Qbits & Weird Quantum Effects

Dirac 3 ~~photon~~ polarizer expt.

Current computers manipulate bits.

A bit is either 0 or 1. Eight bits in a byte.

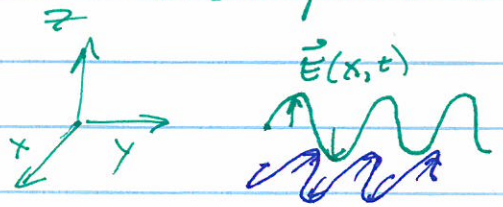
Q: How many bits in a kilobyte?

A: 1024 bytes in a kilobyte

→ 8192 bits.

Quantum systems are described by wavefunctions – superpositions of states. Qbits are the quantum version of bits.

Example: Photon polarization (Dirac 3 Polarizer expt)

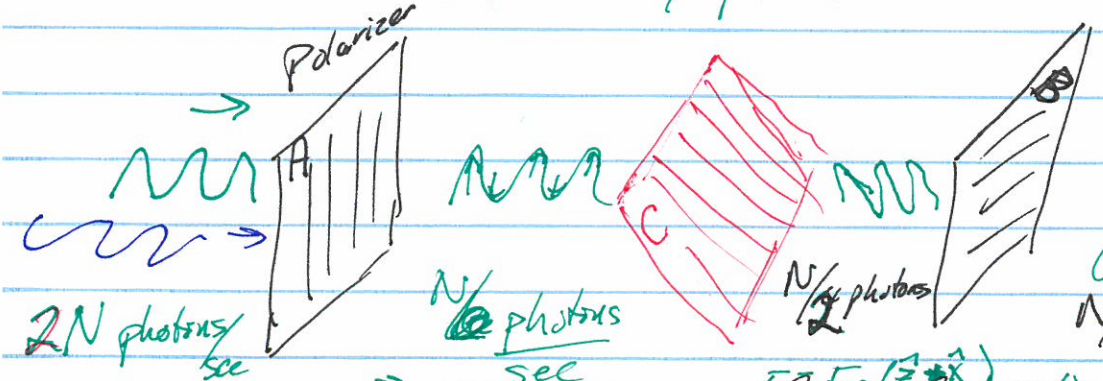


$\vec{E}(x,t)$

$\vec{E} \propto E_0 \hat{z} \cos(kx-\omega t)$ 'vertical' ↔ 1

$\vec{E} \propto E_0 \hat{x} \cos(kx-\omega t)$ 'horizontal' ↔ 0

one bit/photon?



Weird.

Blocking half the photons lets more through

Classical polarizer analysis

$N_{photons} \sim$ Power $\sim E^2$

After A: $\vec{E} = E_0 \hat{z} \cos(kx - \omega t)$ — E_0^2

After C: $\hat{z} = \frac{\hat{z}+\hat{x}}{2} + \frac{\hat{z}-\hat{x}}{2}$

$\vec{E} = E_0 \left(\frac{\hat{z}+\hat{x}}{2}\right) \cos(\ldots)$ — $E_0^2\left(\frac{2}{2^2}\right)$

After B: $\vec{E} = E_0 \left(\frac{\hat{z}}{2}\right) \cos(\ldots)$ — $E_0^2/4$

Photons act like waves.

Quantum polarizer analysis

$|v\rangle \Leftrightarrow |1\rangle \Leftrightarrow \begin{pmatrix}1\\0\end{pmatrix}$ $\quad |h\rangle \Leftrightarrow |0\rangle \Leftrightarrow \begin{pmatrix}0\\1\end{pmatrix}$

After A: $\psi_A = |v\rangle = \begin{pmatrix}1\\0\end{pmatrix}$

After C: $\psi_C = \begin{pmatrix}1/2\\1/2\end{pmatrix}$ ← Not normalized? Polarizer = observation; only half photons get through, 'collapse' of wf

After B: $\psi_B = \begin{pmatrix}1/2\\0\end{pmatrix}$

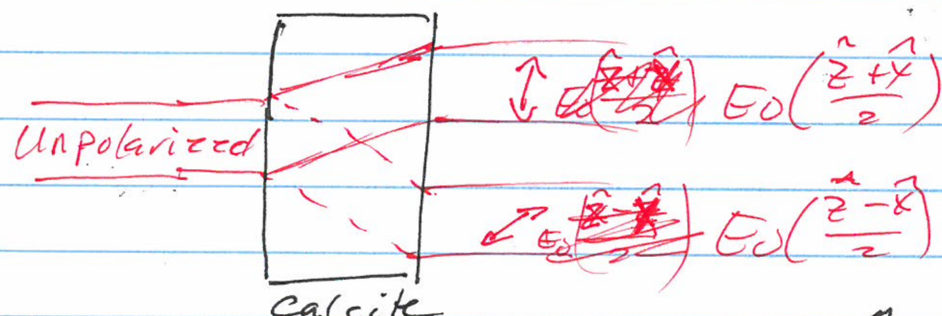
Dirac: "The state of oblique polarization may be regarded as being ~~partly in the state of vertical polarization and partly~~ in the ... in some kind of superposition process applied to the two states [vertical and horizontal]".

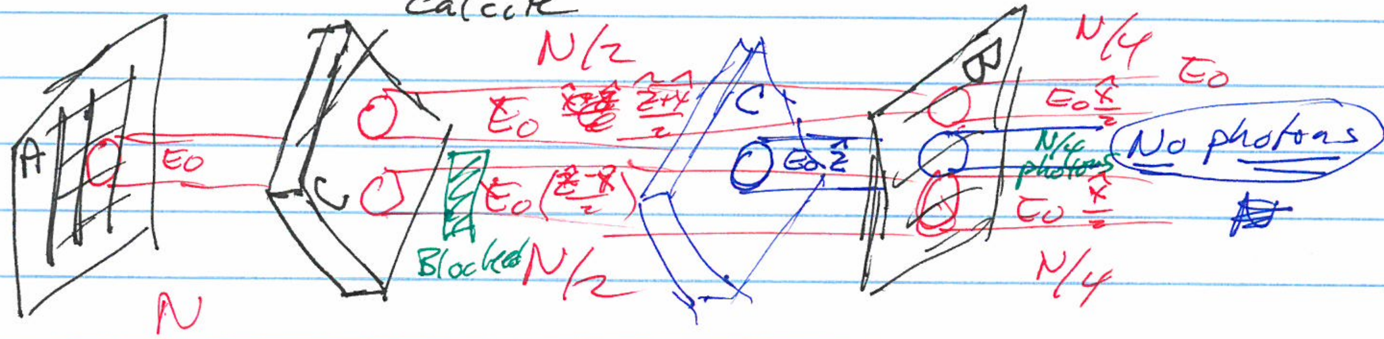
Not so surprising?

¿ Heisenberg: The observation process disturbs the quantum state. ?

Is this why photons get through?
Maybe ~~the~~ filter C 'twists' the photons?

Replace polarizer C with <u>birefringent</u> material (Calcite)





Calcite doesn't 'twist' the photons. It separates them by polarization without 'measuring' them. No transfer of energy, momentum, ... }
informationally isolated, [S&W] c-c chumacher during central region — no Heisenberg 'disturbance'.

But if we block one of the separated beams, N/4 photons get through — just as for the ~~Pol~~ diagonal polaroid.
Not Heisenberg. Just weird.