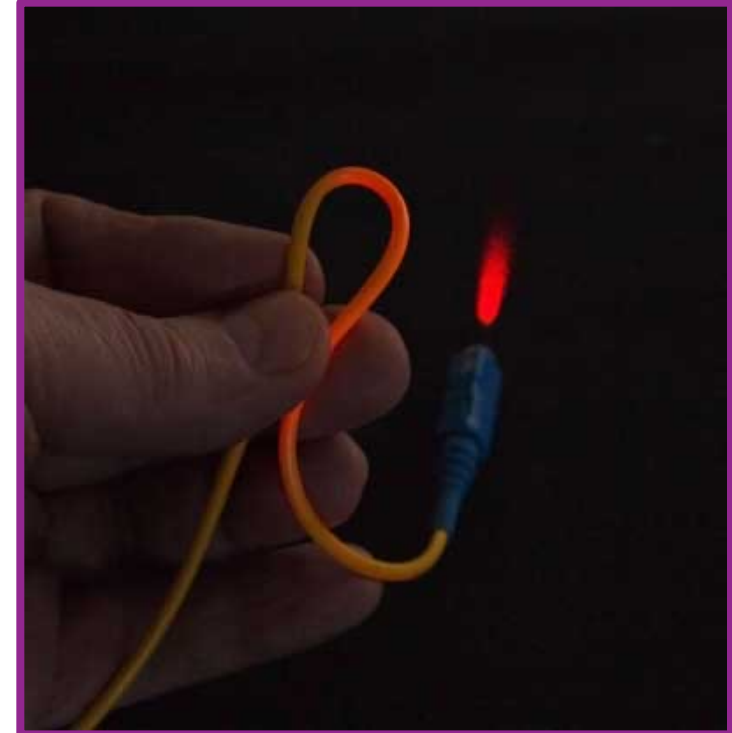
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- ❏ Once Alice & Bob have generated their **shared secret key** using single photons, they can use the key in “**one time pad**” **encryption** to secure their message (**theoretically 100% secure**).
- ❏ The security of QKD is not based on solving hard math problems (like factorizing large numbers). Rather it's based on **Physical Processes** that are not vulnerable to Quantum Computers!



What is the Quantum Internet?

Quantum Internet: Global quantum network connecting quantum-enabled devices, such as quantum sensors, quantum computers, quantum communication systems, etc.

- ❏ We can't just turn up the power or use classical amplifiers to increase the distance like we do for the classical internet.
 - ❏ A small percentage of light leaks out of the fibre core into the cladding, & is lost to the environment (**average 0.3dB/km at 1550nm**)
 - ❏ 'No Cloning Theorem' shows it's fundamentally not allowed by nature to make a perfect copy (amplify) of a quantum state.



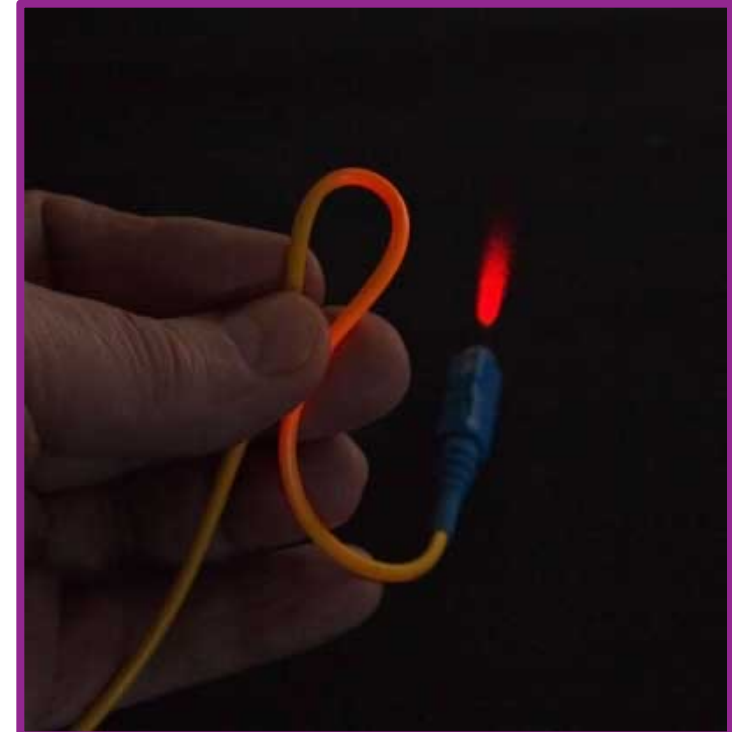
<https://www.thefoa.org/tech/ref/fiber/BIfiber.html>



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 - ❏ 'No Cloning Theorem' shows it's fundamentally not allowed by nature to make a perfect copy (amplify) of a quantum state.
- ❏ Solutions to extend the distance: **Quantum Repeaters/Memories, Non-Linear Amplifiers, ...**
 - ❏ These solutions require operations like *Entanglement Swapping* to transfer quantum information between carrier photons.

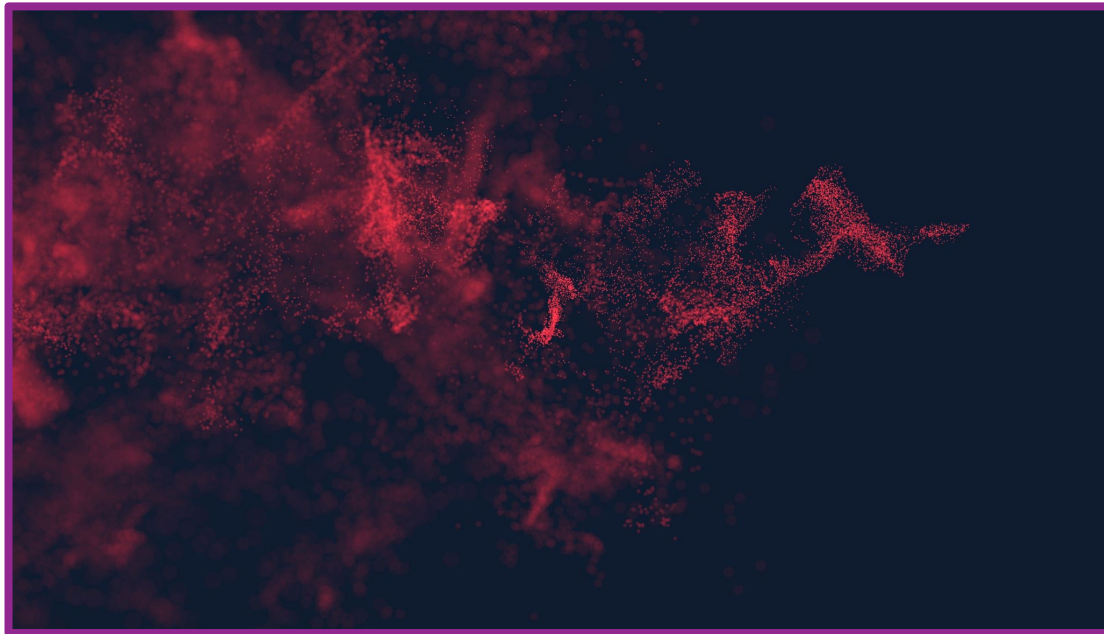


<https://www.thefoa.org/tech/ref/fiber/BIfiber.html>



Quantum Key Distribution

- ❏ Security of **Quantum Key Distribution (QKD)** is guaranteed by quantum properties:
 - ❏ Quantum information can be transferred but *never* copied (**No Cloning Theorem**).
 - ❏ **Measurement disturbs the System or State:** you know if an Eavesdropper is in the quantum channel because they will create errors.
 - ❏ A **single photon** (particle of light) cannot be 'split'; it is an **indivisible bundle of energy** that stores 1 qubit of information (or more if multiplexed state).



Quantum Key Distribution (QKD)

❏ **One Time Pad Encryption:** 100% secure if Encryption Key only used once!

...01100010101111001010...

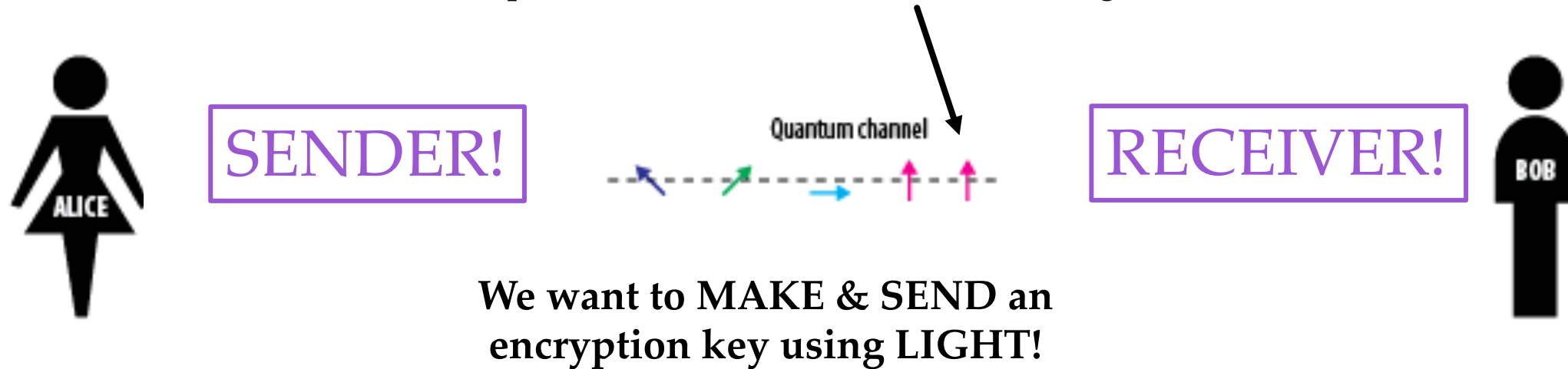
Message	Key	$M \oplus K = K_{\text{Secure}}$
0	0	0
0	1	1
1	0	1
1	1	0



BB84 Protocol (Charles Bennett & Gilles Brassard)

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Each arrow represents a different **Photon** travelling from Alice to Bob



We want to **MAKE & SEND** an encryption key using **LIGHT**!

01100010101111001010

- ❏ **Quantum Key Distribution:** Real time generation of Encryption Key between Alice and Bob!
- ❏ Each Photon carries 1 Qubit of Information!



How to get started? Quantum Training!

Q Qubo Consulting has partnered with the **Northern Alberta Institute of Technology (NAIT)** to offer two Quantum Certificate programs!

Q Next online cohort starts **18 November 2025!** *More sessions in Spring 2026*

Learn more!



Q **Quantum for Executives Certificate** (Non-technical) – 4 x 1hr courses
online live delivery with Dr Katanya Kuntz

- Q CCTM470: Quantum Solutions for Executives
- Q CCTM471: Quantum Computing Use Cases
- Q CCTM472: Data Security & Quantum Communication
- Q CCTM473: Quantum Sensing Use Cases

Q **Quantum for Engineers Certificate** (Technical) – 4 x 2hr courses
online live delivery with Dr Katanya Kuntz

- Q CCTM475: Quantum Intro for Engineers
- Q CCTM477: Intro to Quantum Computing Platforms
- Q CCTM478: Intro to Quantum Sensing Platforms
- Q CCTM479: Intro to Quantum Communication Platforms



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My Journey – 1st Optics Experiment!

📺 I made a **lightsaber** for my undergrad physics thesis project at Uof Calgary...

