Appendix

Quantum Technology Summer School

Sep. 24, 2021

Commutator

Exercise: $[X_1, CNOT_{01}]$

$X_1 \equiv \mathbb{I} \otimes X$: NOT gate define on #Q1

$CNOT_{01}$: CNOT gate defined on #Q0 (control), #Q1 (target)

Kronecker product

$$|\psi_1\rangle \otimes |\psi_2\rangle = \begin{bmatrix} 1 \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} & -1 \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} \\ 0 \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} & i \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} \\ (-1+i) \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} & (1-i) \cdot \begin{bmatrix} i \\ -1 \end{bmatrix} \end{bmatrix} = \begin{bmatrix} i & -i \\ -1 & 1 \\ 0 & -1 \\ 0 & -i \\ -1-i & 1+i \\ 1-i & -1+i \end{bmatrix}$$

Hilbert space

$$\mathscr{H} = \mathscr{H}_1 \otimes \mathscr{H}_2$$

Definition

The commutator of two operators $\hat{A}$ and $\hat{B}$ is defined as

$$[\hat{A}, \hat{B}] := \hat{A}\hat{B} - \hat{B}\hat{A}.$$

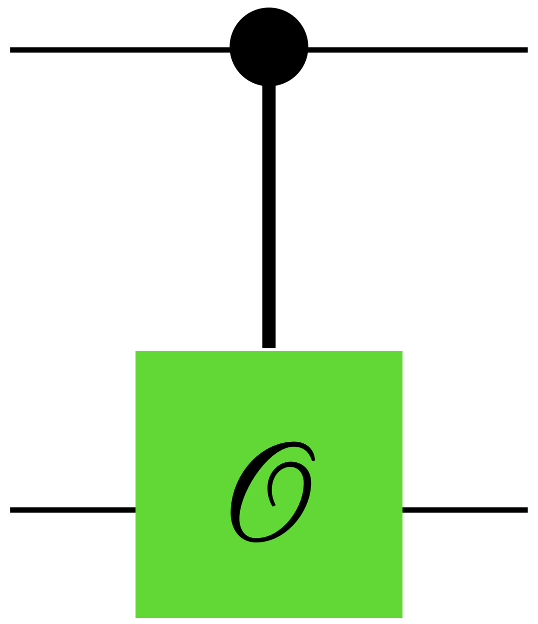
If the value is zero, the two guys $\hat{A}$, $\hat{B}$ are commutable:

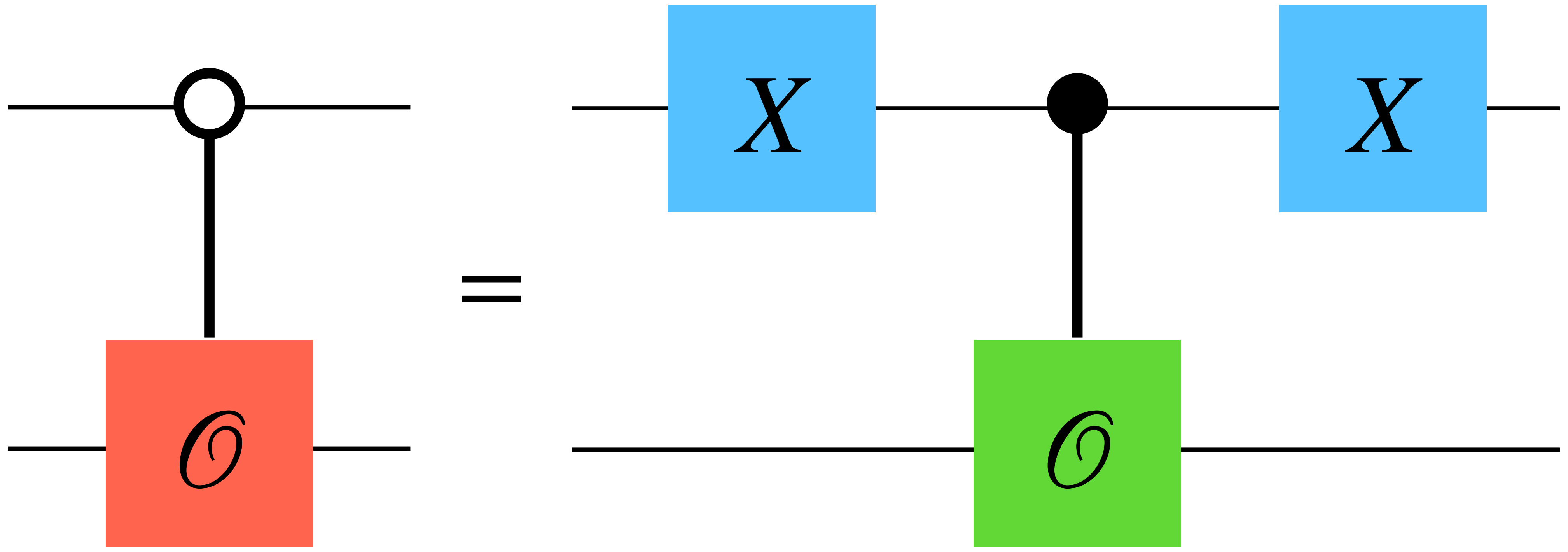
$$[\hat{A}, \hat{B}] = \hat{A}\hat{B} - \hat{B}\hat{A} = 0 \implies \hat{A}\hat{B} = \hat{B}\hat{A}.$$

Controlled gates

Controlled gates
Do operation on the target when all controls are “1”.

Negative controlled gates
Do operation on the target when all controls are “0”.





Project presentation

Time limit: 15min

- Identify problem
  - Motivation, background
- Methodology
  - Model: architecture, operators
  - Quantum circuit
- Results (data)
  - Theoretical prediction
  - Simulator vs. real device
- Analysis & discussion
  - Meaning of results
  - Comparison with classical
  - Possible applications

Project report

- Abstract
  - Short summary, quick look
  - Keywords
- Introduction & model
  - Identify question
  - Historical background
    e.g.: what has been done
    previously (classically)
- Result & discussion
  - Data analysis
- Conclusion
  - Potential research topics
- Reference
  - No need of details in content
  - Be aware of the format