Q3 Application

Q3 is a software package written in the Wolfram Language 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[•]:= << Q3`
```

Quantum Information Systems

```
In[•]:= Let[Qubit, S]
```

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

Out[•]=

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

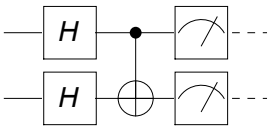
In[•]:=
```
Matrix[out] // Normal
```

Out[•]=

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

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

Out[•]=



Quantum Many-Body Systems

In[•]:=
```
Let[Fermion, c]
```

In[•]:=
```
bs = Basis[c@{1, 2}]
```

Out[•]=

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

In[•]:=
```
H = Q@c@{1, 2}
```

Out[•]=

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

In[•]:=
```
H ** bs
```

Out[•]=

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

Quantum Spin Systems

In[•]:=
```
Let[Spin, J]
```

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

Out[•]=

$$J_1^X J_2^X + J_1^Y J_2^Y$$

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

Out[•]=

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

In[•]:= **vv = H ✱✱ v**

Out[•]=

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