ICFO

A STEP CLOSER TO A QUANTUM RAM:
10 Temporally Multiplexed Quantum Memory Cells

CLASSICAL INFORMATION

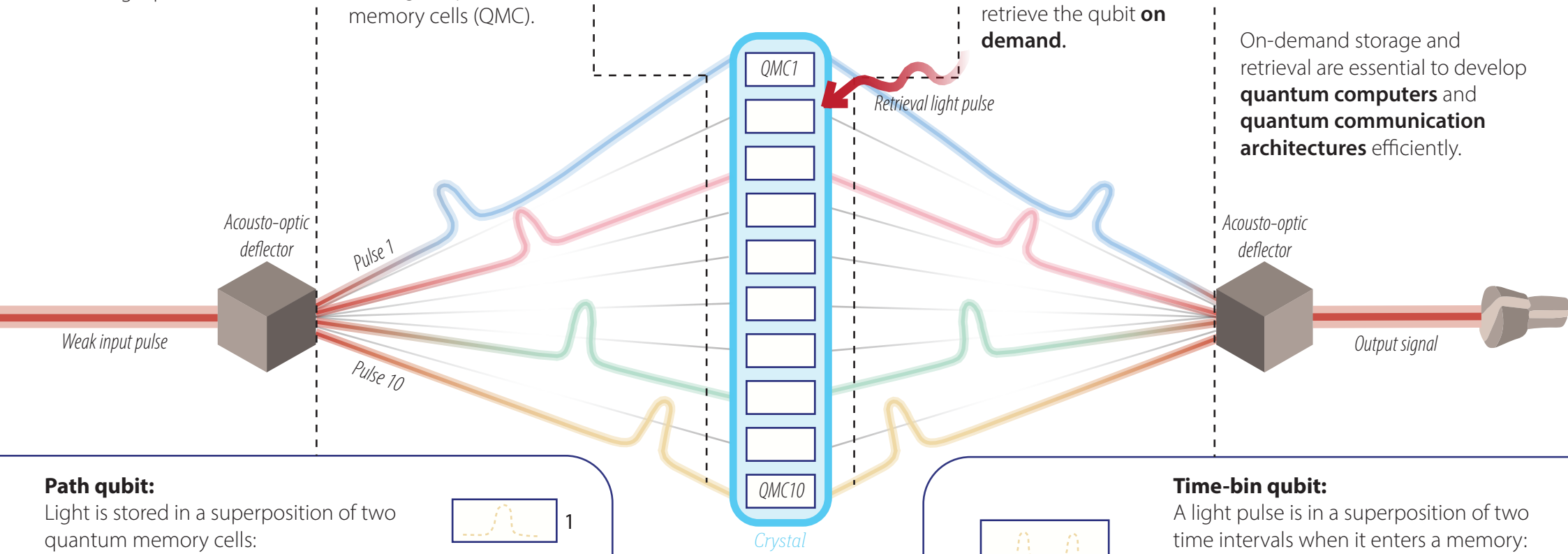
Classical information is expressed in terms of transmitted bits, which can be either a 0 or a 1. Random-access memories (RAMs) are essential to store them temporally and retrieve them on-demand.

QUANTUM INFORMATION

Quantum information is expressed in terms of transmitted qubits, which can be in state 0, 1, or any superposition of the two (their value, 0 or 1, is undefined until measured). To store and retrieve qubits on-demand and in arbitrary order, we need a quantum analogue of a RAM.

1. Quantum bits (qubits) are encoded in light pulses at the level of single photons.
2. The qubits are directed one by one to a crystal hosting 10 quantum memory cells (QMC).
3. We can sequentially store qubits in two cells (path qubit) or in one memory cell (time-bin qubit).
4. Whenever we want, we can send another light pulse to the crystal to retrieve the qubit **on demand.**
5. The retrieved pulses are measured and re-combined into a single light beam.

On-demand storage and retrieval are essential to develop **quantum computers** and **quantum communication architectures** efficiently.



Path qubit:
Light is stored in a superposition of two quantum memory cells:
- The upper one, corresponding to the qubit in 1.
- The down one, corresponding to 0.

1
0
= superposition

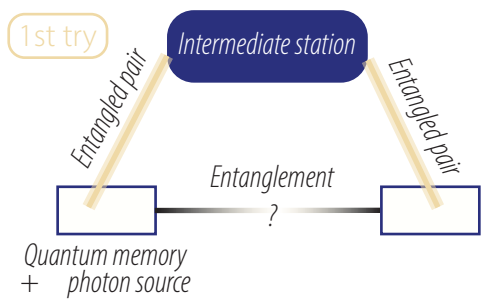
Time-bin qubit:
A light pulse is in a superposition of two time intervals when it enters a memory:
- An earlier time, corresponding to the qubit in state 0.
- A later time, corresponding to 1.

1 0
= superposition

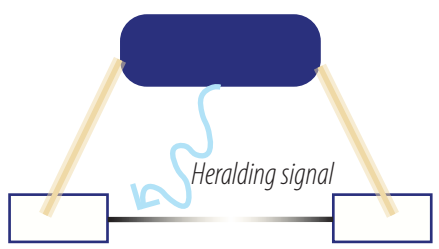
Entangling Distant Memories for Quantum Communication

SINGLE QUANTUM MEMORY

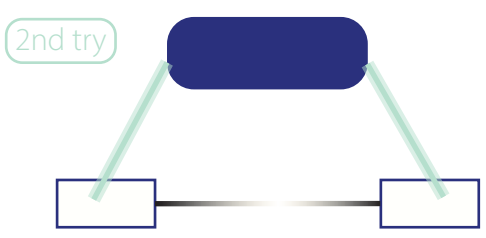
A source of entangled photon pairs at each memory randomly emits a pair: one photon stays in the memory and the other goes to an intermediate station.



Once a photon is detected at the station, we wait for a heralding signal to return. This will tell us that the memories are successfully entangled.

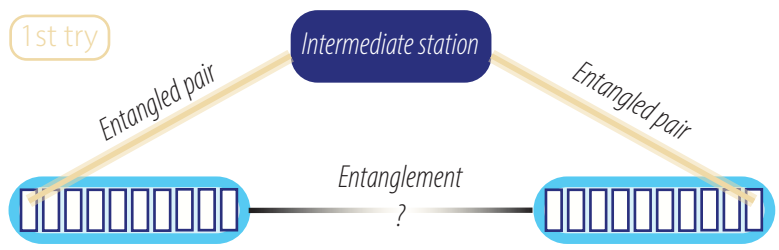


If the process was not successful, we try again. The time between two trials is limited by the travel time of light to the central station and back.

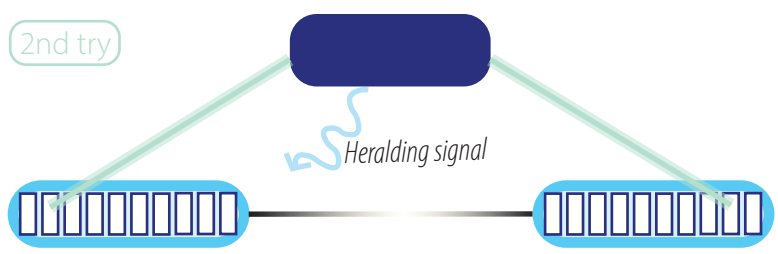


PROPOSED 10 QUANTUM MEMORY CELL ARRAY

We try to establish entanglement between two quantum memory cells.



Before the heralding signal returns, we can already try to establish entanglement with a second memory cell.



Same with a third memory cell, and so on. This could significantly boost the rate at which long-distance entanglement is established.