Goals

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

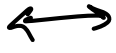
Announcements

Exit Tickets

Qubit = quantum bit

Single photon polarization can encode one qubit

Some familiar qubit states

Photon	Ket Notation	English
	$\|0\rangle$	
	$\|1\rangle$	
	$\|+\rangle = \frac{1}{\sqrt{2}}\|0\rangle + \frac{1}{\sqrt{2}}\|1\rangle$	
	$\|-\rangle = \frac{1}{\sqrt{2}}\|0\rangle - \frac{1}{\sqrt{2}}\|1\rangle$	

Why "Qubit"?

Qubit State:

$$|\psi\rangle =$$

ex: $|0\rangle$:

$|-\rangle$:

:

"Superposition"

See online notes for vector notation

Qubit Measurement

Represented mathematically by orthonormal pair of kets

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

ex:

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

- With probability , get outcome ,
  $|\psi\rangle$ collapses to
- With probability , get outcome ,
  $|\psi\rangle$ collapses to

Can't control outcome of measurement —

Bras

If $|\psi\rangle = a_0|0\rangle + a_1|1\rangle$ $\Rightarrow$ Bra

Brakets / Inner Products

Basic Rules:

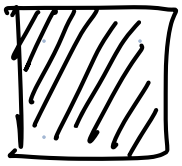
-
-
-
-
-
-

Example

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

$\rightsquigarrow$

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



Probability of no photon exiting

$|-\rangle =$

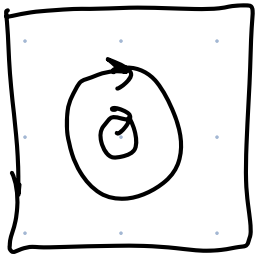
$|\langle -|\circlearrowright\rangle|^2 =$

$=$

$=$

$=$

1:

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

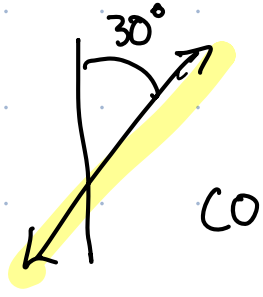
Clockwise Counter-clockwise

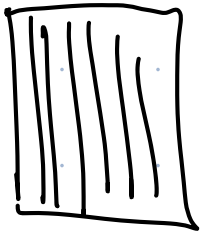
$M = \{\frac{1}{\sqrt{2}}|0\rangle + \frac{i}{\sqrt{2}}|1\rangle, \frac{1}{\sqrt{2}}|0\rangle - \frac{i}{\sqrt{2}}|1\rangle\}$

clockwise polarized filter.

What is probability a photon emerges + what polarization?

2.

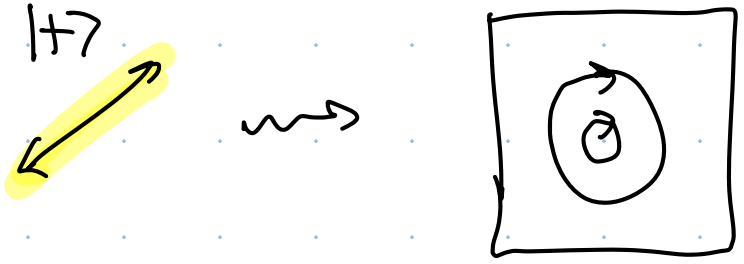


$\cos 30°|0\rangle + \sin 30°|1\rangle \rightsquigarrow$  D-*

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:



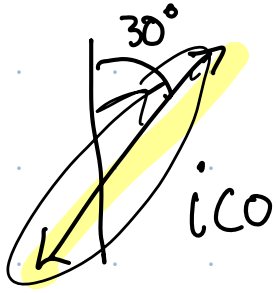
Right circ. , Left circ.

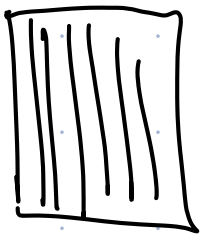
$$M = \left\{ \frac{1}{\sqrt{2}}|0\rangle + \frac{i}{\sqrt{2}}|1\rangle, \frac{1}{\sqrt{2}}|0\rangle - \frac{i}{\sqrt{2}}|1\rangle \right\}$$

Right circularly polarized filter.

What is probability a photon merges + what polarization?

2.



$i\cos 30°|0\rangle + \sin 30°|1\rangle$ ⇝  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 $\langle\psi|\psi\rangle$?