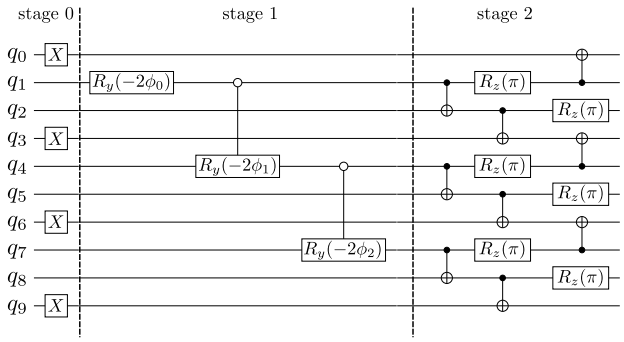
Phys 345 Homework 7

1. Fractional quantum Hall (FQH) states are examples of topological phases of matter. It was shown in [PRX Quantum **1**, 020309 (2020)] that the circuit below, whose structure is shown for $M = 4$ electrons with $3M - 2$ qubits, can simulate a specific FQH state on a quantum computer:



The initial state is $|000..\rangle$, and the angles ϕ_k for $k = 0, ..., M-2$ are obtained from the following recursion relation:

$$\phi_{k-1} = \arctan\left[-t\cos(\phi_k)\right], \quad k = 1, ..., M-2,$$

with

$$\phi_{M-2} = \arctan(-t),$$

where each FQH state is parameterized by a single parameter t.

Write a Qiskit code that takes an integer M and a real number t as input, constructs the circuit above, and gives the expectations values $\langle Z_j \rangle$ for all qubits. Print the circuit and plot $\langle Z_j \rangle$ as a function of j for $M = 5$ and $t = 0.4$. Please submit the python code and the specific print-out of the output.