

Qubits (Quantum Bits)

```
In[*]:= << Q3`
```

How to refer to qubits

A collection of qubits are referred to by choosing a symbol, say, S .

```
In[*]:= Let[Qubit, S]
```

The Pauli X operator acting on different qubits.

```
In[*]:= S[1, 1]
```

```
S[2, 1]
```

```
S[3, 1]
```

```
Out[*]=
```

 S_1^X

```
Out[*]=
```

 S_2^X

```
Out[*]=
```

 S_3^X

```
In[*]:= SX // InputForm
```

```
Out[*]//InputForm=
```

 $S[1, 1]$

```
In[*]:= S[1, 2, 1]
```

```
S[2, 2, 1]
```

```
Out[*]=
```

 $S_{1,2}^X$

```
Out[*]=
```

 $S_{2,2}^X$

Various operators acting on the same qubit.

```

In[*]:= S[1, 0]
        S[1, 1]
        S[1, 2]
        S[1, 3]
        S[1, 4]
        S[1, 5]
        S[1, 6]
        S[1, 7]
        S[1, 8]
        S[1, 9]

```

```
Out[*]=
```

 S_1^0

```
Out[*]=
```

 S_1^X

```
Out[*]=
```

 S_1^Y

```
Out[*]=
```

 S_1^Z

```
Out[*]=
```

 S_1^+

```
Out[*]=
```

 S_1^-

```
Out[*]=
```

 S_1^H

```
Out[*]=
```

 S_1^S

```
Out[*]=
```

 S_1^T

```
Out[*]=
```

 S_1^F

Summary

The relation between the last flavor index and the corresponding operators.

```
In[*]:= Thread[Range[0, 9] → S[1, Range[0, 9]]] // TableForm
```

```
Out[*]//TableForm=
```

 $0 \rightarrow S_1^0$
 $1 \rightarrow S_1^X$
 $2 \rightarrow S_1^Y$
 $3 \rightarrow S_1^Z$
 $4 \rightarrow S_1^+$
 $5 \rightarrow S_1^-$
 $6 \rightarrow S_1^H$
 $7 \rightarrow S_1^S$
 $8 \rightarrow S_1^T$
 $9 \rightarrow S_1^F$

Conventional notations for the Pauli-like operators acting on qubits.

```
In[*]:= Thread[S[1, Range[0, 9]] → PauliForm[S[1, Range[0, 9]]] // TableForm
Out[*]//TableForm=

$$\begin{array}{l} S_1^0 \rightarrow I \\ S_1^X \rightarrow X \\ S_1^Y \rightarrow Y \\ S_1^Z \rightarrow Z \\ S_1^+ \rightarrow X^+ \\ S_1^- \rightarrow X^- \\ S_1^H \rightarrow H \\ S_1^S \rightarrow S \\ S_1^T \rightarrow T \\ S_1^F \rightarrow F \end{array}$$

```

Special flavor index \$

The qubit itself is referred to by putting the special flavor index \$ in the last slot of index.

```
In[*]:= S[1, $]
          S[2, $]
Out[*]=
S1
Out[*]=
S2

In[*]:= S2 // InputForm
Out[*]//InputForm=
S[2, $]

In[*]:= S[1, 2, $]
          S[2, 2, $]
Out[*]=
S1,2
Out[*]=
S2,2
```

Collective reference to several operators on the same qubit

```
In[*]:= Let[Qubit, S]
```

In many cases, we need to deal with all Pauli operators on a particular qubit $S[2, \$]$.

```
In[*]:= {S[2, 1], S[2, 2], S[2, 3]}
Out[*]= {S2X, S2Y, S2Z}
```

It can be achieved in a far simpler way.

```
In[*]:= S[2, All]
Out[*]= {S2X, S2Y, S2Z}
```

If you want to include the identity operator, then this is the way.

```
In[*]:= S[2, Full]
Out[*]= {S20, S2X, S2Y, S2Z}
```

What about this?

```
In[*]:= S[2, {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}]
Out[*]= {S20, S2X, S2Y, S2Z, S2+, S2-, S2H, S2S, S2T, S2F}
```

```
In[*]:= S[2, Range[0, 9]]
Out[*]= {S20, S2X, S2Y, S2Z, S2+, S2-, S2H, S2S, S2T, S2F}
```

Collective reference to many qubits

```
In[*]:= Let[Qubit, S]
```

Sometimes, we also need to deal with many qubits.

```
In[*]:= S[{1, 2, 3, 4}, $]
Out[*]= {S1, S2, S3, S4}
```

The same Pauli X operator on many qubits?

```
In[*]:= S[{1, 2, 3, 4}, 1]
Out[*]= {S1X, S2X, S3X, S4X}
```

Summary

Function

- Let[Qubit, S]
- S[1, \$]
- S[1, 1], S[1, 2], S[2, 3], ...
- S[1, All], S[1, Full], S[1, {1, 2, 3, 4, ...}]
- S[{1, 2, 3, 4, ...}, 1]

- Range

Related Links

- Tutorial: “Quick Quantum Computing with Q3”