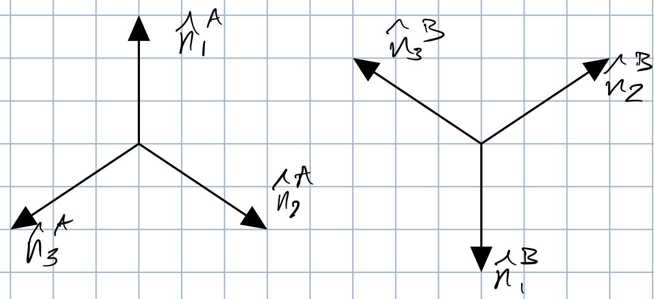
GHZ extension of Bell's Thm

Alice — spacelike seperated — Bob

given entangled states:

$$|S=0\rangle = \frac{1}{\sqrt{2}}\left(|+,z\rangle_A \otimes |-,z\rangle_B - |-,z\rangle_A \otimes |+,z\rangle_B \right)$$

Alice measures $\hat{n}^A \cdot \vec{S}$ along



$$\hat{n}_i^B = -\hat{n}_i^A$$

"local realism"

$$P_{same}(1,2) + P_{same}(1,3) + P_{same}(2,3) \geq 1$$

but QM computation gave 3/4 for this sum

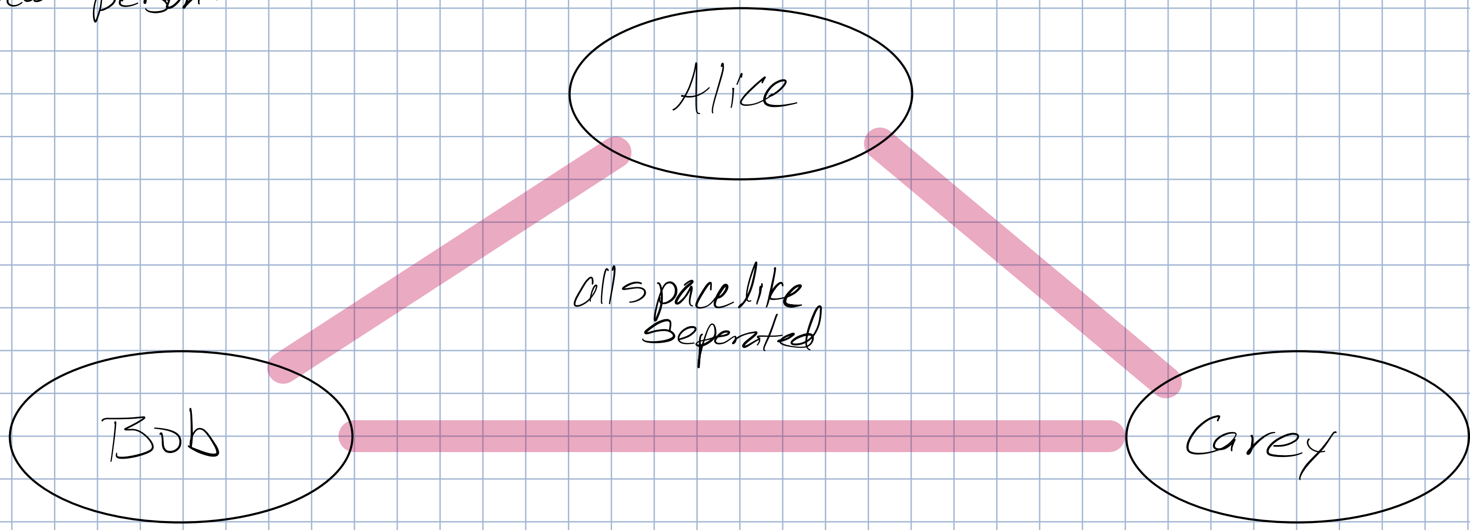
locality: no signal or energy can be sent faster than speed of light

$\longrightarrow$ spacelike measurements can't influence each other

realism: a system "really" has properties that exist indpt. of direct measurement provided properties can be inferred indirectly from experiment

Jeff Harvey Twitter shitposter

New person!



$|+\rangle \equiv |+, z\rangle$

$|\psi_{GHZ}\rangle = \frac{1}{\sqrt{2}}\left(|+++\rangle - |---\rangle\right)$

(A, B, C)

operator $\quad$ sigma

$$\left.\begin{aligned} O^1 &= \sigma_x \otimes \sigma_y \otimes \sigma_z \\ O^2 &= \sigma_y \otimes \sigma_x \otimes \sigma_y \\ O_3 &= \sigma_y \otimes \sigma_y \otimes \sigma_x \end{aligned}\right\} \text{commute!}$$

$\sigma_x \sigma_y = i\sigma_z$

$\sigma_y \sigma_x = -i\sigma_z$

$$[O^1, O^2] = (\sigma_x \otimes \sigma_y \otimes \sigma_x)(\sigma_y \otimes \sigma_x \otimes \sigma_y) - (\sigma_y \otimes \sigma_x \otimes \sigma_y)(\sigma_x \otimes \sigma_y \otimes \sigma_y)$$

$$= i\sigma_z \otimes -i\sigma_z \otimes \mathbb{1}$$

$$-(-i\sigma_z \otimes i\sigma_z \otimes \mathbb{1})$$

$$= \cancel{i\sigma_z \otimes -i\sigma_z \otimes \mathbb{1}} + \cancel{(-i\sigma_z) \otimes (+i\sigma_z) \otimes -\mathbb{1}}$$

$$O^1|\psi_{GHZ}\rangle = (\sigma_x \otimes \sigma_y \otimes \sigma_y)\frac{1}{\sqrt{2}}(|+++\rangle - |---\rangle)$$

$$= \frac{1}{\sqrt{2}}(-i)^2|---\rangle - \frac{1}{\sqrt{2}}(i)^2|+++\rangle$$

$$= \frac{1}{\sqrt{2}}(|+++\rangle - |---\rangle) = |\psi_{GHZ}\rangle$$

$$O^1|\psi_{GHZ}\rangle = O^2|\psi_{GHZ}\rangle = O^3|\psi_{GHZ}\rangle = 1\,|\psi_{GHZ}\rangle$$

$\sigma_x |+\rangle = |-\rangle$

$\sigma_x |-\rangle = |+\rangle$

$\sigma_y |+\rangle = -i|-\rangle$

$\sigma_y |-\rangle = i|+\rangle$

$|+\rangle = \begin{pmatrix}1\\0\end{pmatrix} \quad |-\rangle = \begin{pmatrix}0\\1\end{pmatrix}$

$\sigma_x = \begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix} \quad \sigma_y = \begin{pmatrix}0 & -i\\ i & 0\end{pmatrix}$

say $\begin{array}{ccc} A & B & C \\ \sigma_x & \sigma_y & \sigma_y \end{array}$

B	C	A
1	1	1
-1	-1	1
1	-1	-1
-1	1	-1

need $B \cdot C \cdot A = 1$ for eigenvalue 1

perfect correlation   B, C measure σ_y
& infer m_x^A, real value of Alices component of spin along x

We can ask Bob to measure σ_x, A & C to measure σ_y
" " Carey " ", A & B " "

m_x^A, m_x^B, m_x^C are elements of reality

can infer m_y^A, m_y^B, m_y^C

$A(\sigma_y)$	$B(\sigma_x)$	$C(\sigma_y)$	θ^2
1	1	1	
-1	-1	1	
-1	1	-1	
1	-1	-1	

in conclusion $\quad m_x^A \cdot m_y^B \cdot m_y^C = 1$

$m_y^A \cdot m_x^B \cdot m_y^C = 1$

$$M_y^A \cdot M_y^B \cdot M_x^C = 1$$

$$(M_{x,y}^{A,B,C})^2 = 1$$

Product of all 3 $\longrightarrow$ $M_x^A \cdot M_x^B \cdot M_x^C = 1$

yo?

$$\sigma^4 = \sigma_x \otimes \sigma_x \otimes \sigma_x$$

$$\sigma^4 |\psi_{GHZ}\rangle = (\sigma_x \otimes \sigma_x \otimes \sigma_x) \frac{1}{\sqrt{2}}(|+++\rangle - |---\rangle)$$

$$= \frac{1}{\sqrt{2}} |---\rangle - \frac{1}{\sqrt{2}} |+++\rangle$$

$$= \frac{1}{\sqrt{2}} (|---\rangle - |+++\rangle)$$

$$\sigma^4 |\psi_{GHZ}\rangle = -|\psi_{GHZ}\rangle$$

ayo, measuring σ_x gives eigenvalue -1

$\longrightarrow M_x^A \cdot M_x^B \cdot M_x^C = (-1)^3 = -1$