Experimental one-way quantum computing

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Outline

Introduction

- Typical quantum computers (QC) are arranged similar to classical computers
- However, a QC can be implementated in many ways (i.e. topological computer, KLM model, one-way)

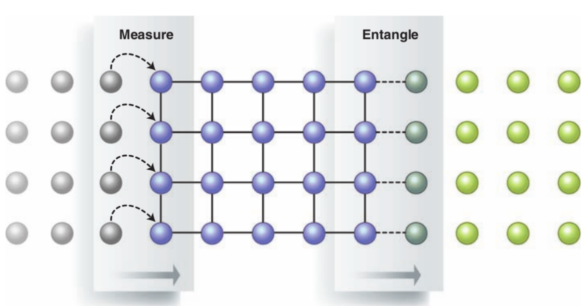
Why pursue such models?

- Original proposals were competing for scalability
- Ease of implementation

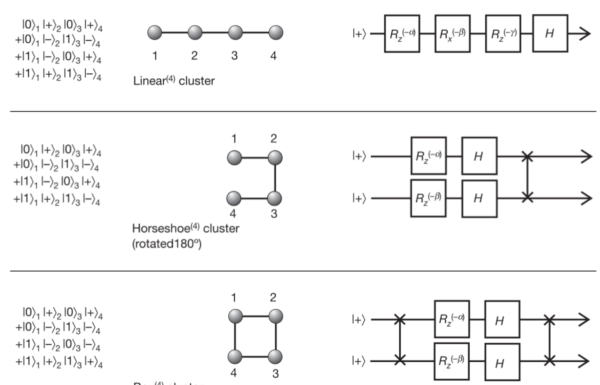
One-way Quantum Computer

- Measurements do all the computation
- Special entangled state is the entire resource for the quantum computing
  - called a cluster state
- Different arrangements of single qubit measurements create different algorithms
  - ordering
  - measurement bases (feedforward)
- Not time reversible, i.e. it is one-way

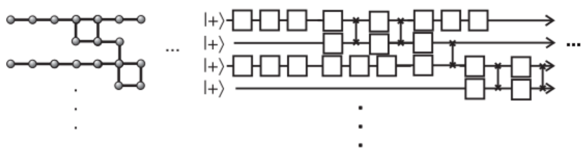
Cluster States



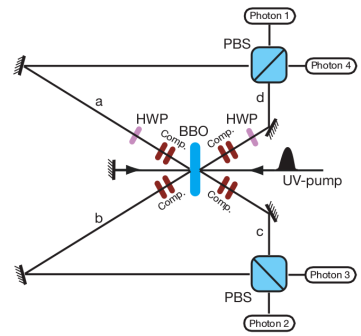
Cluster States



Cluster States



Cluster States



$$|\Phi_{\text{cluster}}\rangle = \frac{1}{2}\left(|HHHH\rangle + |HHVV\rangle + |VVHH\rangle - |VVVV\rangle\right)$$

Experiment

- Implemented single qubit rotations (fidelites = **Over nine-thousand**)
  - No feedforward, so
- Implemented two qubit gates (fidelities = 0.93)
- Grover's search algorithm (90%)
  - All measurement errors are σ_z, which can completely be corrected by post-processing
- First demonstration of a quantum algorithm in a cluster state computer

Conclusions

- Generated four qubit cluster states
- Demonstrated a universal set of gate (single and two qubit)

Challenges

- Creation of cluster state can be improved (more qubits)
- Implement fast feedforward to change measurements in real time

Further reading

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  Nature, 445(7123):65–69, Jan 2007.
- R. Raussendorf and H. J. Briegel.
  A One-Way Quantum Computer.
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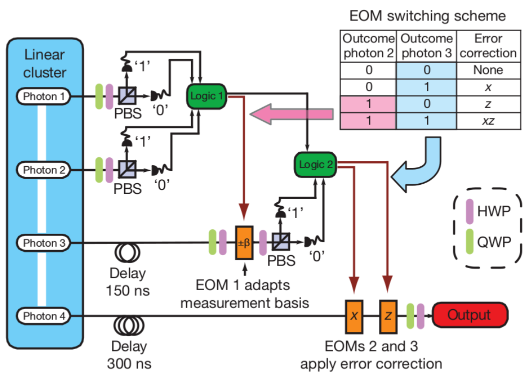
  Experimental one-way quantum computing.
  Nature, 434(7030):169–176, Mar 2005.

Thank you

Feedforward



Outcome photon 2	Outcome photon 3	Error correction
0	0	None
0	1	x
1	0	z
1	1	xz