

Quantum Cube Model LaTeX Package (v0.1.0)

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Introduction

The **Quantum Cube Model (QCM)** package provides commands that make it easy to create diagrams representing the quantum cube model for up to 3 qubits. The package simplifies drawing complex quantum state diagrams inspired by Prof. B. Just's framework.

Requirements

To use this package include `\usepackage{quantumcubemodel}` in your documents preamble. This package depends on the following LaTeX packages:

```
\RequirePackage{braket}
\RequirePackage{xcolor}
\RequirePackage{tikz}
\usetikzlibrary{3d, calc, arrows.meta}
```

License

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References

Bettina Just. *Quantum Computing Compact: Spooky Action at a Distance and Teleportation Easy to Understand*. Berlin, Heidelberg: Springer, 2022. ISBN: 978-3-662-65007-3 978-3-662-65008-0. DOI: 10.1007/978-3-662-65008-0. URL: <https://link.springer.com/10.1007/978-3-662-65008-0> (visited on 05/26/2025)

Provided Commands

Draws a diagram for a **single qubit** with the specified quantum state.

```
\qcmQ{<amplitude>:<phase>}{<amplitude>:<phase>}
```

Draws a diagram for **two qubits** with the given specified quantum state.

```
\qcmQQ{<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
```

Draws a diagram for **three qubits** with the given specified quantum state.

```
\qcmQQQ{<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
  {<amplitude>:<phase>}
```

Changes the scale of the generated diagrams (e.g., `\qcmScale{3}` is a good starting point).

Draws the wireframe of the transition diagram used in the quantum cube model. To be used inside a tikz environment.

```
\qcmWireframe{1} % for a single qubit
\qcmWireframe{2} % for two qubits
\qcmWireframe{3} % for three qubits
```

Transitions for frequently used Gates

```
\qcmTransitionHadamardQ{}
\qcmTransitionPauliXQ{}
\qcmTransitionPauliZQ{}
```

```
\qcmTransitionHadamardQQ{1 or 2}
\qcmTransitionPauliXQQ{1 or 2}
\qcmTransitionPauliZQQ{1 or 2}
\qcmTransitionCNOTQQ{1 or 2}{2 or 1}
```

```
\qcmTransitionHadamardQQQ{1 or 2 or 3}
\qcmTransitionPauliXQQQ{1 or 2 or 3}
\qcmTransitionPauliZQQQ{1 or 2 or 3}
\qcmTransitionCNOTQQQ{1 or 2 or 3}{2 or 3 or 1}
\qcmTransitionToffolieQQQ{1 or 2 or 3}{2 or 3 or 1}{3 or 1 or 2}
```

Usage Examples

Please visit <https://github.com/CedricSchacht/quantumcubemodel> for further example usages.

Single qubit system

```
\qcmQ{1:0}{0:0}
```

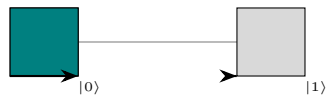


Figure 1: The $|0\rangle = 1 \cdot |0\rangle + 0 \cdot |1\rangle$ state

```
\def\qcmScale(5)  
\qcmQ{1:0}{0:0}
```

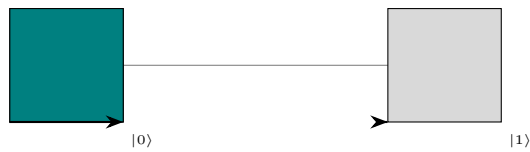


Figure 2: Make it bigger default is 3

```
\qcmQ{0:0}{1:0}
```



Figure 3: The $|1\rangle = 0 \cdot |0\rangle + 1 \cdot |1\rangle$ state

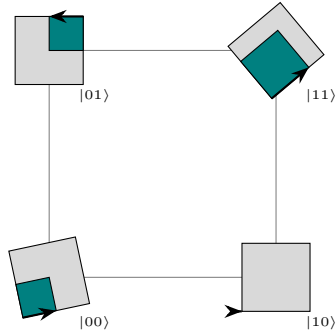
```
\qcmQ{0.5:0}{0.86:90}
```



Figure 4: Superposition state with phase on $|1\rangle$

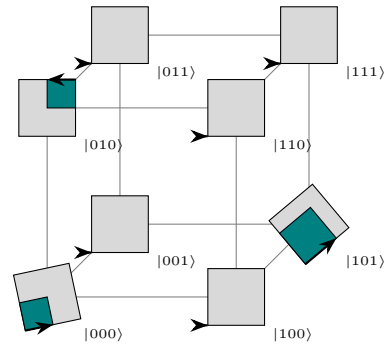
Two qubit systems

`\qcmQQ{0.5:12}{0.5:180}{0:0}{0.71:40}`



Three qubit systems

`\qcmQQQ{0.5:12}{0.5:180}{0:0}{0.71:40}`



Full Diagram

```

\begin{figure}[htbp]
  \centering
  \begin{subfigure}[b]{0.4\textwidth}
    \def\qcmScale{2}
    \centering
    \qcmQQQ{1:0}{0:0}{0:0}{0:0}{0:0}{0:0}{0:0}{0:0}
    \caption{Initial state  $|\text{ket}\{000\}$ }
  \end{subfigure}%
  \begin{subfigure}[b]{0.2\textwidth}
    \centering
    \def\qcmScale{1}
    \qcmTransitionHadamardQQQ{1}
    \vspace*{1.5cm}
  \end{subfigure}%
  \begin{subfigure}[b]{0.4\textwidth}
    \def\qcmScale{2}
    \centering
    \qcmQQQ{0.71:0}{0:0}{0.71:0}{0:0}{0:0}{0:0}{0:0}{0:0}
    \caption{Terminal state  $\frac{1}{\sqrt{2}}(|\text{ket}\{000\} + |\text{ket}\{100\})$ }
  \end{subfigure}
  \caption{Effect of Hadamard on the first bit in a system of three}
\end{figure}

```

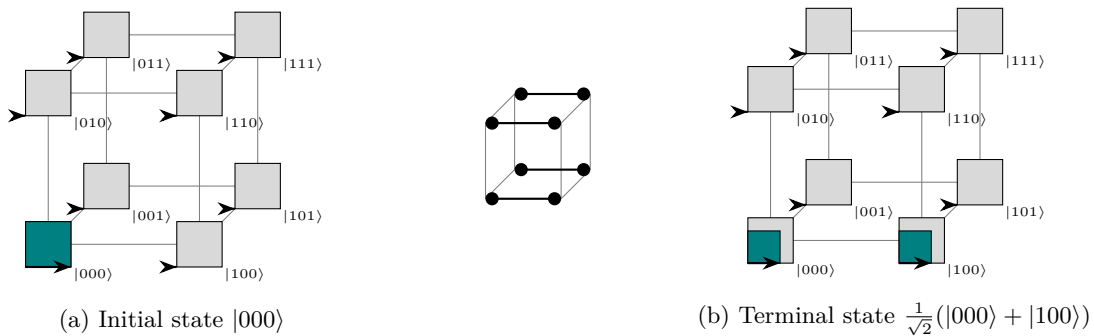


Figure 5: Effect of Hadamard on the first bit in a system of three

Transitions

For one Qubit systems use the `\qcmTransition<GateName>Q{}` commands

`\qcmTransitionHadamardQ{}`

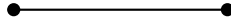


Figure 6: Transition diagram for Hadamard on a single Qubit

`\qcmTransitionPauliXQ{}`



Figure 7: Transition diagram for PauliX on a single Qubit

`\qcmTransitionPauliZQ{}`

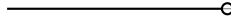


Figure 8: Transition diagram for PauliZ on a single Qubit

For two Qubit systems use the `\qcmTransition<GateName>QQ{<1> or <2>}` commands

`\qcmTransitionHadamardQQ{1}`

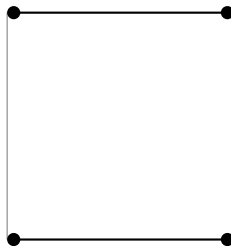


Figure 9: Transition diagram for Hadamard on the first of two Qubits

`\qcmTransitionPauliXQQ{2}`

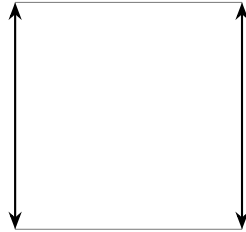


Figure 10: Transition diagram for PauliX on the second of two Qubits

`\qcmTransitionCNOTQQ{1}{2}`

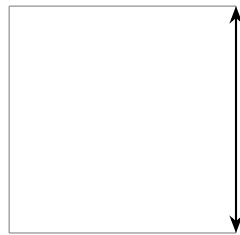


Figure 11: Transition diagram for CNOT with Control=1 and Target=2

`\qcmTransitionCNOTQQ{2}{1}`

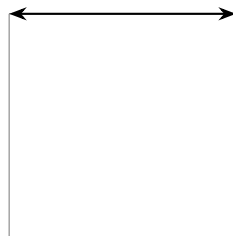


Figure 12: Transition diagram for CNOT with Control=2 and Target=1

\qcmTransitionHadamardQQQ{2}

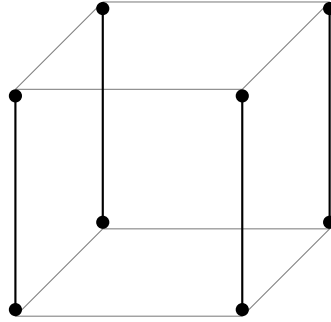


Figure 13: Transition diagram for Hadamard on the second of three Qubits

\qcmTransitionPauliXQQQ{3}

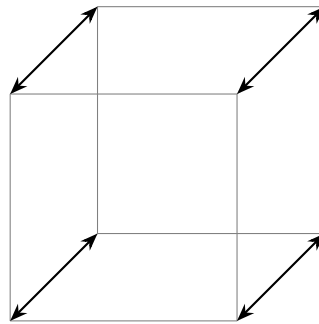


Figure 14: Transition diagram for PauliX on the third of three Qubits

\qcmTransitionCNOTQQQ{1}{2}

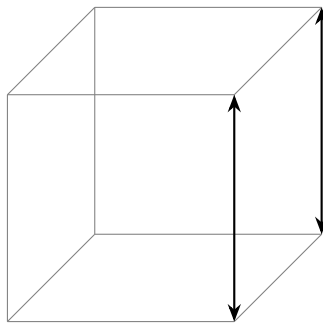


Figure 15: Transition diagram for CNOT with Control=1 and Target=2

`\qcmTransitionCNOTQQQ{3}{1}`

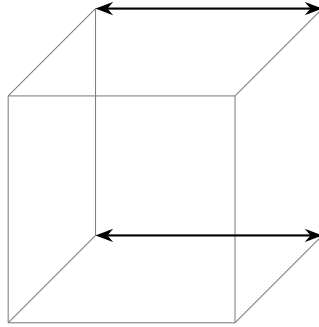


Figure 16: Transition diagram for CNOT with Control=3 and Target=1

`\qcmTransitionToffolieQQQ{1}{2}{3}`

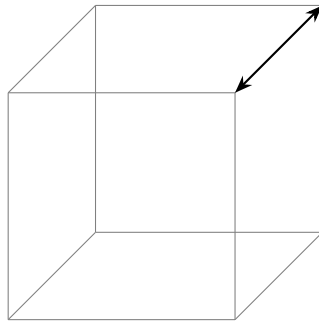


Figure 17: Transition diagram for CNOT with Control= 1 and 2 and Target=3

`\qcmTransitionToffolieQQQ{1}{3}{2}`

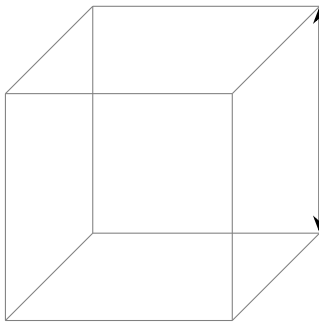


Figure 18: Transition diagram for CNOT with Control= 1 and 3 and Target=2