

```
In [1]:  from qiskit import *
         from math import pi

         import numpy as np
         from qiskit.visualization import plot_bloch_multivector, plot_histogram
         from qiskit_textbook.tools import array_to_latex
```

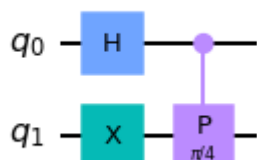
```
In [2]:  backend_s = Aer.get_backend('statevector_simulator')
         backend_u = Aer.get_backend('unitary_simulator')
```

## Phase Kickback

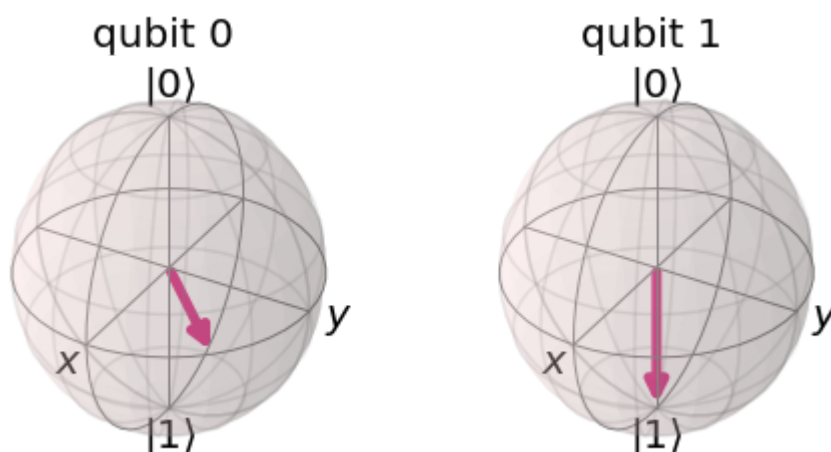
### Solutions

Please note that the circuits follow qiskit's ordering of qubits: topmost qubit in the circuit is written in the left most place.

```
In [3]:  qc = QuantumCircuit(2)
         qc.h(0)
         qc.x(1)
         # Add Controlled-T
         qc.cp(pi/4, 0, 1) # alternatively: qc.cu1(pi/4,0,1)
         display(qc.draw('mpl'))
         # See Results:
         final_state = execute(qc, backend_s).result().get_statevector()
         plot_bloch_multivector(final_state)
```



Out[3]:

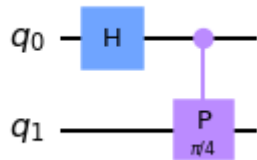


### Quick Exercises

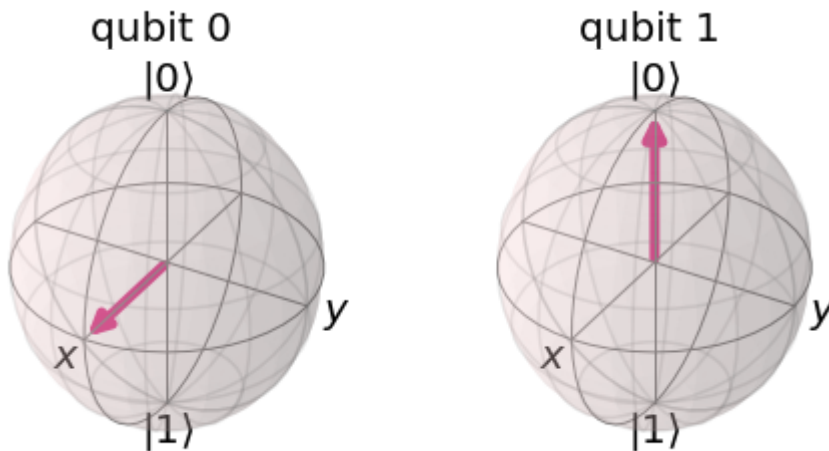
1. What would be the resulting state of the control qubit ( $q_0$ ) if the target qubit

$(q_1)$  was in the state  $|0\rangle$  ? (as shown in the circuit below)? Use Qiskit to check your answer.

```
In [4]:  qc = QuantumCircuit(2)
        qc.h(0)
        # Add Controlled-T
        qc.cp(pi/4, 0, 1) # Alternatively qc.cu1(pi/4,0,1)
        display(qc.draw('mpl'))
        # See Results:
        final_state = execute(qc,backend_s).result().get_statevector()
        plot_bloch_multivector(final_state)
```

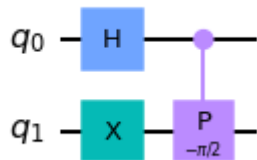


Out[4]:

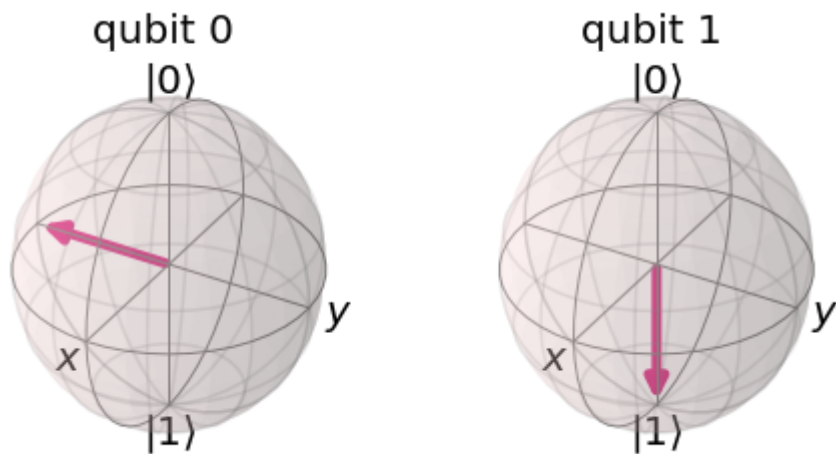


2. What would happen to the control qubit ( $q_0$ ) if the if the target qubit ( $q_1$ ) was in the state  $|1\rangle$ , and the circuit used a controlled-Sdg gate instead of the controlled-T (as shown in the circuit below)?

```
In [5]: ➤ qc = QuantumCircuit(2)
qc.h(0)
qc.x(1)
# Add Controlled-T
qc.cp(-pi/2, 0, 1) #Alternatively qc.cu1(-pi/2,0,1)
display(qc.draw('mpl'))
# See Results:
final_state = execute(qc,backend_s).result().get_statevector()
plot_bloch_multivector(final_state)
```

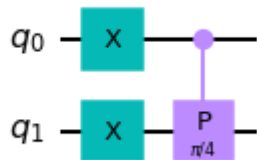


Out[5]:

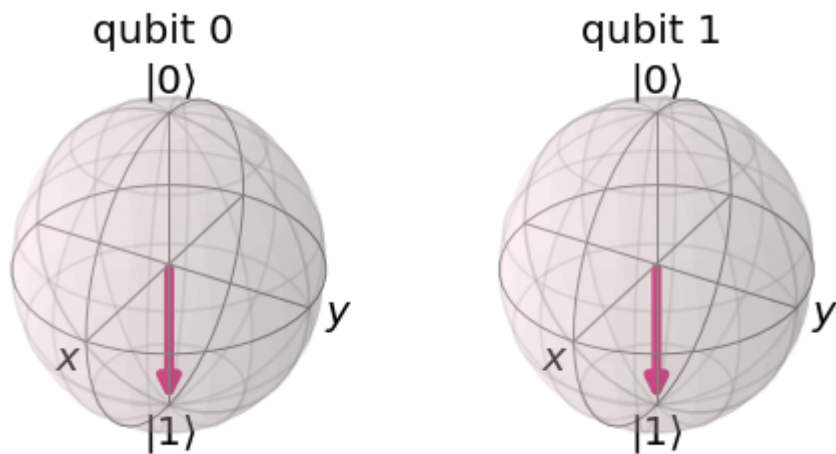


**3. What would happen to the control qubit ( $q_0$ ) if it was in the state  $|1\rangle$  instead of the state  $|+\rangle$  before application of the controlled-T (as shown in the circuit below)?**

```
In [6]: ➤ qc = QuantumCircuit(2)
qc.x(0)
qc.x(1)
# Add Controlled-T
qc.cp(pi/4, 0, 1) # Alternatively, qc.cu1(pi/4,0,1)
display(qc.draw('mpl'))
# See Results:
final_state = execute(qc,backend_s).result().get_statevector()
plot_bloch_multivector(final_state)
```



Out[6]:



```
In [7]: ➤ import qiskit
qiskit.__qiskit_version__
```

Out[7]: {'qiskit-terra': '0.16.1',  
'qiskit-aer': '0.7.1',  
'qiskit-ignis': '0.5.1',  
'qiskit-ibmq-provider': '0.11.1',  
'qiskit-aqua': '0.8.1',  
'qiskit': '0.23.1'}

In [ ]: ➤