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[5]:=
```
<< Q3`
```

Quantum Information Systems

In[6]:=
```
Let[Qubit, S]
```

In[7]:=
```
out = S[1, 6] ** S[2, 6] ** S[3, 6] ** Ket[]
```

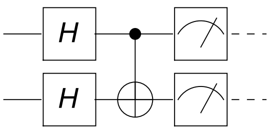
Out[7]=
$$\frac{\left|0_{S_1}0_{S_2}0_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|0_{S_1}0_{S_2}1_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|0_{S_1}1_{S_2}0_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|0_{S_1}1_{S_2}1_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|1_{S_1}0_{S_2}0_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|1_{S_1}0_{S_2}1_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|1_{S_1}1_{S_2}0_{S_3}\right\rangle}{2\sqrt{2}}+\frac{\left|1_{S_1}1_{S_2}1_{S_3}\right\rangle}{2\sqrt{2}}$$

In[8]:=
```
Matrix[out] // Normal
```

Out[8]=
$$\left\{\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}},\frac{1}{2\sqrt{2}}\right\}$$

In[12]:=
```
qc = QuantumCircuit[S[{1, 2}, 6], CNOT[S[1], S[2]], Measurement[S[{1, 2}, 3]]]
```

Out[12]=



Quantum Many-Body Systems

In[13]:=
```
Let[Fermion, c]
```

In[16]:=
```
bs = Basis[c@{1, 2}]
```

Out[16]=
$$\left\{\left|0_{c_1}0_{c_2}\right\rangle,\left|0_{c_1}1_{c_2}\right\rangle,\left|1_{c_1}0_{c_2}\right\rangle,\left|1_{c_1}1_{c_2}\right\rangle\right\}$$

In[17]:=
```
H = Q@c@{1, 2}
```

Out[17]=
$$c_1^{\dagger}c_1+c_2^{\dagger}c_2$$

In[18]:=
```
H ** bs
```

Out[18]=
$$\left\{0,\left|0_{c_1}1_{c_2}\right\rangle,\left|1_{c_1}0_{c_2}\right\rangle,2\left|1_{c_1}1_{c_2}\right\rangle\right\}$$

Quantum Spin Systems

In[19]:=
```
Let[Spin, J]
```

In[20]:=
```
H = J[1, 1] ** J[2, 1] + J[1, 2] ** J[2, 2]
```

Out[20]=
$$J_1^x J_2^x + J_1^y J_2^y$$

In[25]:=
```
v = Ket[J[1] → -1 / 2] + Ket[J[2] → -1 / 2] // KetRegulate
```

Out[25]=
$$\left|-\frac{1}{2}_{J_1}\frac{1}{2}_{J_2}\right\rangle+\left|\frac{1}{2}_{J_1}-\frac{1}{2}_{J_2}\right\rangle$$

In[26]:=
```
vv = H ** v
```

Out[26]=
$$\frac{1}{2}\left|-\frac{1}{2}_{J_1}\frac{1}{2}_{J_2}\right\rangle+\frac{1}{2}\left|\frac{1}{2}_{J_1}-\frac{1}{2}_{J_2}\right\rangle$$