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

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}
```

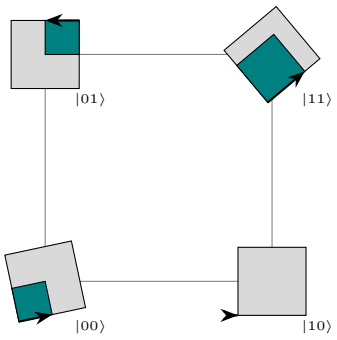
Figure 3: The $|1\rangle = 0 \cdot |0\rangle + 1 \cdot |1\rangle$ state

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

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

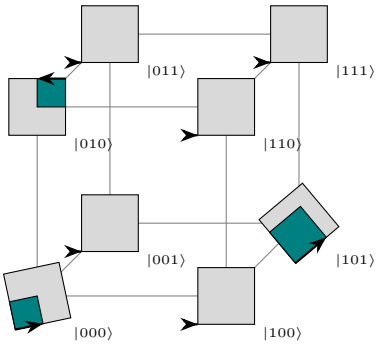
Two qubit systems

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



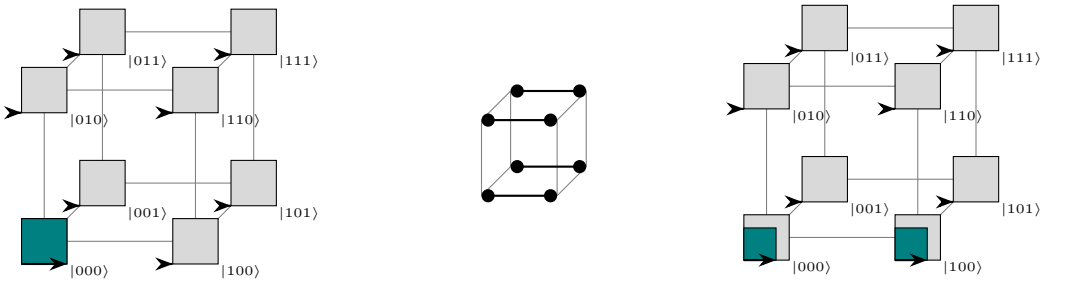
Three qubit systems

```
\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 $\ket{000}$}
    \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 $\frac{1}{\sqrt{2}}(\ket{000} + \ket{100})$ }
    \end{subfigure}
    \caption{Effect of Hadamard on the first bit in a system of three}
\end{figure}
```



(a) Initial state $|000\rangle$

(b) Terminal state $\frac{1}{\sqrt{2}}(|000\rangle + |100\rangle)$

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}`

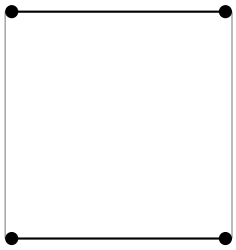


Figure 9: Transition diagram for Hadamard on the first of two Qubits

```
\qcmTransitionPauliXQQ{2}
```

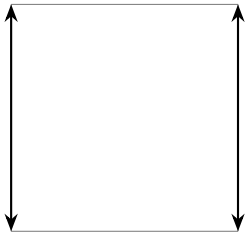


Figure 10: Transition diagram for PauliX on the second of two Qubits

```
\qcmTransitionCNOTQQ{1}{2}
```

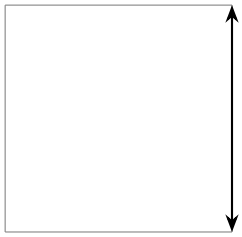


Figure 11: Transition diagram for CNOT with Control=1 and Target=2

```
\qcmTransitionCNOTQQ{2}{1}
```

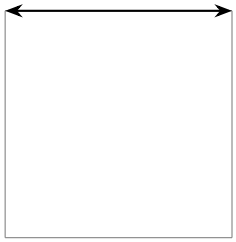


Figure 12: Transition diagram for CNOT with Control=2 and Target=1

```
\qcmTransitionHadamardQQQ{2}
```

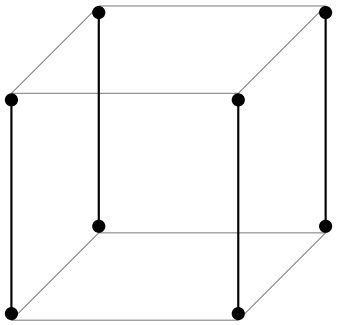


Figure 13: Transition diagram for Hadamard on the second of three Qubits

```
\qcmTransitionPauliXQQQ{3}
```

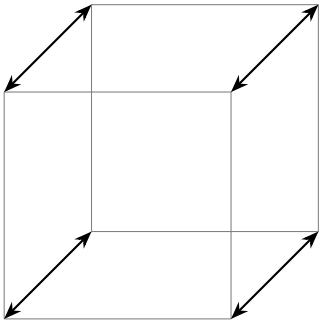


Figure 14: Transition diagram for PauliX on the third of three Qubits

```
\qcmTransitionCNOTQQQ{1}{2}
```

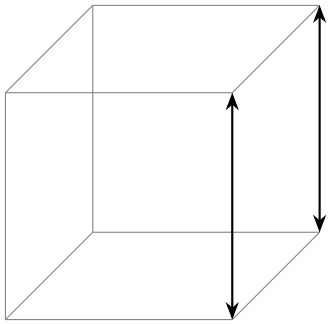


Figure 15: Transition diagram for CNOT with Control=1 and Target=2

```
\qcmTransitionCNOTQQQ{3}{1}
```

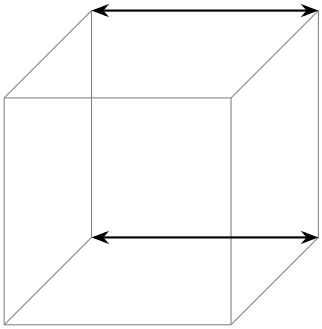


Figure 16: Transition diagram for CNOT with Control=3 and Target=1

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

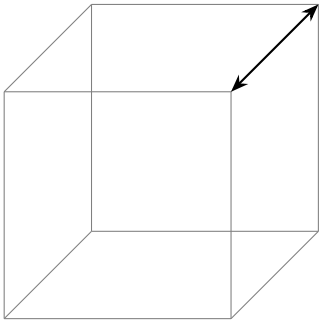


Figure 17: Transition diagram for CNOT with Control= 1 and 2 and Target=3

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

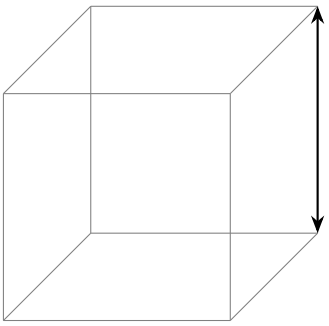


Figure 18: Transition diagram for CNOT with Control= 1 and 3 and Target=2