Feedback - Teleportation

Hi. So we've talked a lot about entanglement, but now we will see how we can use this entanglement to teleport a certain quantum state. So let's take a look at how this works. First, we have two stations: we have station Alice and we have station Bob. Alice and Bob share an entangled state, which means Bob has one qubit of the entangled state and Alice has the other one of the entangled state. What Alice also has is another qubit which is not entangled with any of those which has a state A. Alice and Bob's goal is to teleport Alice's state A to Bob's qubit.

The first thing they do is to perform some operations which we again denote as a black box. After the operations have been done, Alice will measure her qubits. Since Alice has 2 qubits the total outcome can be 4 different situations. For example: both the qubits could be measured into the state empty, the first qubit might have been full and the second empty and vice versa. And there is also the situation where both of the qubits are measured to be full. And these four situation also results in 4 different states for Bob.

So in the empty-empty case we get the full state A back, but as you can see not all the measurement outcomes result in this nice state A. They do resemble A, but they are rotated or flipped a bit. So Bob needs to do something in order to correctly retrieve the state A. And for this he needs Alice's help. What does Alice do? Alice uses her information she had on the measured qubits to send Bob instructions. If her first bit was measured to be full, she says to Bob: rotate your qubit 180 degrees clockwise. If it's empty, do nothing. Almost the same goes for the second qubit, only now the rotation is 90 degrees clockwise. So if it's full, Bob has to rotate the bit, if it's empty Bob has to do nothing. So let's take a look at what this would result in.

So let's take a look at the first case: Alice measured empty-empty. She knows now: I measured empty-empty, and because of my clever operations in the black box I know that Bob must already be in the state A. So I order him to do nothing. She sends Bob this information over a classical internet, so she cannot exceed the speed of light on this one.

Then we go to the second possibility, so she measured full on the first qubit and empty on the second qubit. Remember: the instruction on this one was: rotate your qubit 180 degrees clockwise. So let's take a look. We see we have an A upside down here, and we have to rotate it 180 degrees. And we see that we get the correct state A. So it works for this outcome.

But now we take a look at what happened for the third possibility. What is the first qubit was empty and the second qubit was full. This corresponds to a 90 degrees clockwise rotation. So she sends this information to Bob, and Bob says: OK, right, 90 degrees, I can do this! So we see we have this sort of flipped A here, and were going to rotate it 90 degrees clockwise, again resulting in the state A. And you can already a little bit check for the final case, when both the qubits are full, we have to rotate 180 degrees clockwise and also rotate

90 degrees clockwise. So this would again result in: first the 180 degrees clockwise and now the 90 degrees clockwise, which is again the state A.

So if Bob follows the orders of Alice correctly, and Alice of course sends the correct information, Bob will always retrieve the quantum state A that Alice initially had. So the quantum state has been teleported from Alice's lab to Bob's lab.