Basics of quantum information and quantum computing

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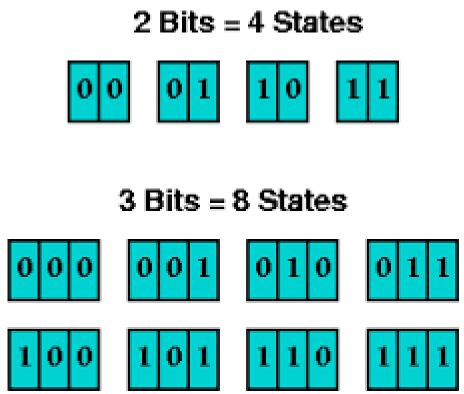
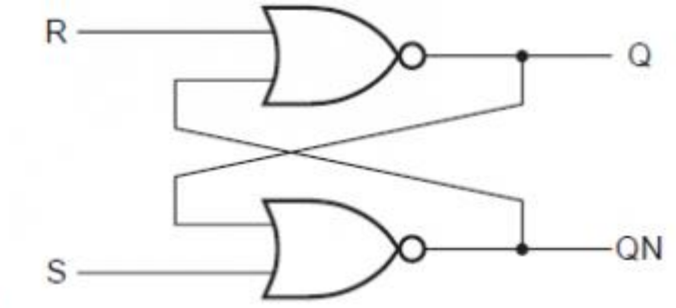
https://www.research.ibm.com/ibm-q/

Why quantum computer

- Simulate quantum phenomena
- Shor’s factorization algorithm (encryption and decryption)
- Grover’s algorithm for unstructured search

- Classical information
- Bit/binary



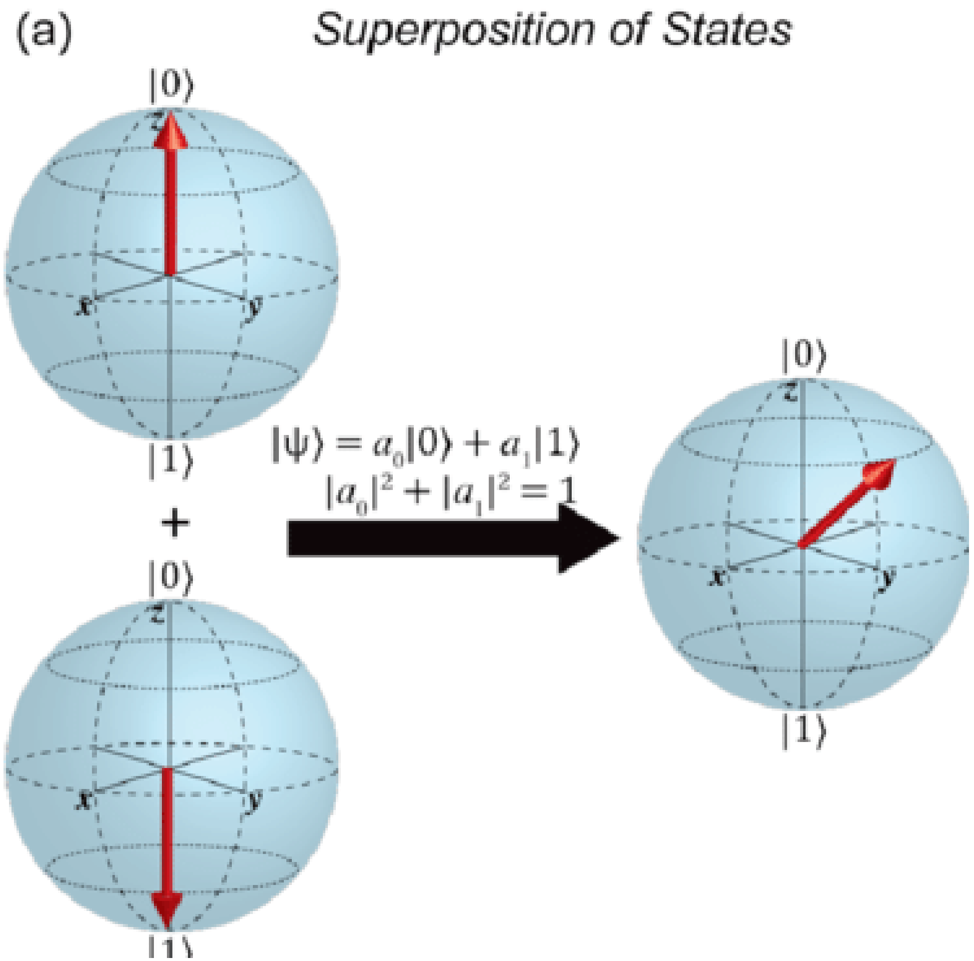


(a)

(b)

S	R	Q	QN
0	0	last Q	last QN
0	1	0	1
1	0	1	0
1	1	0	0

- Quantum information
- Qubit (Bloch sphere) and superposition



Implementation of qubit

- Linearly polarized photon

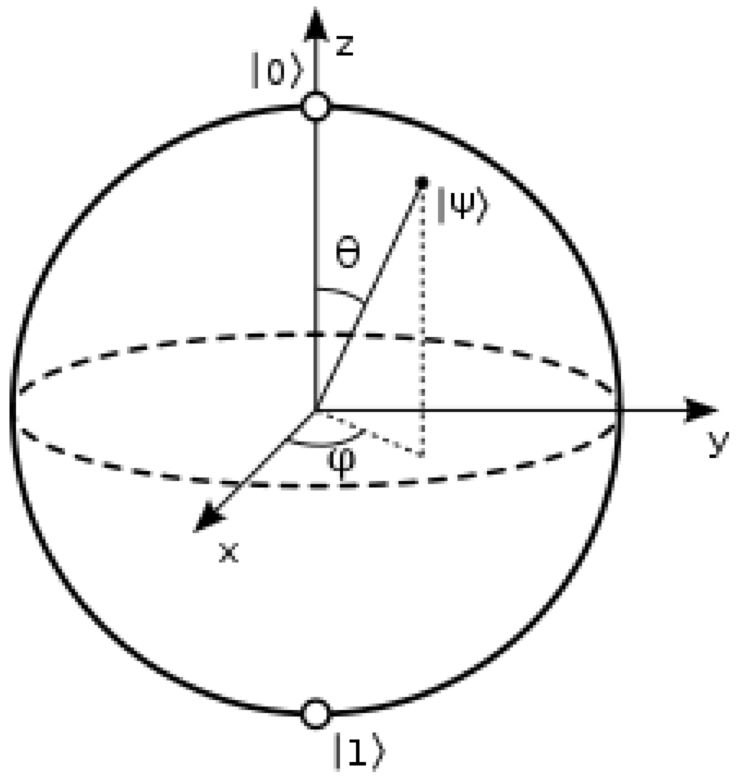
$|0>: E_x\hat{x}$

$|1>: E_y\hat{y}$

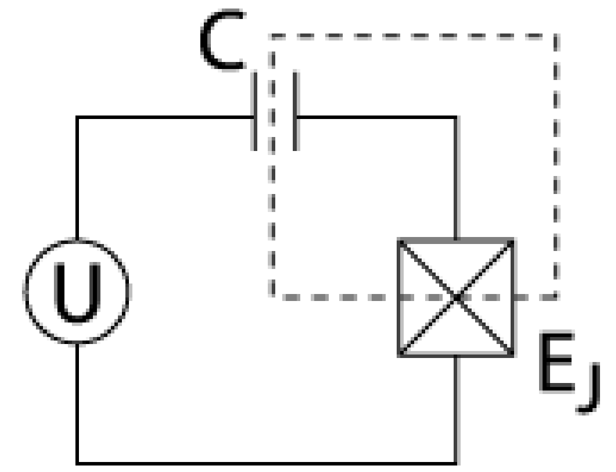
$|\psi>: E_x\hat{x} + e^{i\phi}E_y\hat{y}$

Elliptical photon

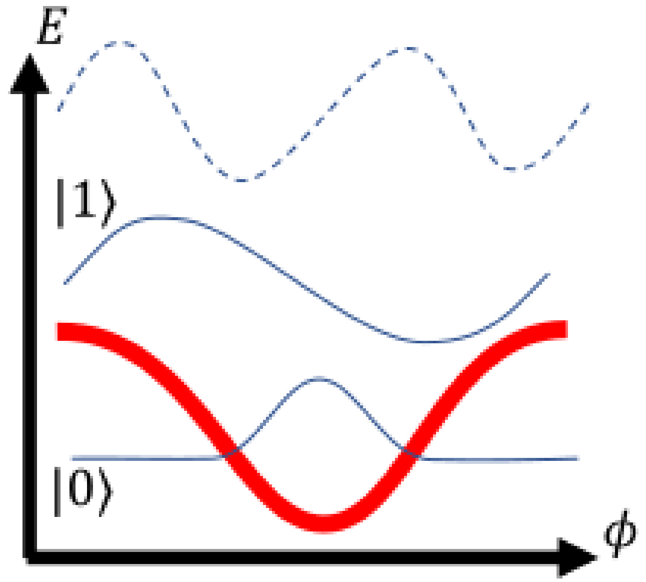
$$E_y/E_x = \tan(\theta)$$



Implementation of qubit



- Macroscopic quantum state (superconducting state)
- Josephson junction (two superconductor separated by an insulator with phase change ϕ.



Superconducting island in dashed line

$$E = E_c(N - N_g) - E_j \cos(\quad)$$

N: number of cooper pairs

N_g, E_j constants.

Entanglement

- Superposition of many-body states

$$\frac{1}{\sqrt{2}}(|01>+|10>)$$

When quit 1 measures |0>, qubit 2 must measure |1>. This is entanglement.