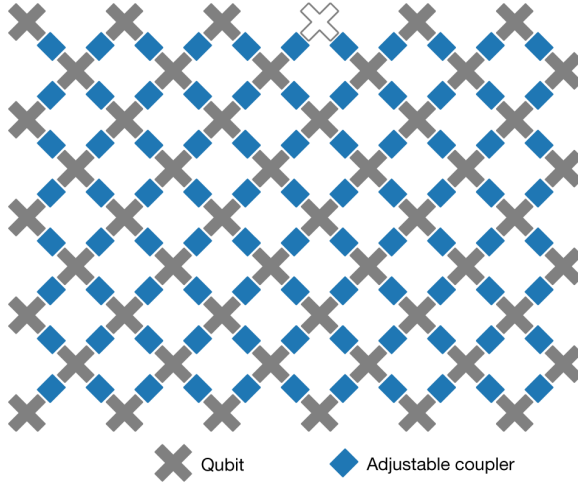


Can we implement good quantum LDPC codes on near-term devices?

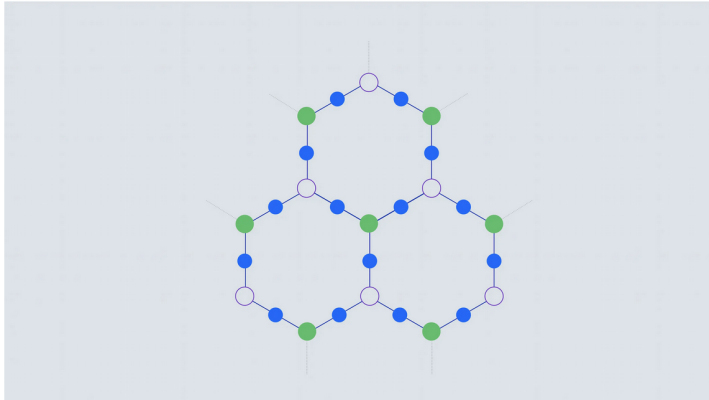
Maxime Tremblay¹, Michael Beverland², Nicolas Delfosse²



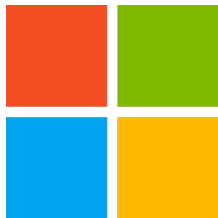
Arute et al. Nature 574, 505–510 (2019)

The IBM Quantum heavy hex lattice

As of August 8, 2021, the topology of all active IBM Quantum devices will use the heavy-hex lattice, including the IBM Quantum System One's Falcon processors installed in Germany and Japan.



Near-term quantum computers will be
locally connected.



Can we achieve large scale fault-tolerant quantum computing on locally connected devices?

Tradeoffs for reliable quantum information storage in 2D systems

Sergey Bravyi,¹ David Poulin,² and Barbara Terhal¹

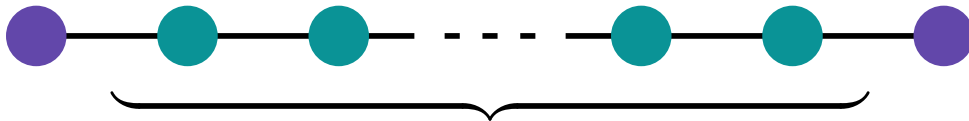
¹*IBM Watson Research Center, Yorktown Heights NY 10598, USA*

²*Département de Physique, Université de Sherbrooke, Québec, Canada*

(Dated: September 11, 2018)

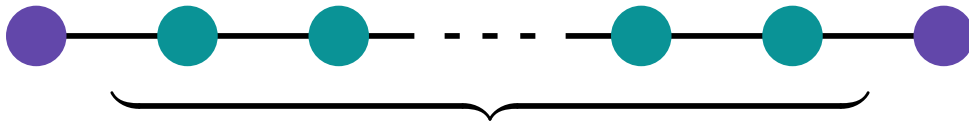
Long range interactions from local operations

Long range interactions from local operations

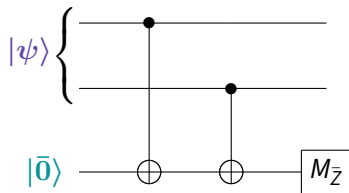


$$|\bar{0}\rangle \equiv |++\cdots++\rangle + |--\cdots--\rangle$$

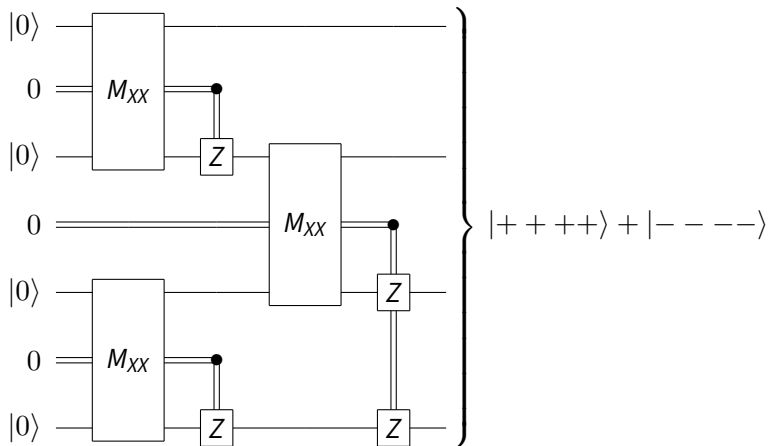
Long range interactions from local operations



$$|\bar{0}\rangle \equiv |++\cdots++\rangle + |--\cdots--\rangle$$



Long range interactions from local operations



Main results

Theorem

Let C be a Clifford circuit measuring computing Pauli operators S_1, \dots, S_r . Then, for any subset of qubits L , we have

$$\text{depth}(C) \geq \frac{n_{\text{cut}}}{64|\partial L|}.$$

Main results

Theorem

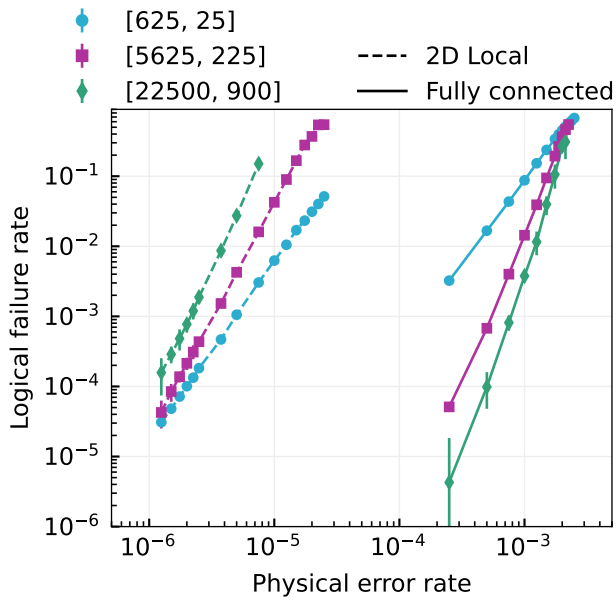
Let C be a Clifford circuit measuring commuting Pauli operators S_1, \dots, S_r . Then, for any subset of qubits L , we have

$$\text{depth}(C) \geq \frac{n_{\text{cut}}}{64|\partial L|}.$$

Corollary

For families of local-expander quantum LDPC codes of length n , a syndrome extraction circuit C implemented as a local Clifford circuit on a $\sqrt{N} \times \sqrt{N}$ grid of qubits satisfies

$$\text{depth}(C) \geq \Omega\left(\frac{n}{\sqrt{N}}\right).$$



References

- ❖ Bounds on stabilizer measurement circuits and obstructions to local implementations of quantum LDPC codes
[arXiv 2109.14599](#)
- ❖ Constant-overhead quantum error correction with thin planar connectivity
[arXiv 2109.14609](#)

Outline

1. Quick review of stabilizer codes
2. Graphs, graphs and more graphs
3. Proof of the main theorem
4. Circuit implementations