Learn to represent and visualize basic qubit states on the Bloch Sphere

1 - Pure Qubit

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle,\ |\alpha|^2 + |\beta|^2 = 1$$

Being

$|\psi\rangle$ - a representation of the state vector of a 2-dimensional complex vector space (C2).

α, β - are complex numbers, amplitudes for the Qubit, two real angles that can be represented in a Bloch Sphere.

$|0\rangle$, $|1\rangle$ - are computational basis states

Mathematically:

$$|0\rangle = \begin{vmatrix} 1 \\ 0 \end{vmatrix} \qquad |1\rangle = \begin{vmatrix} 0 \\ 1 \end{vmatrix}$$

Physically: spin up or down, depending of the processor model (Superconducting, Trapped Ion, Neutral Atom, Quantum Dots)

$|\alpha|^2$, $|\beta|^2$ - probabilities of measuring the qubit in $|0\rangle$, $|1\rangle$ in modulus.

2 - Qubit State in terms of angles

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle = \mathbf{\cos(\theta/2)\,|0\rangle + e^{i\phi}\sin(\theta/2)\,|1\rangle}$$

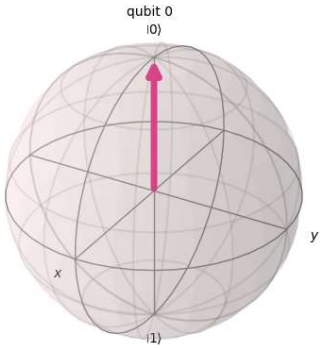
θ represent the balance between $|0\rangle$ and $|1\rangle$

ϕ represent the imaginary part (phase).

Exercise:

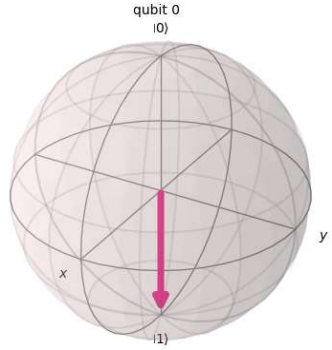
Initialize a Qubit in the $|0\rangle$ state:

- Create a simple quantum circuit with one qubit in the $|0\rangle$ state
- visualize this state on the Bloch Sphere



Change to |1⟩ state:

- Apply the X gate (NOT gate) to change the Qubit to |1⟩.
- visualize this state on the Bloch Sphere



Create a superposition:

- Apply the Hadamard gate to create superposition state
- visualize this state on the Bloch Sphere