$A \otimes B \neq B \otimes A$

$\langle \psi | A \otimes B | \psi \rangle = \langle \chi | B \otimes A | \chi \rangle$

$|\psi_A\rangle = \frac{1}{\sqrt{2}} |\uparrow\rangle_A + \frac{1}{\sqrt{2}} |\downarrow\rangle_A$

$|\psi_B\rangle = \frac{1}{\sqrt{2}} |\uparrow\rangle_B + \frac{1}{\sqrt{2}} |\downarrow\rangle_B$

$|\psi_{AB}\rangle = |\psi_A\rangle \otimes |\psi_B\rangle$

$= \frac{1}{2} [|\uparrow_A \uparrow_B\rangle + |\uparrow_A \downarrow_B\rangle + |\downarrow_A \downarrow_B\rangle + |\downarrow_A \uparrow_B\rangle]$

Schrodinger Cat

$|\psi_{CB}\rangle = \frac{1}{2} |\uparrow_C \uparrow_B\rangle + \frac{1}{2} |\uparrow_C \downarrow_B\rangle + \frac{1}{2} |\downarrow_C \uparrow_B\rangle + \frac{1}{2} |\downarrow_C \downarrow_B\rangle$

$|\uparrow_C\rangle$ - cat alive $|\downarrow_C\rangle$ - cat ded

$|\uparrow_B\rangle$ - Bomb not exploded $|\downarrow_B\rangle$ - Bomb exploded

$|\psi_{CB}\rangle = \frac{1}{2} |\uparrow_C \uparrow_B\rangle + \frac{1}{2} |\downarrow_C \downarrow_B\rangle$ (other 2 states are not physical states)

$\neq |\psi_C\rangle \otimes |\psi_B\rangle$ ↳ cannot write

Entangled State

Entanglement is a physical phenomenon

This is a bad example

$$|\psi_{nl}\rangle = |n\,l\,m\,s\rangle = |n\rangle \otimes |l\rangle \otimes |m\rangle \otimes |s\rangle$$

$$\langle \uparrow | \chi \rangle = \frac{1}{2}\langle \uparrow | \uparrow \rangle + \frac{1}{2}\langle \uparrow | \downarrow \rangle$$

$$= \frac{1}{2}\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}1\\0\end{bmatrix} + \frac{1}{2}\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}0\\1\end{bmatrix}$$

$$= \frac{1}{2} + 0 = \frac{1}{2}$$

$$\langle \downarrow | \chi \rangle = \frac{1}{2}$$