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QTC301-R

How quantum key distribution and entanglement impact cloud security

David Levonian

Quantum Research Scientist
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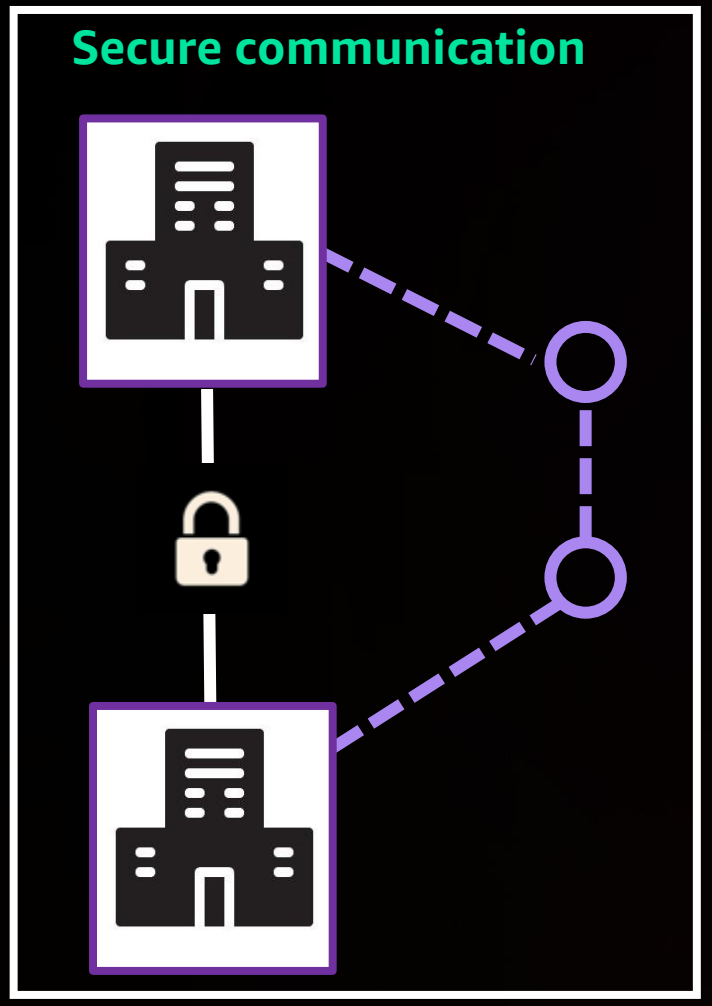
Cyrus Proctor

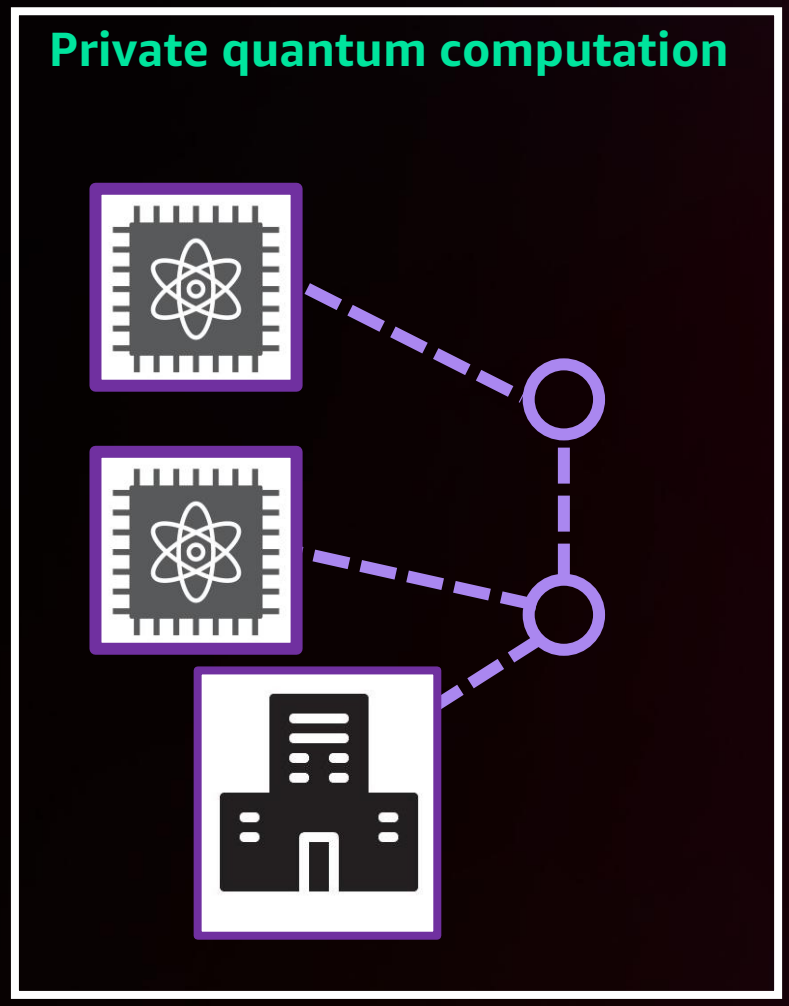
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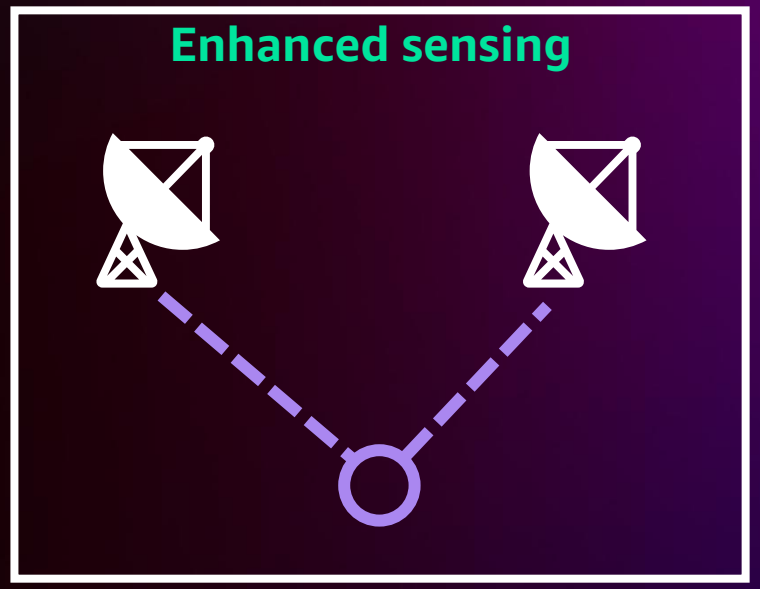
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Quantum networks

How can we use entangled pairs of quantum bits at distant locations?







Entanglement distribution

Quantum network nodes

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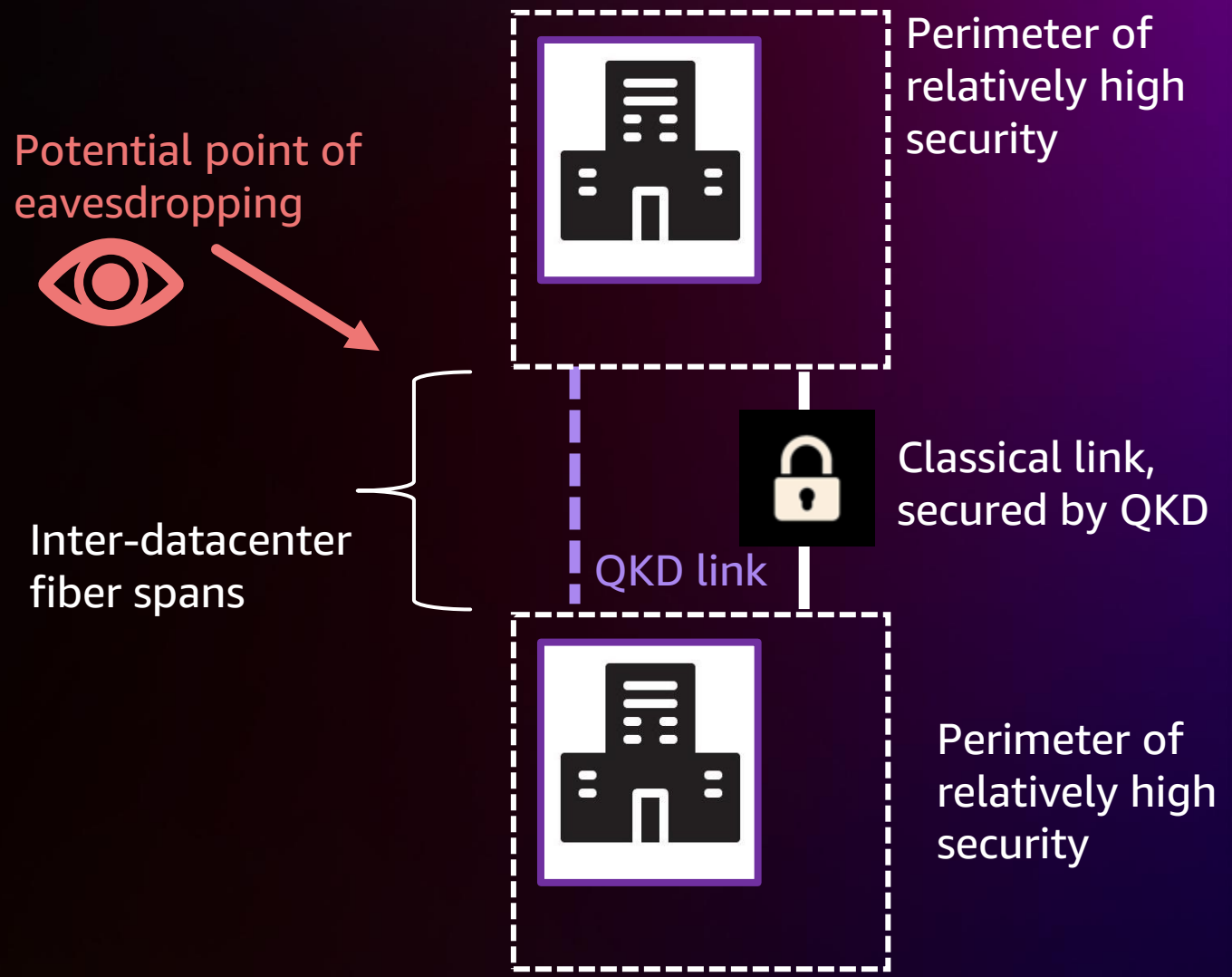
Quantum networking

- Quantum network applications
  - Secure communication
  - Private quantum computation
  - Advanced sensing
- AWS efforts in quantum networking
- Infrastructure for quantum networks
  - Entanglement basics
  - Quantum repeaters
  - State of the art
- Quantum key distribution in classical networks

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Quantum key distribution (QKD)

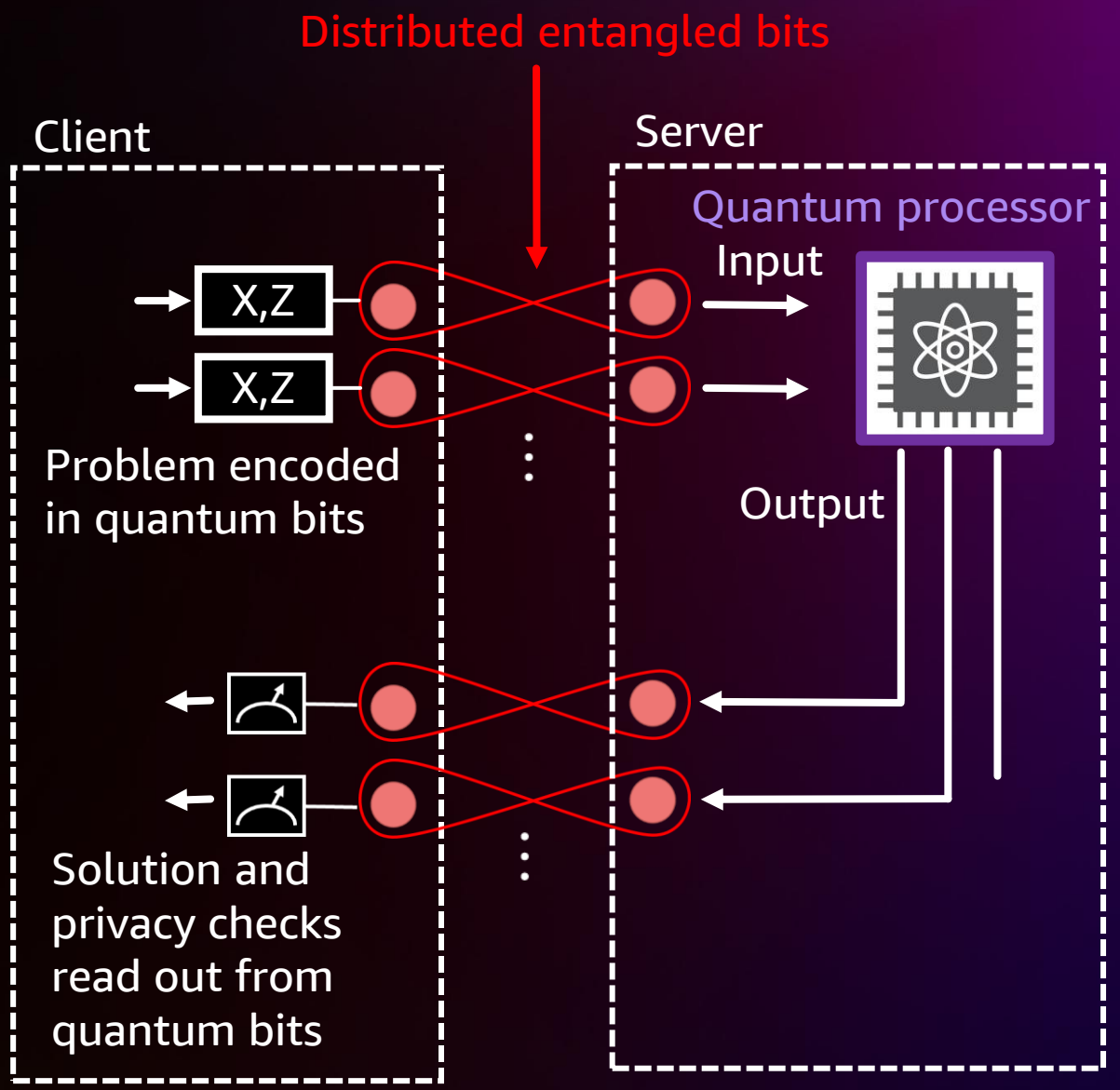
- While data centers can guarantee physical security, fiber spans between them are less well protected
- Quantum bits can be encoded in particles of light (photons) and sent over fiber spans between data centers
- Quantum correlations between these qubits can be used to generate cryptographic keys that are **provably secure against eavesdroppers**



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Private quantum computing

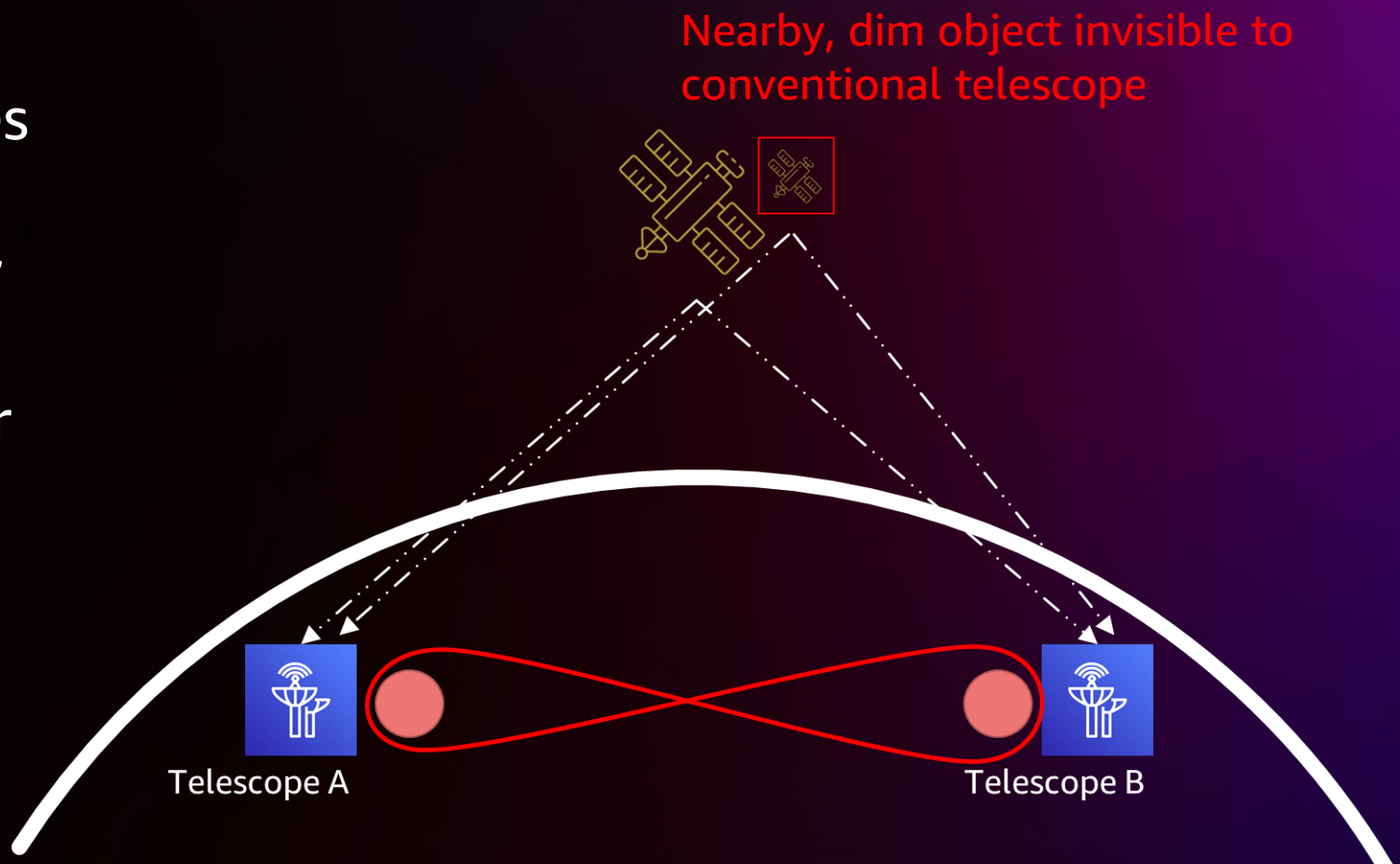
- Allows customers of third-party quantum computer providers to maintain data and algorithm privacy
- Distributed entanglement can be used to teleport quantum information to and from a networked quantum computer
- Users can verify that the algorithms and data were not viewed by quantum computer providers



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Entanglement – Enhanced sensing

- Some sensing applications, like identifying small satellites in close proximity to larger ones, require high-resolution, high-SNR optical sensing
- Phased arrays can be used for high-resolution sensing, but fail at very low signal levels
- Distributed quantum bits can be used to operate optical phased arrays at single photon levels



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AWS Center for Quantum Networking

AWS Quantum Computing Blog



Announcing the AWS Center for Quantum Networking

by Denis Sukachev and Mihir Bhaskar | on 21 JUN 2022 | in Amazon Quantum Solutions Lab, Announcements, AWS Center For Quantum Computing, Quantum Technologies | Permalink | Share

Over the last decade, governments and technology companies have invested heavily in research and development of quantum computers that have the potential to revolutionize science and technology. While there is still a long way ahead, these investments have already transformed quantum computers: They have evolved from delicate laboratory systems accessible to only a few research […]

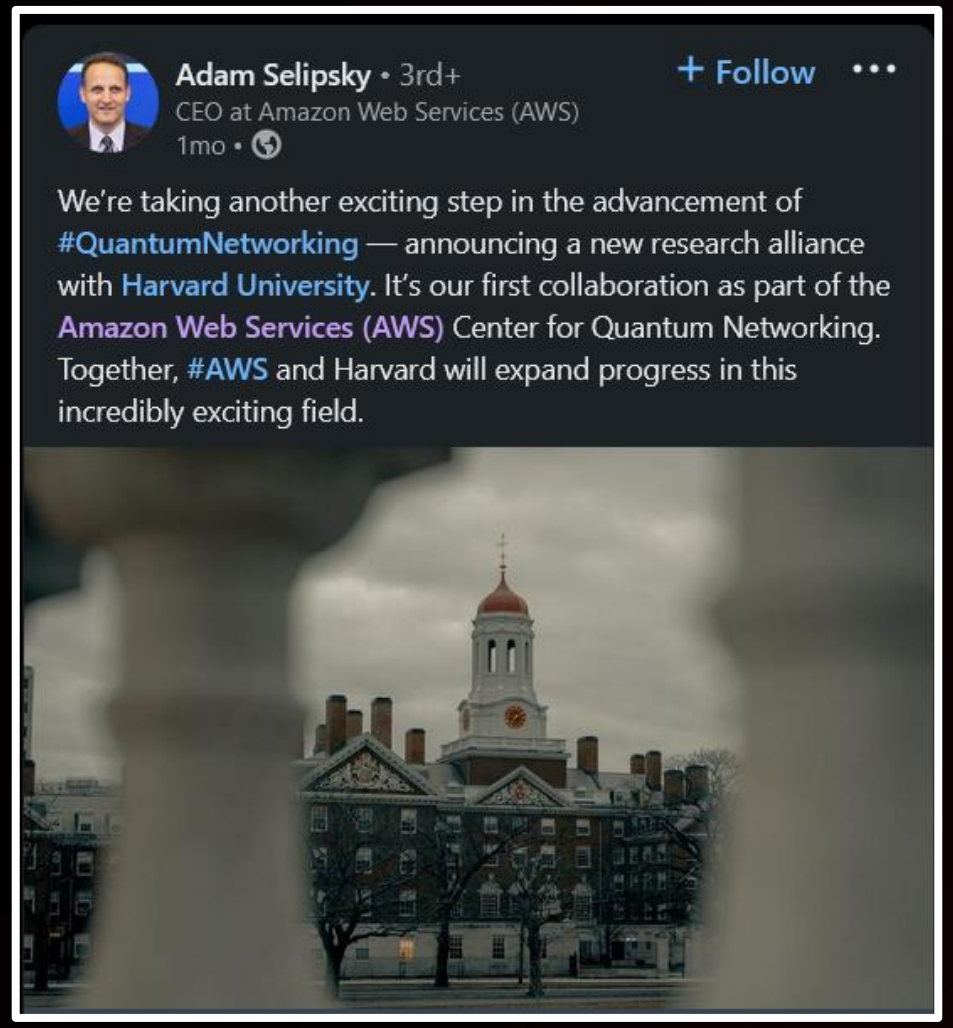


Adam Selipsky
@aselipsky

Introducing the #AWS Center for Quantum Networking, our new home for #quantum networking R&D. We're on a mission to build the underlying technologies that will enable the distribution of quantum information anywhere on Earth.

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AWS research alliance with Harvard University



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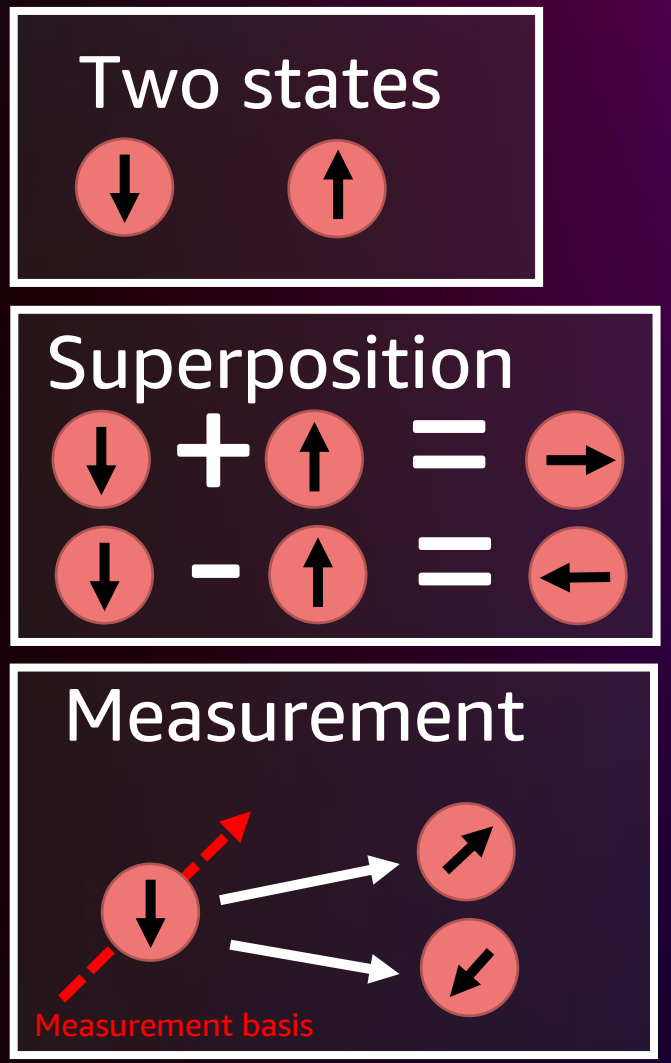
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Quantum bits (qubits)

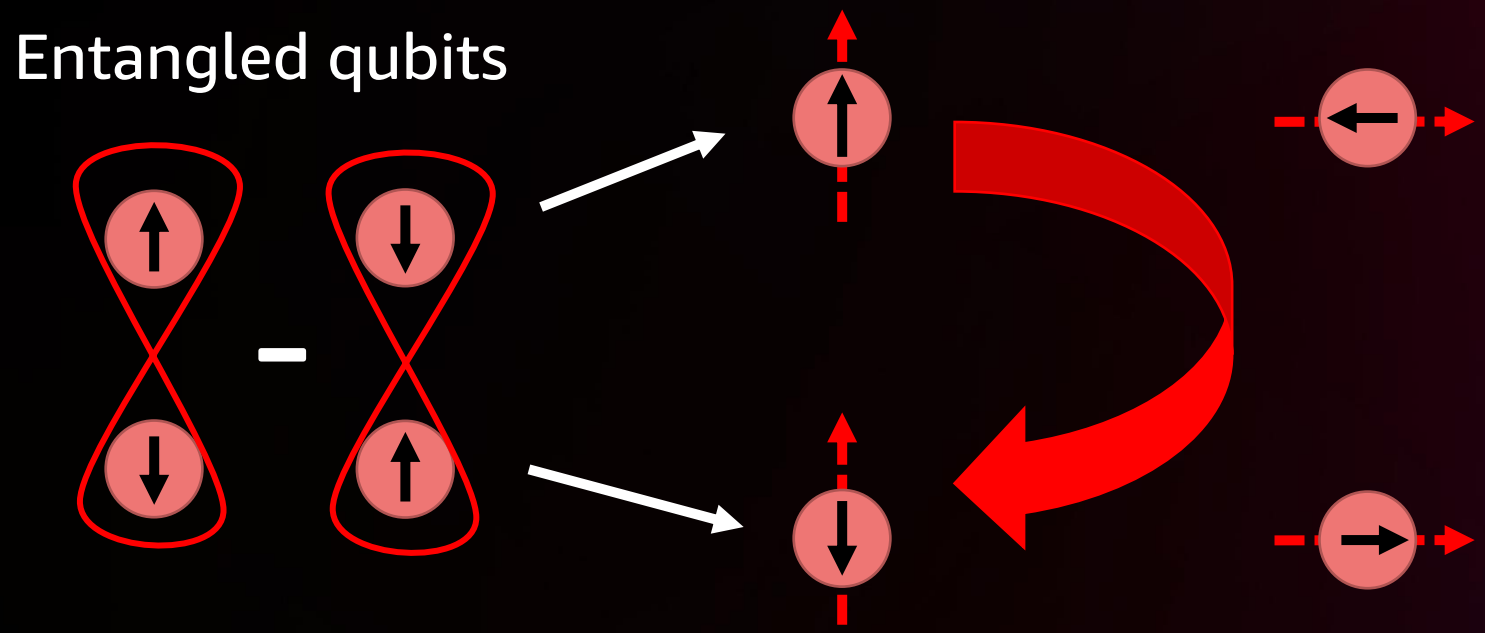
- Two states (0 and 1) like normal bits
- Any system that can be in a quantum superposition of two different states can be a quantum bit



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Quantum entanglement

When measured in the same basis, qubits always point opposite directions

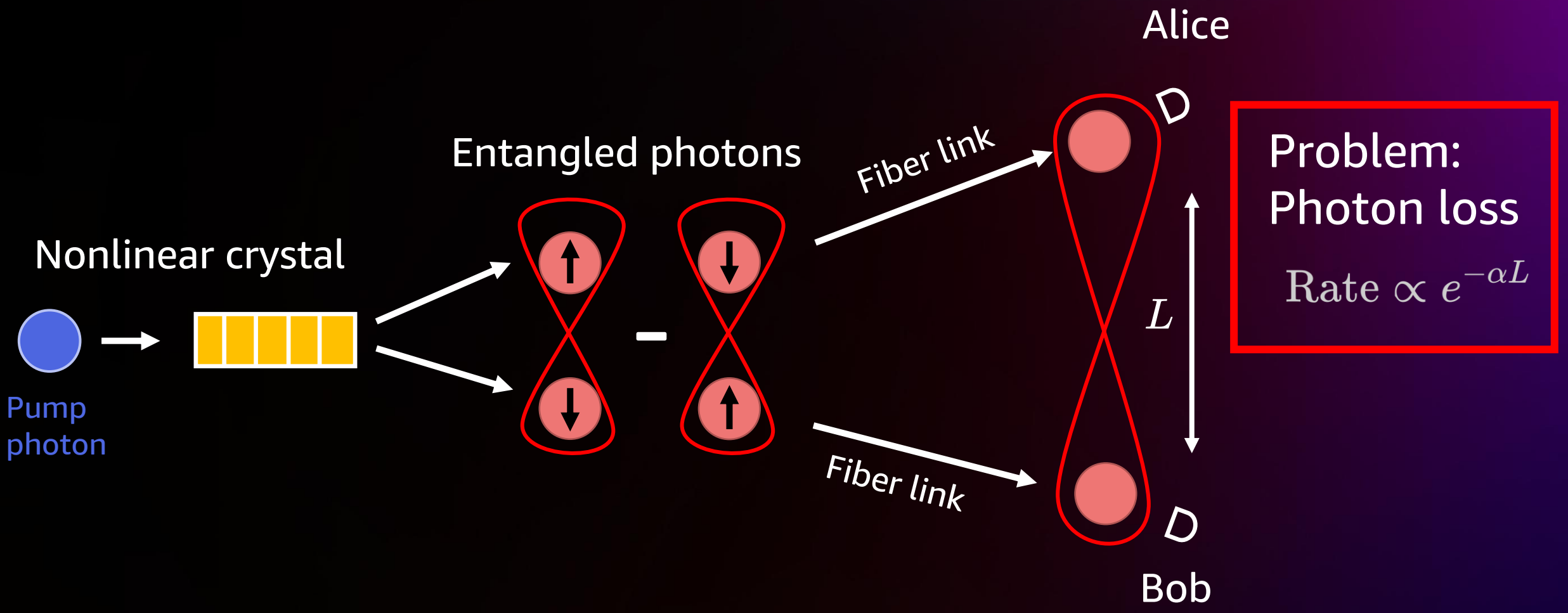


True regardless of the measurement basis or distance between qubits (only possible in quantum mechanics)

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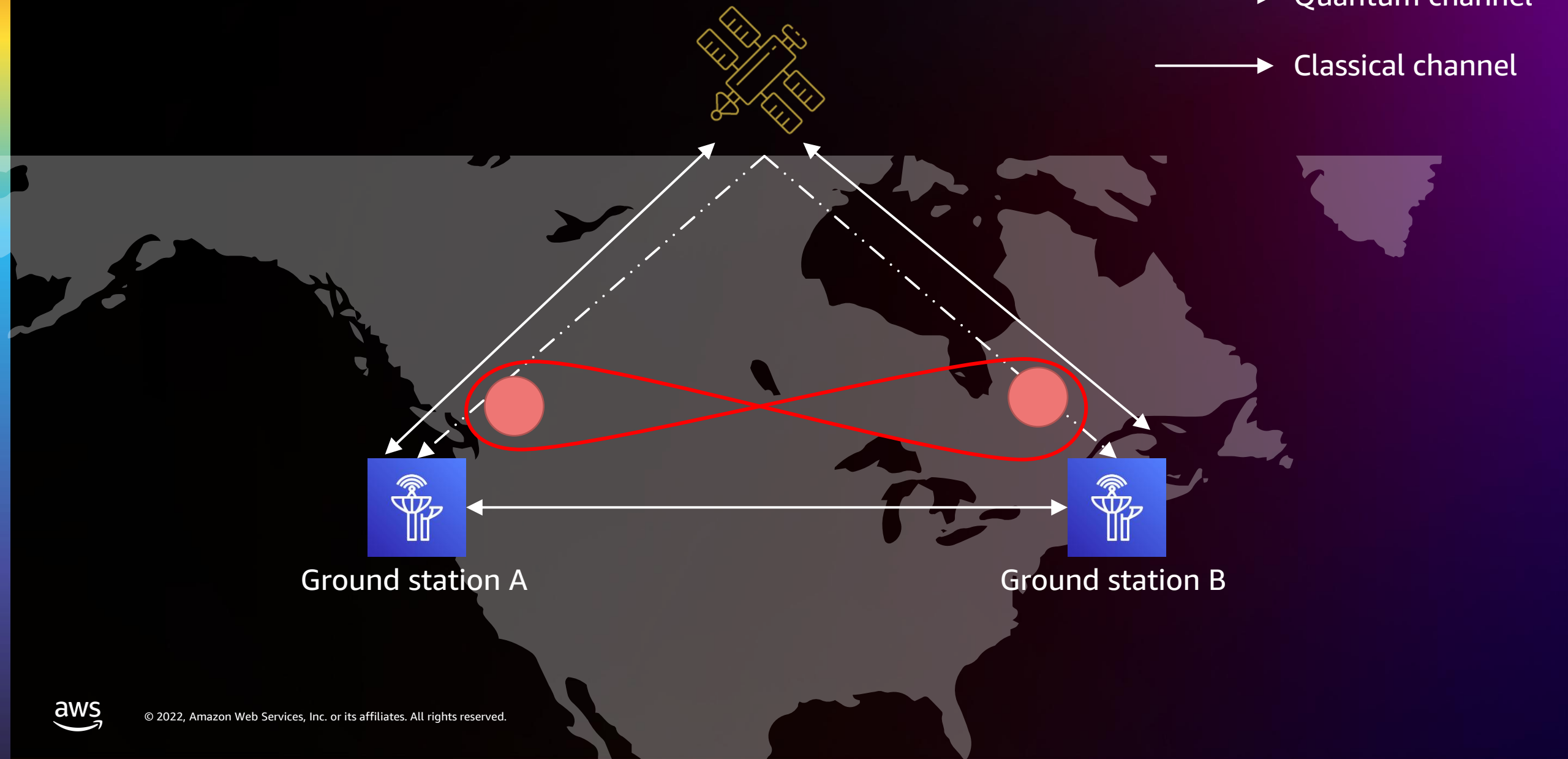
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Entangled photon sources



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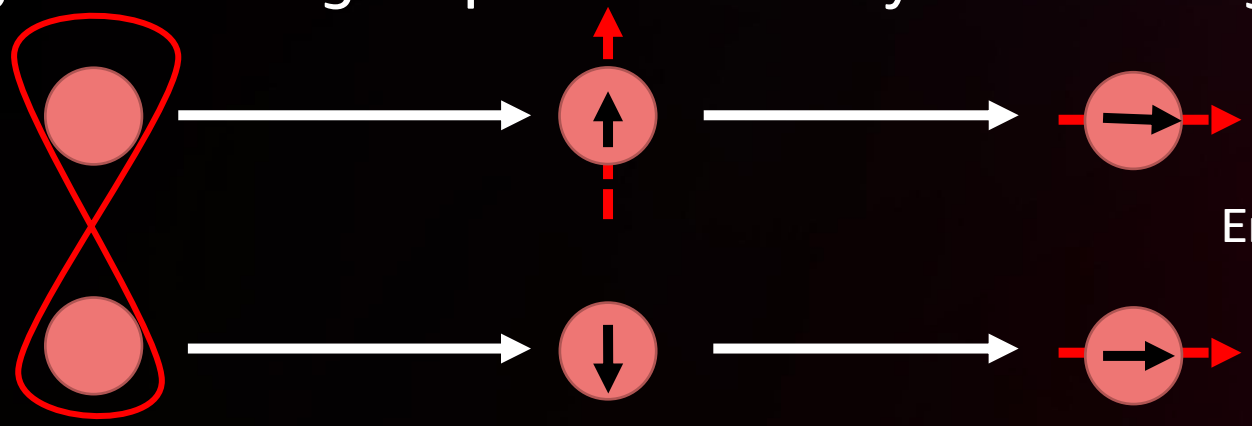
Quantum entanglement via satellite



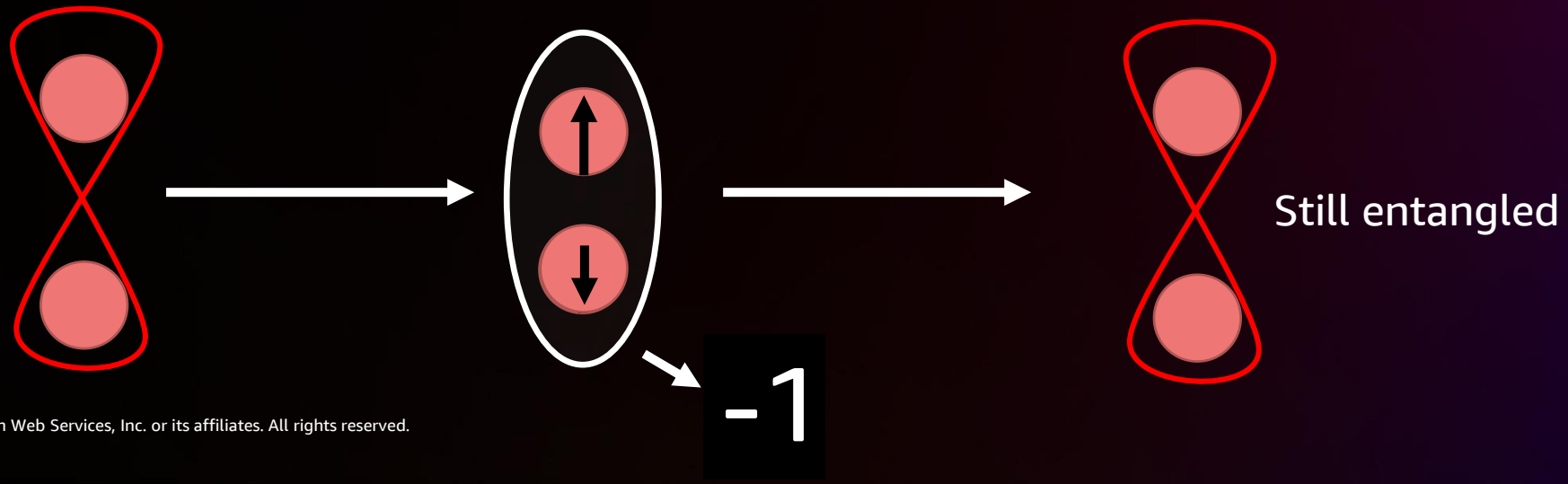
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Quantum parity measurement

Measuring one entangled particle destroys the entanglement



A joint quantum measurement preserves entanglement



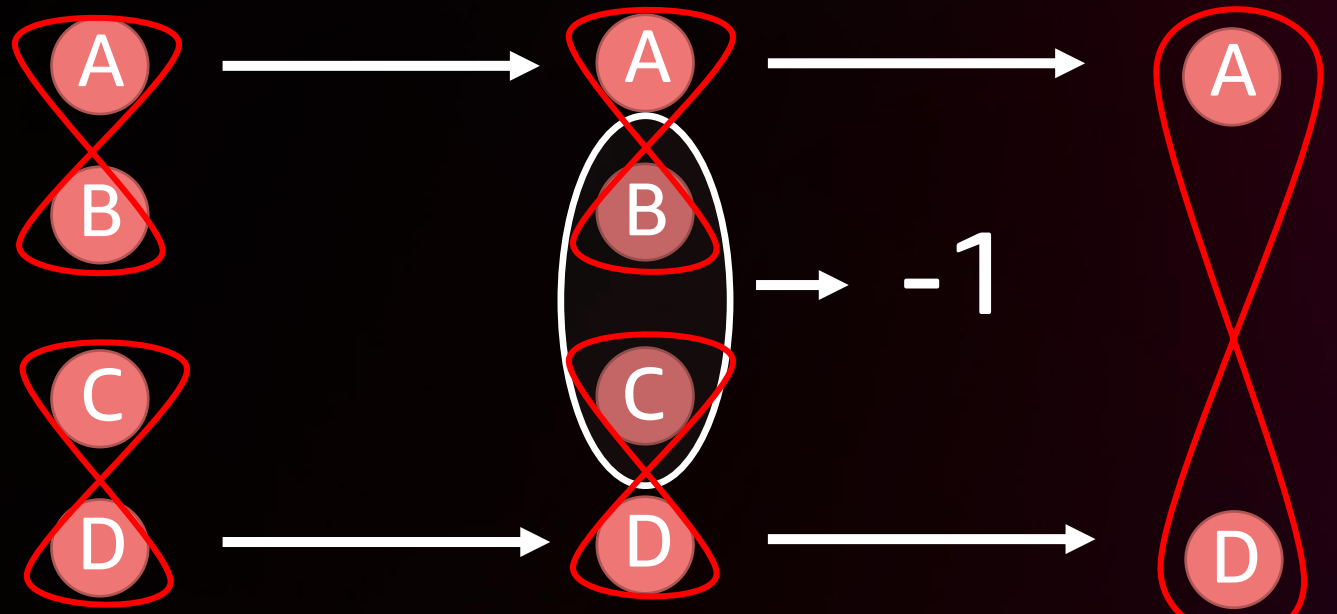
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Entanglement swapping

Start with 2 entangled pairs

Parity measurement on 1 particle from each entangled pair

The remaining 2 particles are now entangled

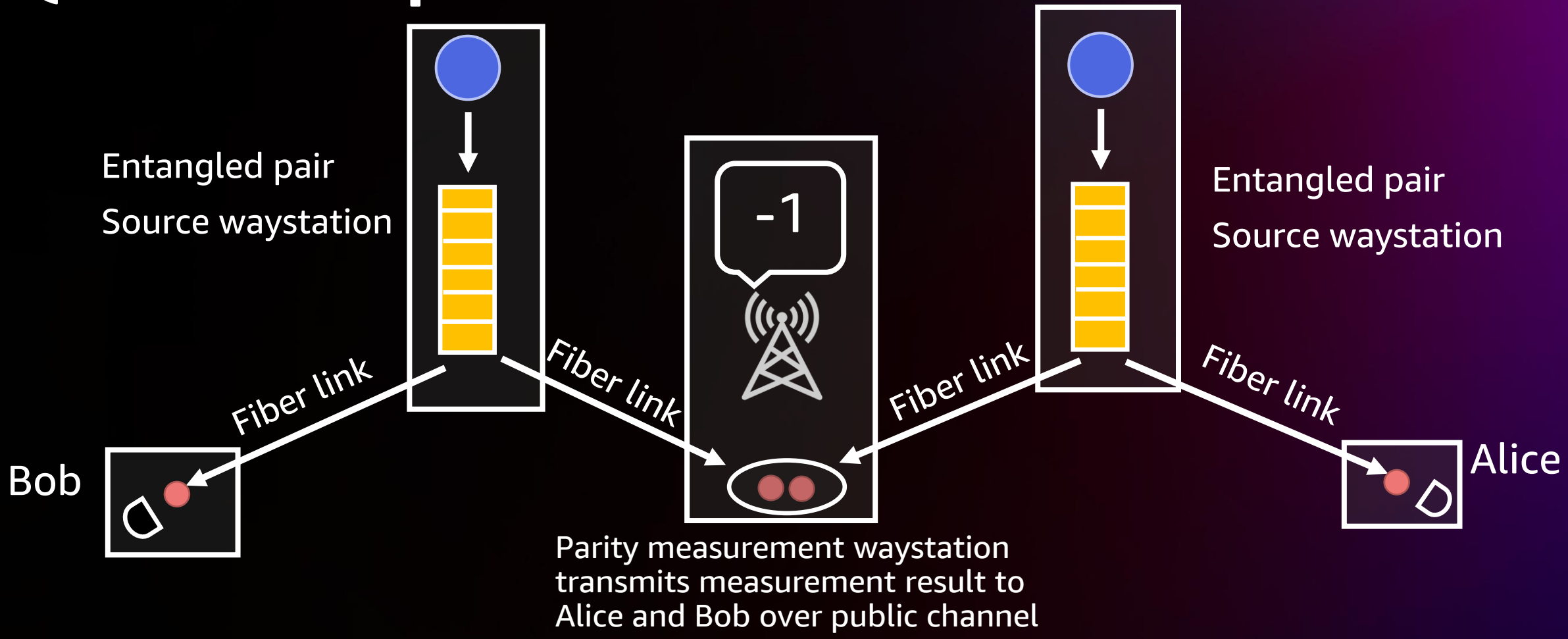


A and B are opposite
C and D are opposite

B and C are opposite → A and D are opposite

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Quantum repeaters

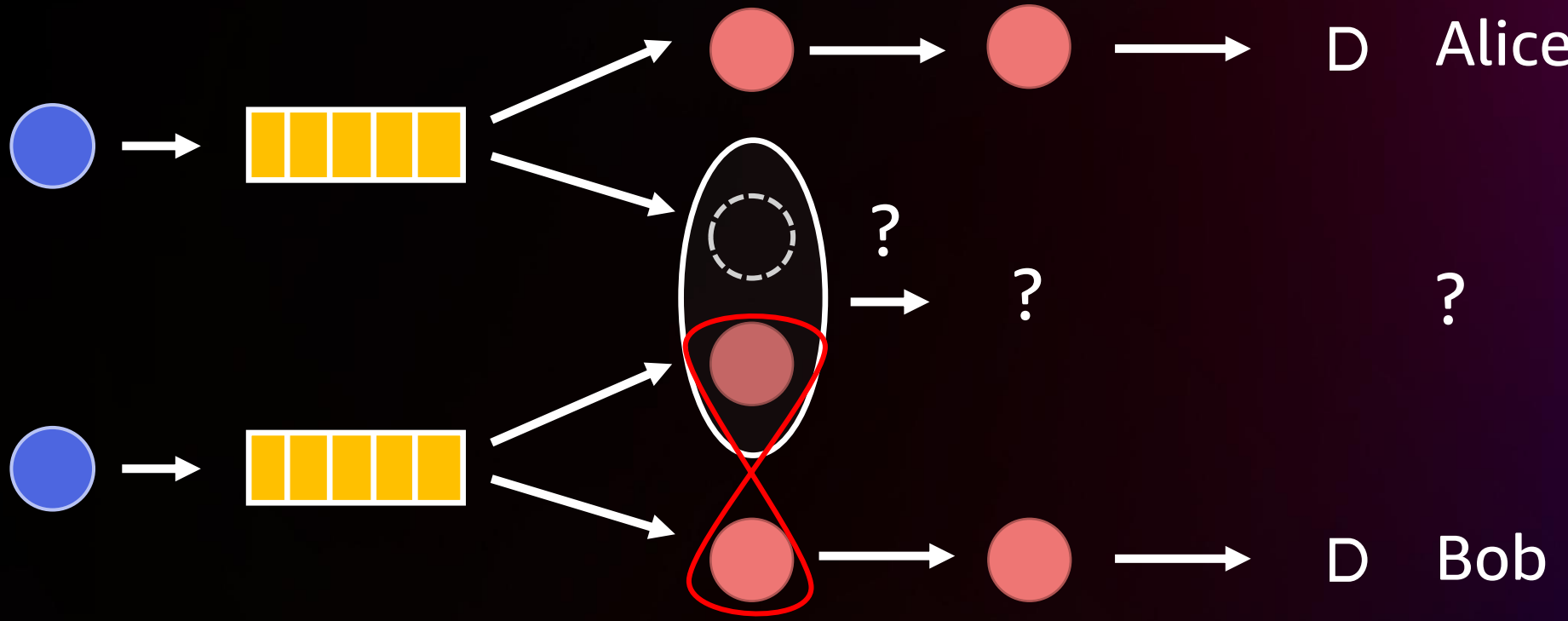


The distance between Alice and Bob is now divided into four instead of two fiber links, with less chance of losing a photon in each stretch

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Lost photon

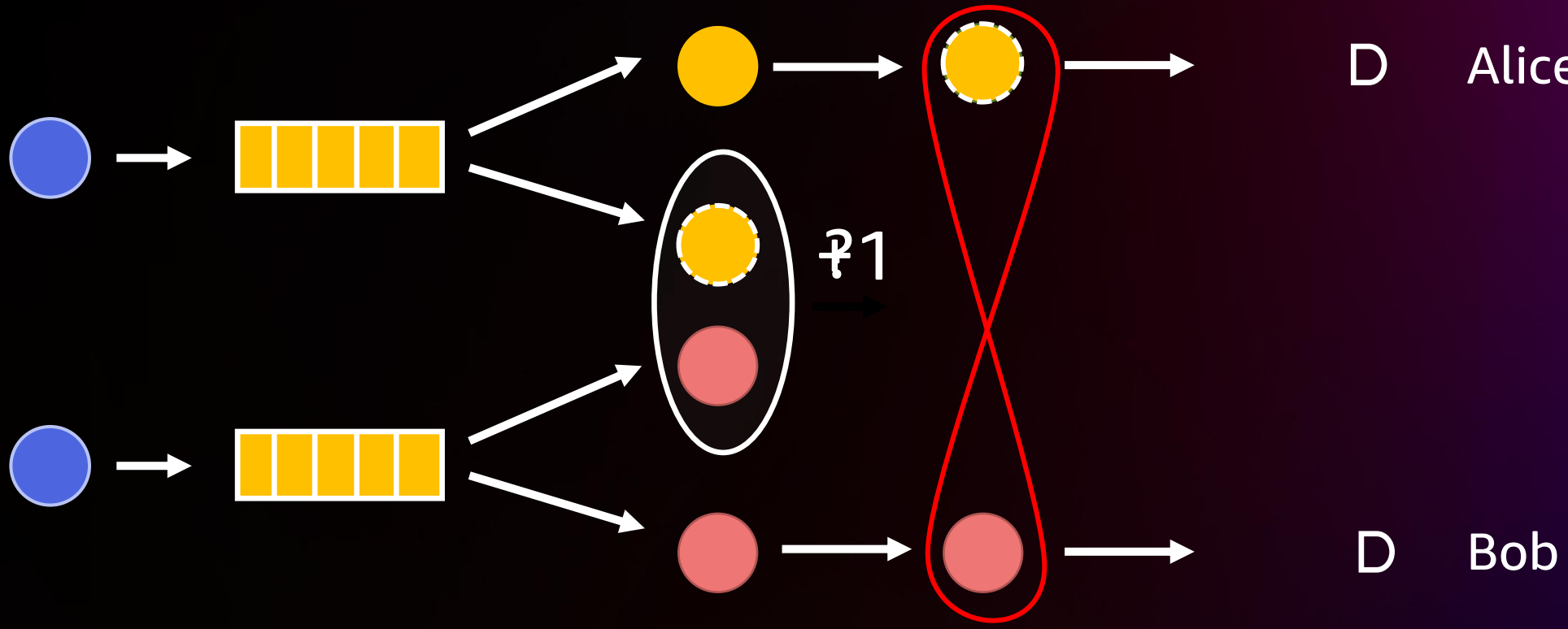
If a photon is lost, the protocol fails



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Quantum memory

If the parity measurement device can store a photon, it can wait until it receives a photon from both pair sources



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Challenge #1 for quantum network nodes

Measuring an entangled state destroys it

Any interaction revealing the state counts as measurement (decoherence)

Entangled states are very fragile!

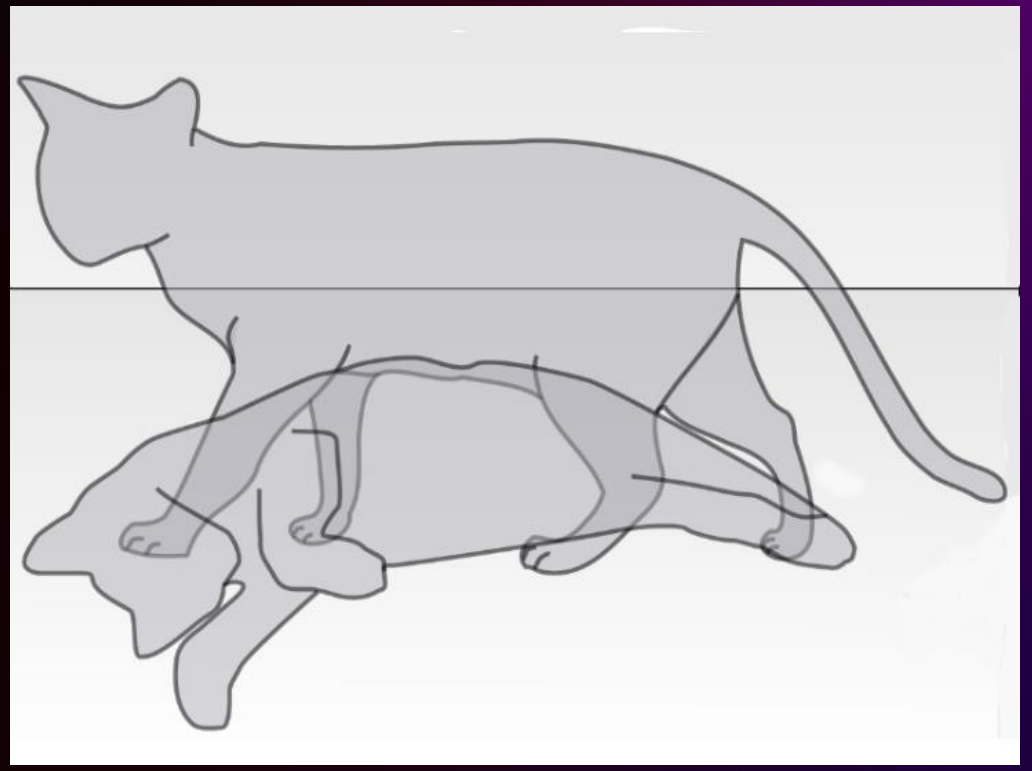


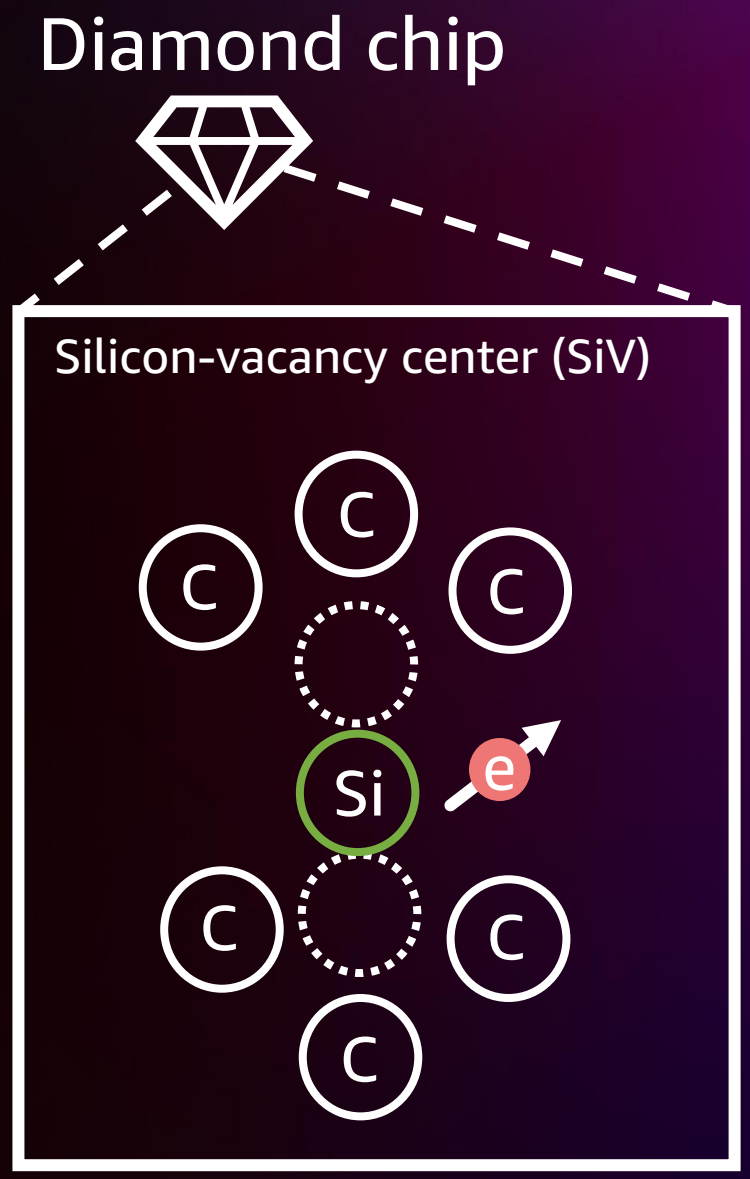
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Spin memories in diamond

- Electrons have tiny magnetic fields (spin)
- Quantum states stored in electron spin only interact with magnetic fields, which are small and easy to shield against
- Quantum states in the silicon-vacancy center in diamond last for seconds (compared to millisecond network latencies)



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Challenge #2 for quantum network nodes

The SiV has a low chance of interacting with a single photon

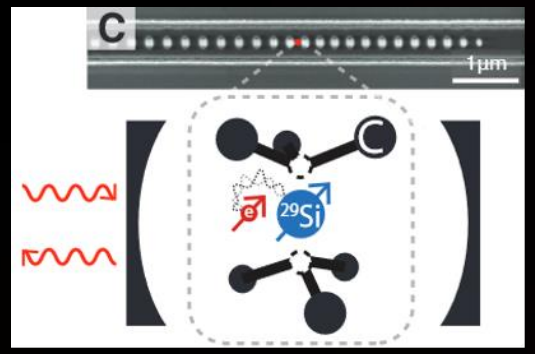


Solution – Reflect the photon with mirrors to pass by the SiV many times

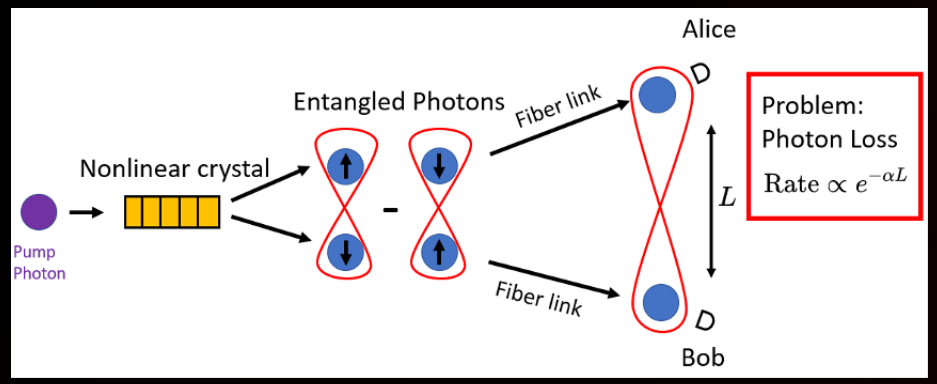


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Progress at the Center for Quantum Networking



New research from Harvard and AWS will enable higher temperature operation of quantum communications networks



An Illustrated Introduction to Quantum Networks and Quantum Repeaters

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How can Quantum Key Distribution be used with a classical network?

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Thank you!

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