Online Quantum Mechanics & Quantum Computing: Theory, COMSOL Simulation & Coding

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Assignment On Qiskit Coding

***Please Note**: Use a single notebook for all the problems. For each problem, write your codes in a code cell and explain your understanding of each problem's solution in a text cell. For submission only a single .ipynb file is required and put your name at the top in a text cell and send it to the email mentioned above. Implement visualization techniques you learned for every problem below.* **Marks**: 5+5+10=20

Out: 23.09.2022 **Due:** 15.11.2022

1. Initialize a one qubit circuit with state $(|0\rangle + i|1\rangle)/\sqrt{2}$. Measure the state in X and Y basis respectively. Qiskit by default can measure in Z basis. So, modify your circuit according to it. Also explain the reason behind the modification by finding the unitary matrix (using Qiskit). Can you relate the measurement result of these two cases with any quantum theory? Explain briefly. **You must explain each step on your own. Copying is strictly prohibited.**
2. Create a 3-qubit circuit and use H and CX gates to make the overall state $(|000\rangle + |111\rangle)/\sqrt{2}$. Now apply measurement in all qubits and run on both simulator and real device. Apply measurement error mitigation with weak noise & explain your understanding in each step. **You must explain each step on your own. Copying is strictly prohibited.**
3. In this problem, instead of Bell States, we will use the following bipartite entangled states: $|P^{\pm}\rangle = \frac{1}{\sqrt{2}}(|00\rangle \pm i|11\rangle)$ and $|Q^{\pm}\rangle = \frac{1}{\sqrt{2}}(|01\rangle \pm i|10\rangle)$

   Alice has qubits C & A; Bob has qubit B. Qubit A & B are initially entangled with state $|Q^{-}\rangle$ and the Qubit C stores the state $|C\rangle = \left(\frac{\sqrt{3}}{2}|0\rangle + \frac{i}{2}|1\rangle\right)$, but obviously Alice doesn't know that. Now, Alice will make a teleportation circuit to teleport the state of C to B, by using measurement in $\{|P^{+}\rangle, |P^{-}\rangle, |Q^{+}\rangle, |Q^{-}\rangle\}$ basis and classical communication. Bob will perform certain local operations requested by Alice to make the teleportation possible. Now your task is to make the circuit of the whole process using Qiskit. You must follow the following instructions during the implementation:

   (i) You cannot use circuit initialization. Use Unitary gates to establish $|C\rangle$ and $|Q^{-}\rangle$ states. You may need to design an alternative measurement method since Qiskit only supports computational basis measurement.

   (ii) Name the qubits as C, A, B instead of q2, q1, q0 respectively.

   (iii) Suppose you applied unitary U to generate $|C\rangle$ state from $|0\rangle$. Apply the inverse of U in qubit B after the teleportation is complete. If your circuit is right, then after that the state of B will always be $|0\rangle$ (there maybe some global phase, but no need to worry about that).

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