

Goals

- Describe qubits + quantum measurement using kets
- Connect ket notation to physical intuition
- Analyze novel situations using kets

Announcements

Exit Tickets

Qubit = quantum bit

Single photon polarization can encode one qubit

Some familiar qubit states	<u>Photon</u>	<u>Ket Notation</u>	<u>English</u>
		$ 0\rangle$	
		$ 1\rangle$	—
			
			

$\{|0\rangle, |1\rangle\} \Rightarrow$

basis

$\{|+\rangle, |-\rangle\} \Rightarrow$

basis

Why "qubit"?

Qubit State:

$$|\psi\rangle = a_0|0\rangle + a_1|1\rangle$$

normalization:

ex:

See online notes for
vector notation

"Superposition" -

Qubit Measurement

Represented mathematically by orthonormal pair of kets

$$M = \{ |\phi_1\rangle, |\phi_2\rangle \}$$

ex: $\boxed{\text{IIII}} = \{ |10\rangle, |11\rangle \}$

If measure state $|\psi\rangle$ with $M = \{ |\phi_1\rangle, |\phi_2\rangle \}$:

- With probability $|\langle \phi_1 | \psi \rangle|^2$
- With probability $|\langle \phi_2 | \psi \rangle|^2$

Can't control outcome of measurement — Probabilistic

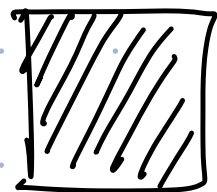
Bra

$$\text{If } |\psi\rangle = a_0|0\rangle + a_1|1\rangle \quad \text{Bra} \Rightarrow$$

Brackets / Inner Products

Example

$$\frac{1}{\sqrt{2}}|0\rangle + \frac{i}{\sqrt{2}}|1\rangle$$

$$M = \{ \overset{\square}{|+\rangle}, \overset{\square}{|-\rangle} \}$$

QI2

Probability of no photon exiting =

Collapse:

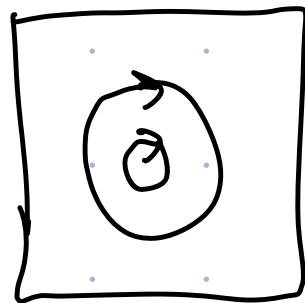
1:

Q12

Clockwise

Counter-clockwise

$$\frac{1}{\sqrt{3}}|0\rangle + \sqrt{\frac{2}{3}}|1\rangle \rightarrow$$

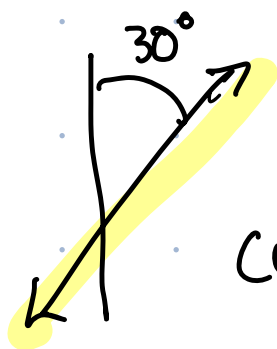


$$M = \left\{ \frac{1}{\sqrt{2}}|0\rangle + \frac{i}{\sqrt{2}}|1\rangle, \frac{1}{\sqrt{2}}|0\rangle - \frac{i}{\sqrt{2}}|1\rangle \right\}$$

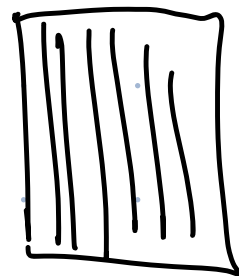
clockwise polarized filter.

What is probability a photon emerges + what polarization?

2.



$$\cos 30^\circ |0\rangle + \sin 30^\circ |1\rangle$$

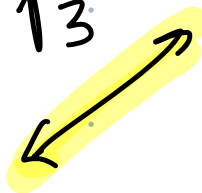


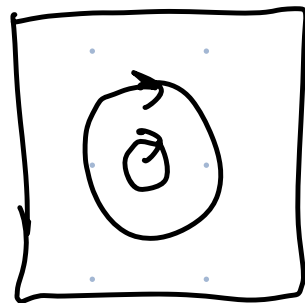
D*

What is prob of detection/no detection?

3. If state $|\psi\rangle = a_0|0\rangle + a_1|1\rangle$, what is $\langle\psi|\psi\rangle$?

1: $\frac{1}{\sqrt{3}}|0\rangle + \sqrt{\frac{2}{3}}|1\rangle$





clockwise

counterclockwise

$$M = \left\{ \frac{1}{\sqrt{2}}|0\rangle + \frac{i}{\sqrt{2}}|1\rangle, \frac{1}{\sqrt{2}}|0\rangle - \frac{i}{\sqrt{2}}|1\rangle \right\}$$

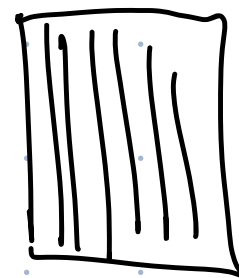
Right circularly polarized filter.

What is probability a photon emerges + what polarization?

2.



$$i \cos 30^\circ |0\rangle + \sin 30^\circ |1\rangle$$



D*

What is prob of detection / no detection?

Detection:



No detection

3. If state $|\psi\rangle = a_0|0\rangle + a_1|1\rangle$, what is $\langle\psi|\psi\rangle$?

A properly normalized state has inner product 1 with itself.