Q3: Symbolic Quantum Simulation

Q3 is a symbolic quantum simulation framework 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/PacletRepository/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]
```

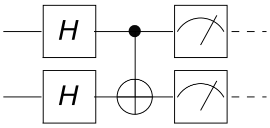
In[ ]:=
```
out = S[1, 6] ** S[2, 6] ** S[3, 6] ** Ket[]
```
Out[ ]=

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

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[ ]=

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