

Encyclopedia of Lattice-Surgery Operations

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1 Lattice Surgery

1.1 HERE Code

1. Shapes

- Textbook shape $d=7$: 7×7 physical qubits

```
  ^  ^  ^
XOXOXO>
<OXOXOX
XOXOXO>
<OXOXOX
XOXOXO>
<OXOXOX
  v  v  v
```

- (more)

2. **MORE** "Logical contributions" of physical qubit neighborhoods

- In the bulk: $1-(1/4+1/4+1/4+1/4) = 0$

- 0 X
 - .
 - X 0
- On an edge: $1-(1/4-1/4-1/2) = 0$
- X
 - .
 - 0 \rangle
- Convex corner : $1-(1/4-1/2) = 1/4$
- \wedge
 - .
 - 0 \rangle
- etc
- etc
- etc

1.2 TODO Memory

1.2.1 Syndrome measurement

1.2.2 Decoding

1.2.3 Fixing

1.3 Operations

1.3.1 MORE Single qubit Clifford gates

1. Pauli- $\{X,Z\}$ gates

Transversal (Only if length of observable is odd)¹

- Space-time cost: Time = 1 cycle
- Error cost:
 - **Z**: with *virtual* Z-gate: 0
 - **X**, **Z** w/o virtual Z-gate: loads of 1-qubit gates

Virtual P Flip *frame* of every physical qubit & **propagate**

- ??? This doesn't look like it makes any sense...

Virtual L Flip sign of logical op¹

2. Pauli-Y gate

Transversal (Only if lengths of Z,X observables are both odd)¹

Apply $\rightarrow \mathbf{Z} \rightarrow \mathbf{X} \rightarrow$

¹: arXiv:2307.03233 "Compilation of a simple chemistry application" (Riverlane)

1.3.2 Preparation

1. **MORE** $\pm Z, \pm X$

- $+\sigma$ where $\sigma \in \{Z, X\}$:
 for q in dataqubits:
 q.init($+\sigma$)
 EC(d times)

TODO There's sure to be a shortcut for preparing $-Z$ and $-X$

2. **TODO** $\pm Y$

2 Footnotes = Bibliography

1. Riverlane ¹