Experimental demonstration of a quantum-inspired Fredkin gate based on spatial modes of light

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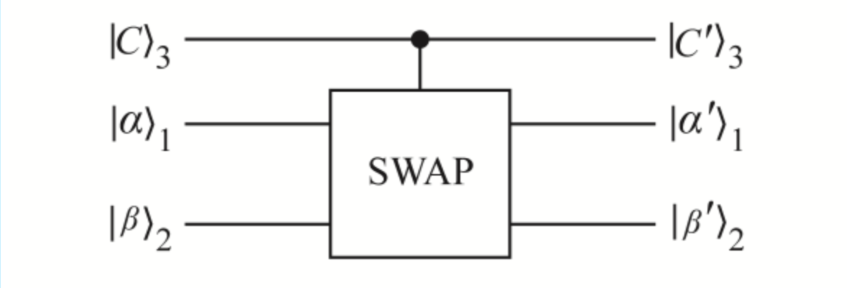
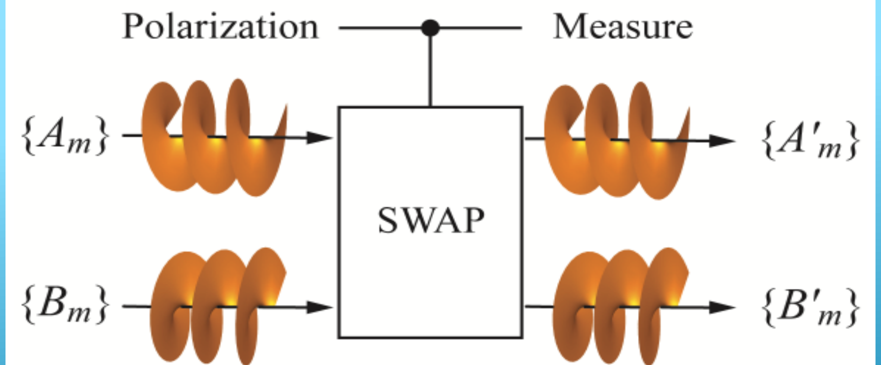
From the quantum Fredkin gate



(a)

to a classical *quantum-inspired* Fredkin gate



(b)

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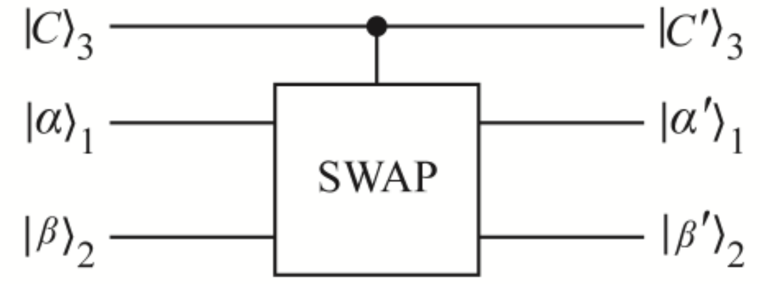
The quantum Fredkin gate is a three-qubits gate. A control qubit and two qubits that carry information. The value of the control determines whether information of the other qubits is swapped.



(a)

$If\ |C = 0\rangle$

$|\alpha\rangle_1 \Rightarrow |\alpha\rangle_1$

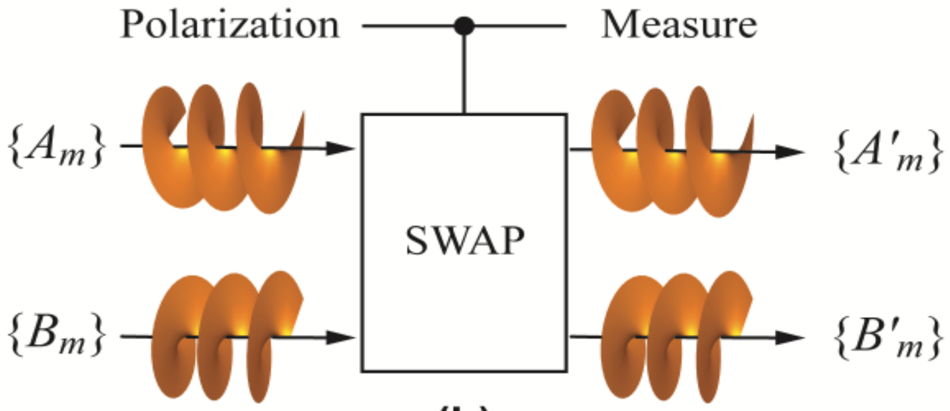
$|\beta\rangle_2 \Rightarrow |\beta\rangle_2$

$If\ |C = 1\rangle$

$|\alpha\rangle_1 \Rightarrow |\beta\rangle_1$

$|\beta\rangle_2 \Rightarrow |\alpha\rangle_2$

In the quantum-inspired Fredkin gate, the information channels are spatial modes with OAM and the control is the polarization of the beams. Information is codified in the amplitude of the electric field. Information is swapped when the polarization of the beams (control) is vertical, and it is not when is horizontal.



(b)

$If\ Polarization = H$

$\{A_m\} \Rightarrow \{A_m\}$

$\{B_m\} \Rightarrow \{B_m\}$

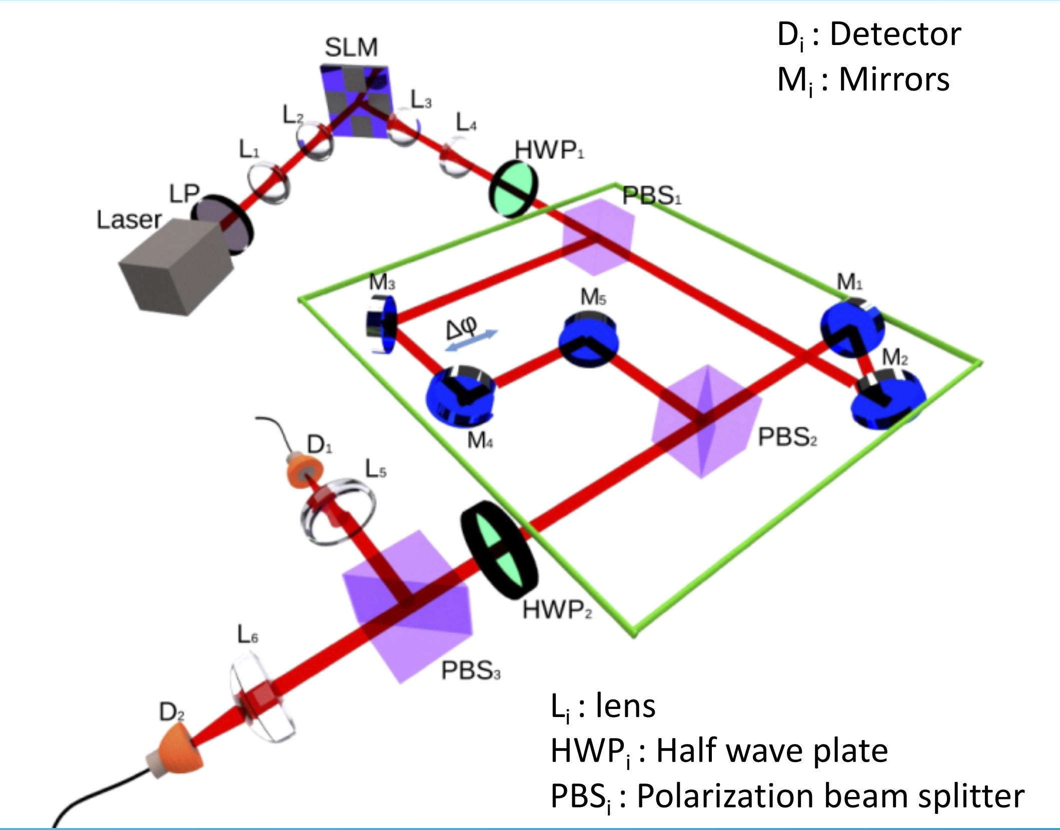
$If\ Polarization = V$

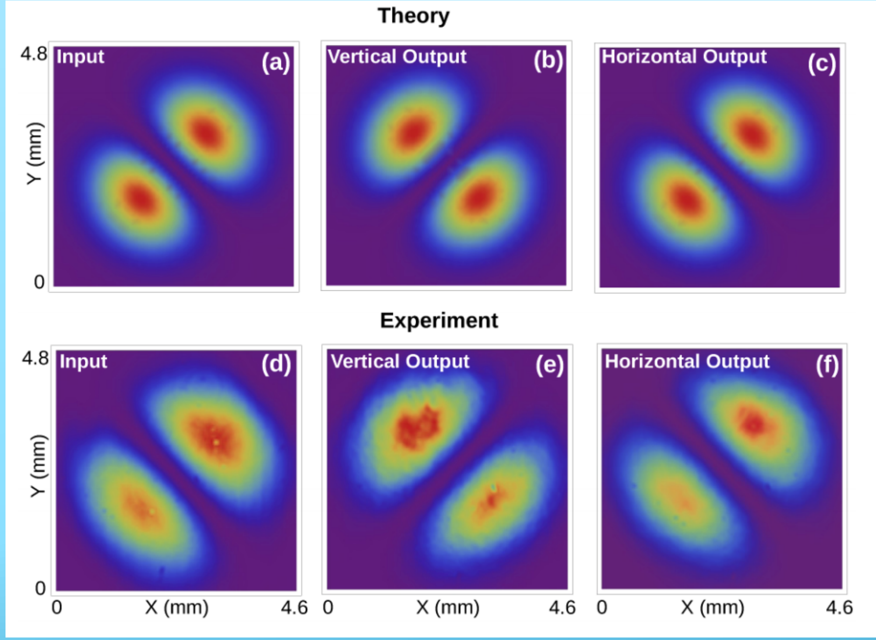
$\{A_m\} \Rightarrow \{B_m\}$

$\{B_m\} \Rightarrow \{A_m\}$

Experimental implementation of the Fredkin gate

In the experiment, a SLM is used to generate both the channels (spatial modes) and encode information. The Fredkin gate (green rectangle) is implemented using a polarization-sensitive Mach-Zehnder interferometer. In order to compare waveforms or strings of data, a polarization analysis system is used.

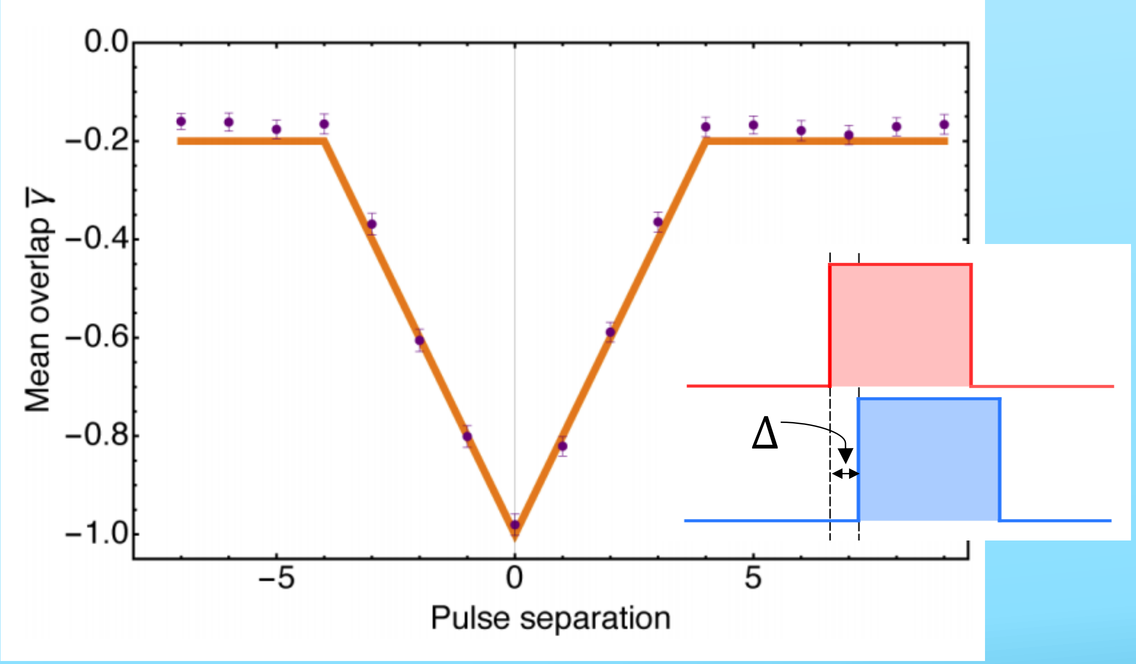




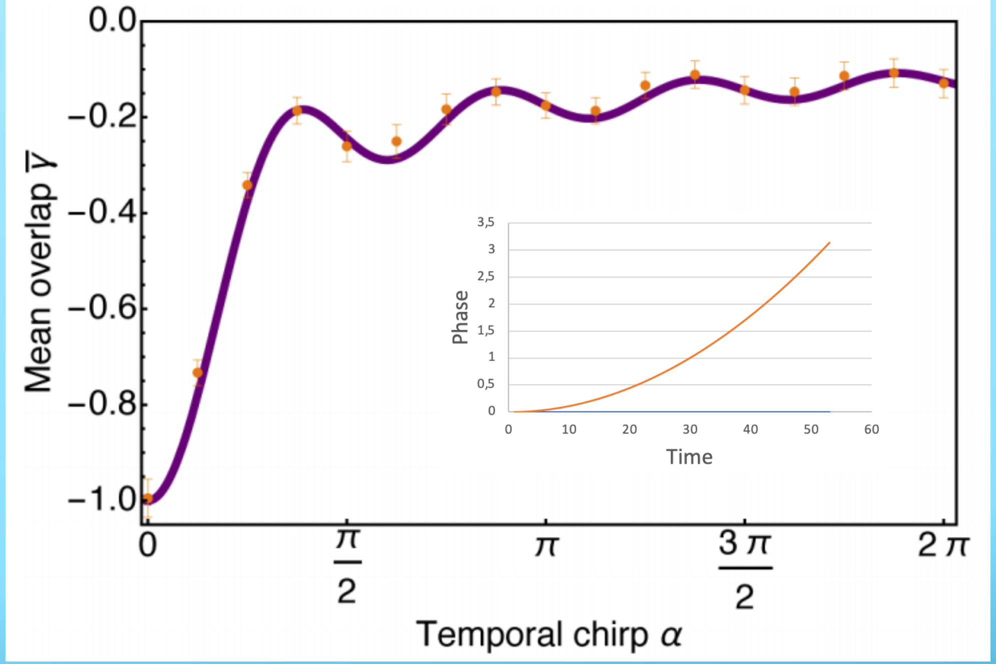
The polarization-dependent change of spatial orientation of the output beam with respect to the input beam is the demonstration of the successful operation of the Fredkin gate.

Examples of applications of the quantum-inspired Fredkin gate

The mean overlap $\bar{\gamma}$ can be used to measure the degree of similarity of two waveform or strings of data. A value if $\bar{\gamma} = -1$ corresponds to equal waveforms or strings, and $\bar{\gamma} = 0$ when they are orthogonal.

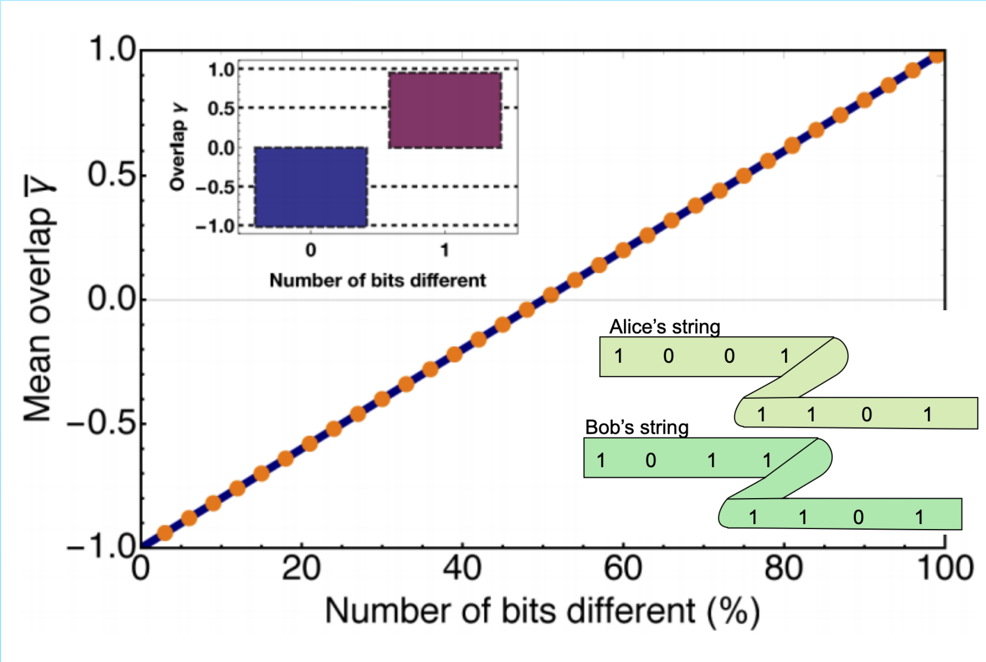


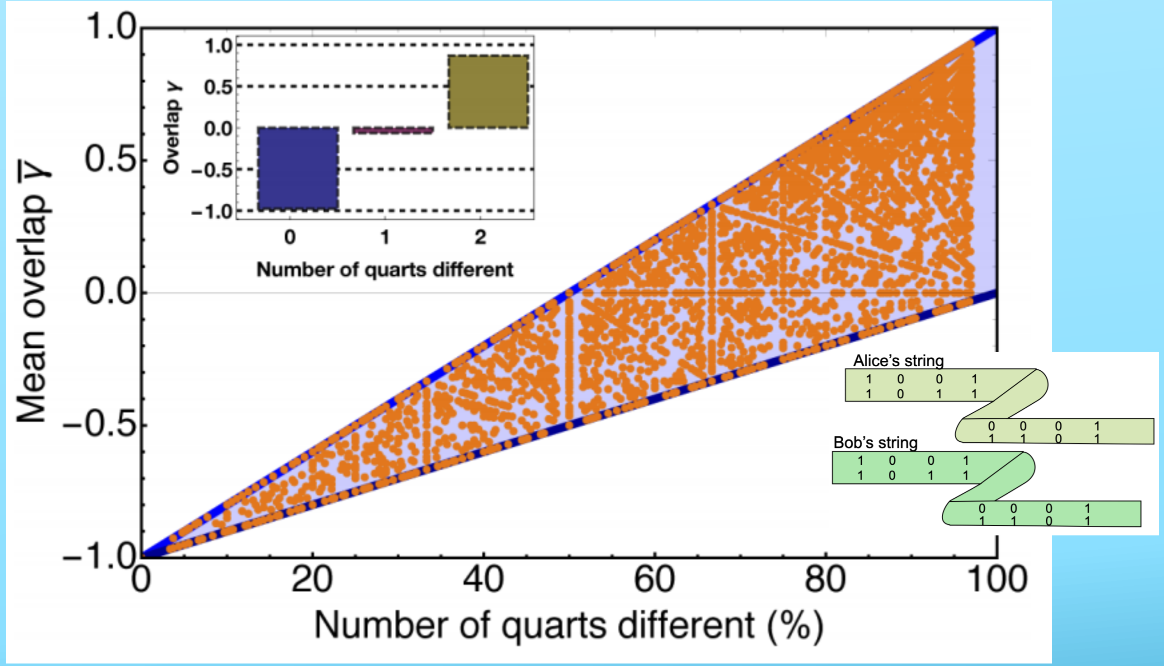
Mean overlap $\bar{\gamma}$ between two equal square pulses varying the delay between them



Mean overlap $\bar{\gamma}$ between two pulses with equal temporal width but different temporal chirp

Examples of applications of the quantum-inspired Fredkin gate



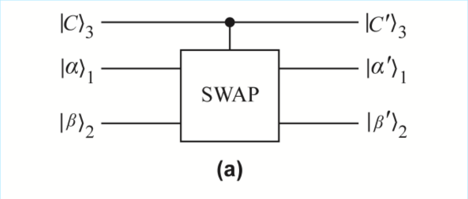


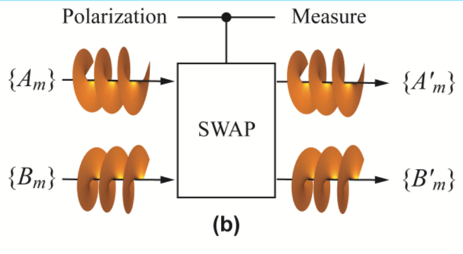
Mean overlap $\bar{\gamma}$ between two string of bits. $\bar{\gamma}$ is a measure of the numbers of bits that are different.

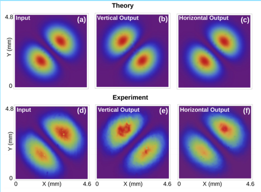
Mean overlap $\bar{\gamma}$ between two string of quarts: $\{A_1, A_2\}$ and $\{B_1, B_2\}$. Two quarts can be different because one, or two bits, are different.

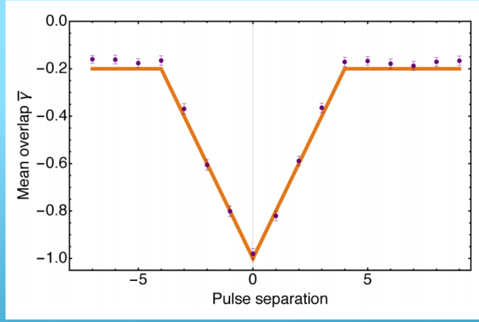
Summary

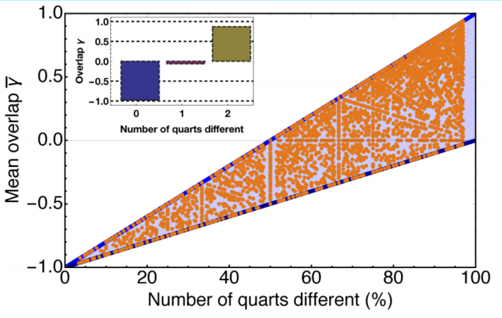
We demonstrated a quantum-inspired Fredkin gate based on the spatial mode of light. With the help of a polarization-sensitive detection system, it is possible to evaluate the degree of similarity between two waveforms and two strings of data without getting access to the information encoded in the signals.











References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