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[ ]:= $S_1^{\text{"X"}}$ // 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=

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

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=

$S_1^0 \to I$
$S_1^X \to X$
$S_1^Y \to Y$
$S_1^Z \to Z$
$S_1^+ \to X^+$
$S_1^- \to X^-$
$S_1^H \to H$
$S_1^S \to S$
$S_1^T \to T$
$S_1^F \to F$

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[ ]=

S_1

Out[ ]=

S_2

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

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

$S_{1,2}$

Out[ ]=

$S_{2,2}$

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[ ]=

$\{S_2^X, S_2^Y, S_2^Z\}$

It can be achieved in a far simpler way.

In[ ]:=
```
S[2, All]
```
Out[ ]=

$\{S_2^X, S_2^Y, S_2^Z\}$

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

In[ ]:=
```
S[2, Full]
```
Out[ ]=

$\{S_2^0, S_2^X, S_2^Y, S_2^Z\}$

What about this?

In[ ]:=
```
S[2, {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}]
```
Out[ ]=

$\{S_2^0, S_2^X, S_2^Y, S_2^Z, S_2^+, S_2^-, S_2^H, S_2^S, S_2^T, S_2^F\}$

In[ ]:=
```
S[2, Range[0, 9]]
```
Out[ ]=

$\{S_2^0, S_2^X, S_2^Y, S_2^Z, S_2^+, S_2^-, S_2^H, S_2^S, S_2^T, S_2^F\}$

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[ ]=

$\{S_1, S_2, S_3, S_4\}$

The same Pauli X operator on many qubits?

In[ ]:=
```
S[{1, 2, 3, 4}, 1]
```
Out[ ]=

$\{S_1^X, S_2^X, S_3^X, S_4^X\}$

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”