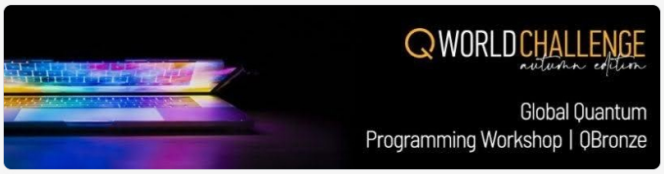

QWorld Global QBronze Workshop | Homework Day 4

Total points 20/20

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Questions

✓ Mark the true one(s). 2/2

- [ ] Faster than light communication is possible with entanglement.
- [ ] There is only a single entangled state, namely 1/sqrt(2) (|00) + |11)).
- [x] In superdense coding we send 2 bits of information using 1 qubit. ✓
- [ ] Using quantum teleportation, we can create multiples copies of the same qubit.
- [ ] In superdense coding, the operations applied by the receiver depends on the message to be sent.

✓ Which one(s) are entangled states? 2/2

- [ ] 1/√2 (|0)-|1))
- [x] 1/√2 (|10) - |01)) ✓
- [x] 1/√2 (|00) - |11)) ✓
- [ ] 1/2 (|00) + |01) + |10) + |11))

✓ Which ones are true about the following state: 1/sqrt(3) (|000)+|001)+|111)) (Order: |first,second,third)) 2/2

- [ ] By measuring the value of the second qubit, we can not decide the value of the first qubit.
- [ ] If we measure the first two qubits, then the third qubit will be always measured as 1
- [x] When the first qubit is measured and the outcome is 1, then the third qubit will be also measured as 1 with probability 1 ✓
- [x] When the first qubit is measured and the outcome is 0, then the second qubit will be also measured as 0 with probability 1 ✓
- [ ] When the first qubit is measured and the outcome is 0, then the third qubit will be also measured as 1 with probability 1

✓ How do you obtain state 1/√2 (|10)-|01)) if to start with you have state 1/√2 (|00)+|11)) (Order: |first,second)) 2/2

- ( ) Apply H to both qubits
- ( ) Apply Z to second qubit
- (•) Apply first Z then X to first qubit ✓

Apply Z to first qubit

Apply CNOT where second qubit is the control first qubit is the target

Protocol

Suppose that Asia want to send the message '1302' to Balvis using superdense coding. Asia will send the digits one by one: first 1, then 3 , then 0 and finally 2 and she makes the following encoding: 0:00 1:01 2:10 3:11 .Hence, To send 1302, she will send 8 bits of information. As you know, in superdense coding we can send 2 bits at once ,therefore she will use the protocol 4 times.

✓ How many entangled pair of qubits do Asia and Balvis need in total? 2/2

1 pair (2 qubits) is enough, we can use the same pair each time

4 pairs (8 qubits), we need a different pair each time ✓

8 pairs (16 qubits), we need 2 pairs each time

We don't need entangled pair of qubits

✓ To start with, Asia sends '01'. Which operations should she apply to her qubit? 2/2

Apply X ✓

Apply Z

Apply X and Z

Apply nothing

✓ Balvis has received the first qubit from Asia but he has lost his own qubit which was initially entangled with Asia's qubit. Is it possible for him to recover the message? 2/2

He should apply H to the qubit he has received and then measure to recover the message.

He should apply X to the qubit he has received and then measure to recover the message.

He should create the copy of the qubit sent by Asia and then measure both.

It is not possible to recover the message. ✓

Quantum Teleportation

```
# post-processing done by Balvis

qc.a(q[0])
```

✓ In the above code, you see the post processing performed by Balvis at the end of the quantum teleportation protocol. If Asia tells him that she has measured '10', which gate is a? 2/2

z ✓

✓ Suppose that Asia makes the measurement and we use statevector simulator to get the current vector. All entries of the vector are 0 except the first 2. What can you conclude about the measurement result of Asia? (Assuming that qubits are in the same order as described in the notebook) 2/2

00 ✓

01

10

11

✓ At the end of quantum teleportation protocol, how many qubits does Balvis have? 2/2

- (●) 1 ✓
- ( ) 2
- ( ) 3
- ( ) 0