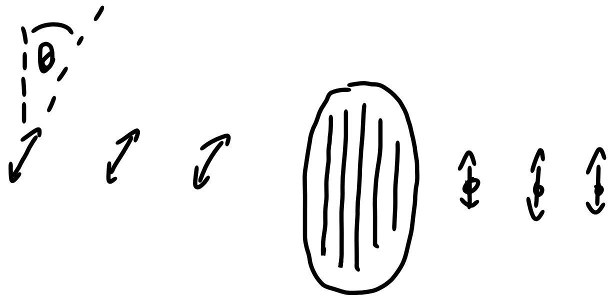
Last time: for a polarizer at an angle θ to the polarization of the incoming photons, the probability that any photon gets through was $\cos^2\theta$

Let the polarizer be aligned vertically (call that 0 degrees) and let the photons be polarized at an angle θ from the vertical:



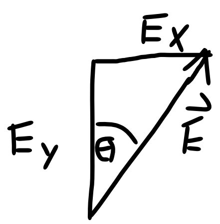
Let's introduce some new notation: represent polarization state by a unit vector, for example

$\uparrow \; = \; |0^\circ\rangle \qquad\qquad \rightarrow \; = \; |90^\circ\rangle$

$\nearrow \; = \; |30^\circ\rangle \qquad\qquad$ ETC...

What is $|\theta\rangle$ in terms of $|0^\circ\rangle$ & $|90^\circ\rangle$?

$\vec{E} = \hat{y} E_y + \hat{x} E_x$



$E_x = E \sin\theta$

$E_y = E \cos\theta$

$$\therefore \; |\theta\rangle = \cos\theta \, |0^\circ\rangle + \sin\theta \, |90^\circ\rangle \qquad \text{BY ANALOGY}$$

Recall that probability of going through the polarizer at 0 is $\cos^2\theta$

with probability $\cos^2\theta$ photon acts as if it was $|0\rangle$ -> transmitted and becomes $|0\rangle$

with probability $\sin^2\theta$ photon acts as if it were $|90\rangle$ -> absorbed

This is a generic behaviour in QM. Let's describe it using some standard terminology.

We have a QUANTUM STATE which describes the actual state of the particle (photon)

We have a MEASUREMENT - the polarizer is a way of measuring the polarization of the photon

For any given measurement (orientation of the polarizer) we have some special states called EIGENSTATES for which the outcome of the measurement is certain - states parallel to and orthogonal to the orientation of the polarizer, here.

Any quantum state can be writen as a QUANTUM SUPERPOSITON (sum with some coefficients) of the eigenstates.

When the measurement is made (photon hits the polarizer), it **completely changes into one of the eigenstates**.
It then behaves that way forever afterwards, unless something changes it again.

The above process is **random with probability** given by the square of (the magnitude of) the coefficient in superposition.

The above is the basic framework of all quantum mechanics.

-> clicker question

-> Clicker question
It is not possible to determine the quantum state of a single photon

-> clicker question
-> a quantum superposition is not the same as a mixture - extra information is carried by the relative sign (phase)
-> clicker question

Recall that to express non-linear polarizations (such as circular polarization), we needed to express the polarization vector using complex numbers (tut 8). The coefficients in front of the eigenstates are an analog of the polarization vector.
-> these can be complex.

eg: a circularly polarized photon has a quantum state given by $(|0\rangle + i|90\rangle)/\sqrt{2}$
-> clicker question
more on circularly polarized photons in PS 8