Coding challenge

1. Build a 20-qubit Hamiltonian simulation circuit with $H_{XYZ} = \sum_i (J_{xx} X_i X_{i+1} + J_{yy} Y_i Y_{i+1} + J_{zz} Z_i Z_{i+1}) + \sum_i (h_x X_i + h_y Y_i + h_z Z_i)$. Take any non-zero values for the constants. Use linear coupling map. You can do this using qiskit-addon-utils, also check relevant tutorials from https://quantum.cloud.ibm.com/docs/en/tutorials.

2. Build the trotterized circuit with time of evolution = 0.2 and 2 trotter steps with Lie Trotter method. You can do this using qiskit-addon-utils, also check relevant tutorials from https://quantum.cloud.ibm.com/docs/en/tutorials.

3. Take your observable to be $O = \frac{1}{n} \sum_i Z_i$ where $n = 20$ is the number of qubits. Find the expectation value using ideal simulator and EstimatorV2.

4. Consider 3 linear layouts – range(20), range(10,31) and range(20,41). Create three transpiler circuits using these three layouts with FakeTorino as the backend, which will be your noisy simulator.

5. Cliffordize your three transpiled circuit using the NEAT tool. Do noisy simulation of the three cliffordized circuits (using the NEAT tool) and find the layout for which the outcome is closest to the ideal outcome.

6. Transpile the circuit on the best layout (as obtained from analysis using NEAT) with ibm_torino as the backend (note that this should be the original hardware, not noisy simulator). Run the transpiled circuit on ibm_torino using the following:
    a. Turn off measurement_mitigation
    b. Turn on gate and measurement twirling
    c. Turn off dynamical decoupling
    d. Perform ZNE with ‘gate_folding’ as the amplifier, noise factors (1,2,3) and extrapolators ‘linear’ and ‘exponential’.

7. Report the following:
    a. Mitigated expectation value
    b. Raw expectation value (you are not allowed to run a separate circuit for this; you should extract this from the above execution itself)
    c. Which extrapolator (linear or exponential) was used for the reported expectation value