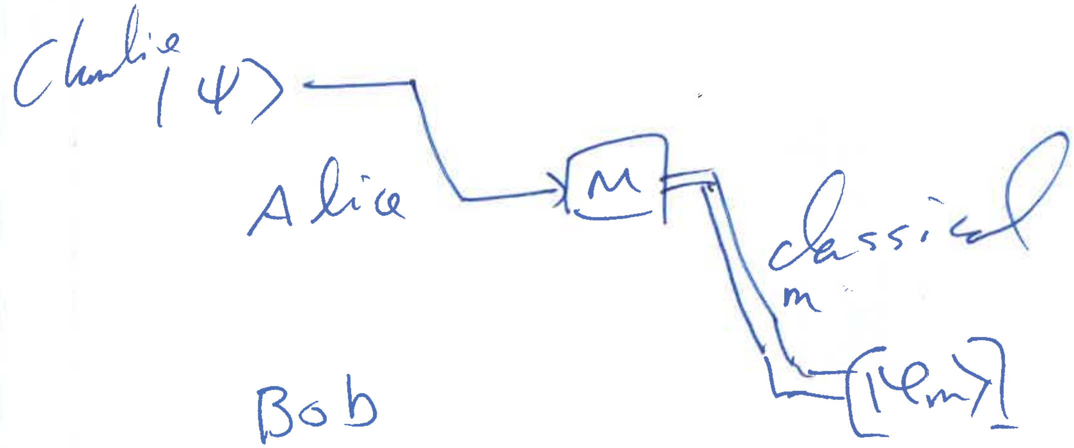
Quantum Communication: The Setting.

Charlie makes a state $|\psi\rangle$, hands it to Alice. She wants to get it over to Bob, but she only has a classical channel



can't do it perfectly

in fact $\max |\langle \varphi_m|\psi\rangle|^2 = 2/3$

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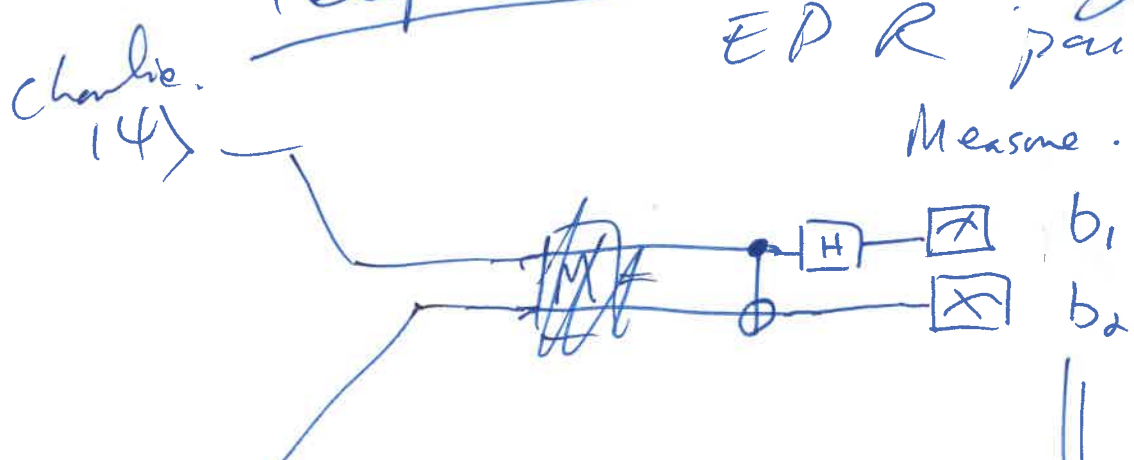
Teleportation: if they share an EPR pair,



which $|\phi_{b_1 b_2}\rangle$ did we get?

Bob Applie

Why does it work?

let $|\psi\rangle = a|0\rangle_C + b|1\rangle_C$.

$$|\psi\rangle_C |\phi_0\rangle_{AB} = \left(a|0\rangle_C + b|1\rangle_C\right)\left(\frac{1}{\sqrt{2}}\left[|00\rangle_{AB} + |11\rangle_{AB}\right]\right)$$

$$= \frac{1}{\sqrt{2}}\left[a|000\rangle_{CAB} + a|011\rangle_{CAB} + b|100\rangle_{CAB} + b|111\rangle_{CAB}\right]$$

$$= \frac{1}{\sqrt{2}}\Big\{\frac{1}{2}a\left(|\phi_{00}\rangle_{CA} + |\phi_{10}\rangle_{CA}\right)|0\rangle_B + \frac{1}{2}a\left[|\phi_{01}\rangle_{CA} + |\phi_{11}\rangle_{CA}\right]|1\rangle_B$$
$$+ \frac{1}{2}b\left[|\phi_{01}\rangle_{CA} - |\phi_{11}\rangle_{CA}\right]|0\rangle_B + \frac{1}{2}b\left[|\phi_{00}\rangle_{CA} - |\phi_{10}\rangle_{CA}\right]|1\rangle_B$$

$\boxed{5}$

Write First:

$$|\phi_{00}\rangle = \frac{1}{\sqrt{2}}\left[|00\rangle + |11\rangle\right]$$

$$|\phi_{01}\rangle = \frac{1}{\sqrt{2}}\left[|01\rangle + |10\rangle\right]$$

$$|\phi_{10}\rangle = \frac{1}{\sqrt{2}}\left[|00\rangle - |11\rangle\right]$$

$$= \frac{1}{2}|\phi_{00}\rangle_{CA}\left(a|0\rangle_B + b|1\rangle_B\right)$$

$$+ \frac{1}{2}|\phi_{01}\rangle_{CA}\left(a|1\rangle_B + b|0\rangle_B\right)$$

$$+ \frac{1}{2}|\phi_{10}\rangle_{CA}\left(a|0\rangle_B - b|1\rangle_B\right)$$

$$+ \frac{1}{2}|\phi_{11}\rangle_{CA}\left(a|1\rangle_B - b|0\rangle_B\right)$$

$$= \frac{1}{2}|\phi_{00}\rangle_{CA}|\psi\rangle_B + \frac{1}{2}|\phi_{01}\rangle_{CA}X|\psi\rangle_B$$

$$+ \frac{1}{2}|\phi_{10}\rangle Z|\psi\rangle_B + \frac{1}{2}|\phi_{11}\rangle_{CA}XZ|\psi\rangle_B$$

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When Alice Measures CA, She collapses Bob to one of:

$|\psi\rangle$, $X|\psi\rangle$, $XZ|\psi\rangle$, $Z|\psi\rangle$.

Tells Bob which one, and he can fix it up.

Next class:

there's a lot of randomness in QM. Measurement collapse, etc.

Would be nice if there was a more fundamental theory: maybe randomness in quantum mech is due to our ignorance of some underlying state that we don't know how to measure yet.

NOPE: LHVs inconsistent with QM
(GHZ – read 6.6)

T9

Einstein Locality (aka Local Hidden Variables)

Einstein did not like entanglement.

Alice can do a measurement that instantaneously changes the state of Bob.
Can't send info but still seemed iffy to him.
Einstein thought this meant QM was incomplete.
Wanted Local Realism:
A & B spacelike separated. Then, in a complete description of physical reality, an action on A cannot modify the description of B.

Entanglement ~~sse~~ violates this.
therefore QM is not complete

What did Einstein want?

hidden variable theory (in today's language)

How about entangled states?

Einstein Hoped: if alice measures her half, gets more information about Bob's hidden variable(λ), which is why she updates her description of the state (but it's underlying value λ doesn't change).

Friday: no such theory can explain QM.

L4

e.g. given $|0\rangle$, if we measure it in the $|\theta_+\rangle = \cos\theta|0\rangle + \sin\theta|1\rangle$
$|\theta_-\rangle = -\sin\theta|0\rangle + \cos\theta|1\rangle$

$Pr(\theta_+) = \cos^2\theta$.

Suppose $|0\rangle$ was more fundamentally:

$|0, \lambda\rangle$ ... $\lambda \in [0,1]$ λ determi...