Q3 Application

Q3 is a Mathematica application to help study *quantum information systems*, *quantum many-body systems*, and *quantum spin systems*. It provides various tools and utilities for symbolic and numerical calculations in these areas of quantum physics.

Installation

Q3 is distributed through the GitHub repository, https://github.com/quantum-mob/Q3App. It provides a fully automatic installation and update. Just evaluate (press the key combination **Shift-Enter**) the following code:

```
Module[{ps}, ps =
  PacletSiteRegister["https://github.com/quantum-mob/PacletServer/raw/main",
   "Quantum Mob Paclet Server"];
 PacletSiteUpdate[ps];
 PacletInstall["Q3"]
]
```

Once Q3 is installed, use **Q3CheckUpdate** and **Q3Update** to check for updates and install an update remotely.

Quick Start

Once Q3 is installed, put **Q3** or **Q3/guide/Q3** in the search field of the Wolfram Language Documentation Center (Mathematica help window) to get detailed technical information about the application . It will give you users' guides and tutorials .

A Quick Look

Make sure that the Q3 package is loaded.

In[37]:=
```
<< Q3`
```

Quantum Information Systems

In[38]:=
```
Let[Qubit, S]
```

In[39]:=
```
out = S[1, 6] ** S[2, 6] ** S[3, 6] ** Ket[];
out // LogicalForm
```

Out[40]=

$$\frac{|0_{S_1}0_{S_2}0_{S_3}\rangle}{2\sqrt{2}} + \frac{|0_{S_1}0_{S_2}1_{S_3}\rangle}{2\sqrt{2}} + \frac{|0_{S_1}1_{S_2}0_{S_3}\rangle}{2\sqrt{2}} + \frac{|0_{S_1}1_{S_2}1_{S_3}\rangle}{2\sqrt{2}} + \frac{|1_{S_1}0_{S_2}0_{S_3}\rangle}{2\sqrt{2}} + \frac{|1_{S_1}0_{S_2}1_{S_3}\rangle}{2\sqrt{2}} + \frac{|1_{S_1}1_{S_2}0_{S_3}\rangle}{2\sqrt{2}} + \frac{|1_{S_1}1_{S_2}1_{S_3}\rangle}{2\sqrt{2}}$$

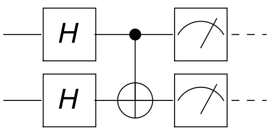
In[41]:=
```
Matrix[out] // Normal
```

Out[41]=

$$\left\{\frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}, \frac{1}{2\sqrt{2}}\right\}$$

In[42]:=
```
QuantumCircuit[S[{1, 2}, 6], CNOT[S[1], S[2]], Measurement[S[{1, 2}, 3]]]
```

Out[42]=



Quantum Many-Body Systems

In[43]:=
```
Let[Fermion, c]
```

In[44]:=
```
bs = Basis[c@{1, 2}];
bs // LogicalForm
```

Out[45]=

$$\{|0_{c_1}0_{c_2}\rangle, |0_{c_1}1_{c_2}\rangle, |1_{c_1}0_{c_2}\rangle, |1_{c_1}1_{c_2}\rangle\}$$

In[46]:=
```
H = Q@c@{1, 2}
```

Out[46]=

$$c_1^\dagger c_1 + c_2^\dagger c_2$$

In[47]:=
```
H ** bs
```

Out[47]=

$$\{0, |1_{c_2}\rangle, |1_{c_1}\rangle, 2\,|1_{c_1}1_{c_2}\rangle\}$$

Quantum Spin Systems

In[48]:=
```
Let[Spin, J]
```

In[49]:=
```
H = J[1, 1] ** J[2, 1] + J[1, 2] ** J[2, 2]
```

Out[49]=

$$J_1^x J_2^x + J_1^y J_2^y$$

In[50]:=
```
v = Ket[J[1] → -1 / 2] + Ket[J[2] → -1 / 2];
v // LogicalForm
```

Out[51]=

$$\left|-\frac{1}{2}_{J_1} \frac{1}{2}_{J_2}\right\rangle + \left|\frac{1}{2}_{J_1} -\frac{1}{2}_{J_2}\right\rangle$$

In[52]:=
```
vv = H ** v;
vv // LogicalForm
```

Out[53]=

$$\frac{1}{2}\left|-\frac{1}{2}_{J_1}\frac{1}{2}_{J_2}\right\rangle+\frac{1}{2}\left|\frac{1}{2}_{J_1}-\frac{1}{2}_{J_2}\right\rangle$$