

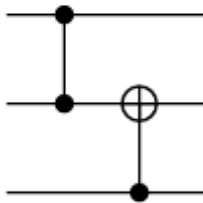
# The Rydbergs

## Quera Challenge Solution

In this write-up, we present our approach to the iQuHACK 2025 challenge, detailing the problem statements, our methodology, and the implementation of our solution. Let's discuss the solutions to the given problems sequentially.

### Problem 1a.

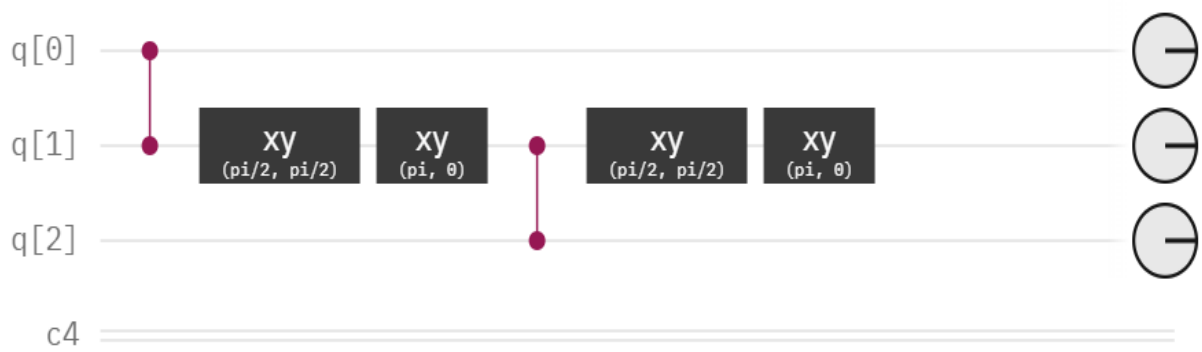
This problem is on optimizing a simple circuit with basis gates  $R_z$ ,  $C_z$ , and  $R_{xy}$ .



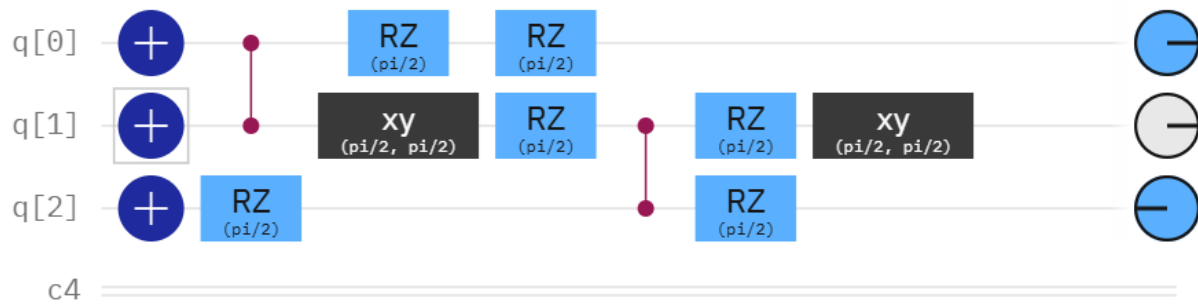
*Circuit A*

### Solution-

1. We construct this circuit on IBM's qiskit and use the **transpiler** library to start our first layer of optimization.



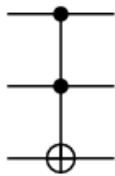
- Next we minimize Rxy gates by applying global Rz gates to minimize the cost function



- Finally we focus on minimizing the number of moves and the travel distance of neutral atoms by applying our **optimization algorithm**. We were able to optimize this circuit in 2 moves with an overall cost of 6.5919.

## Problem 1b.

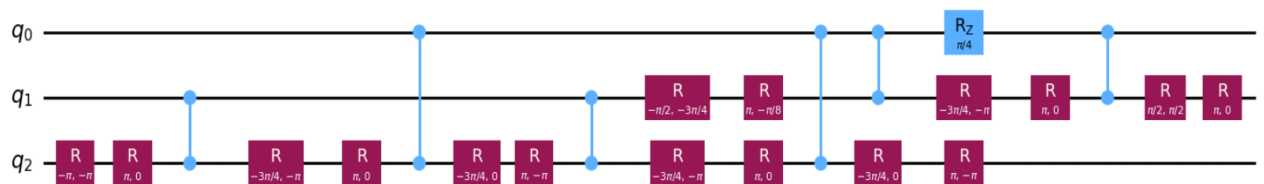
We need to optimize the Toffoli gate with basis gates  $Rz$ ,  $Cz$ , and  $Rxy$ .



*Toffoli gate*

## Solution-

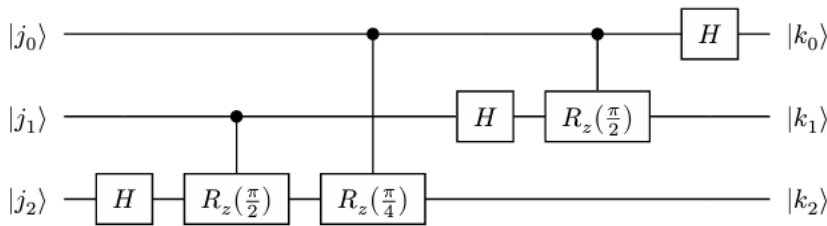
- As we did for the first circuit we transpile the toffoli gate.



2. Reduce the number of moves and travel distance of the neutral atoms. We were able to optimize this circuit in 10 moves with an overall cost of 22.40.

## Problem 2.

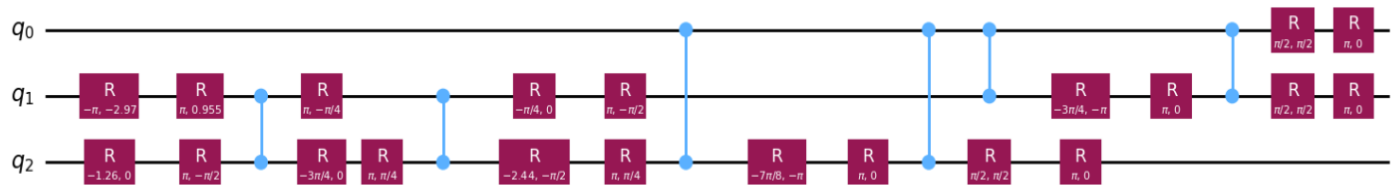
Let's optimize a standard quantum Fourier transform circuit.



*QFT circuit*

## Solution-

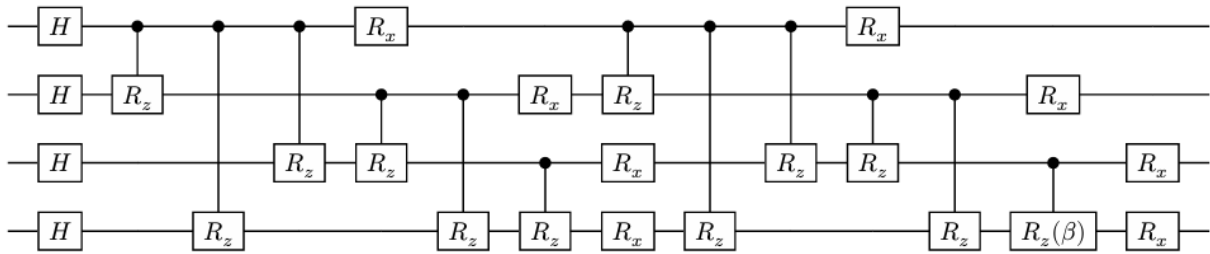
1. Transpile the circuit.



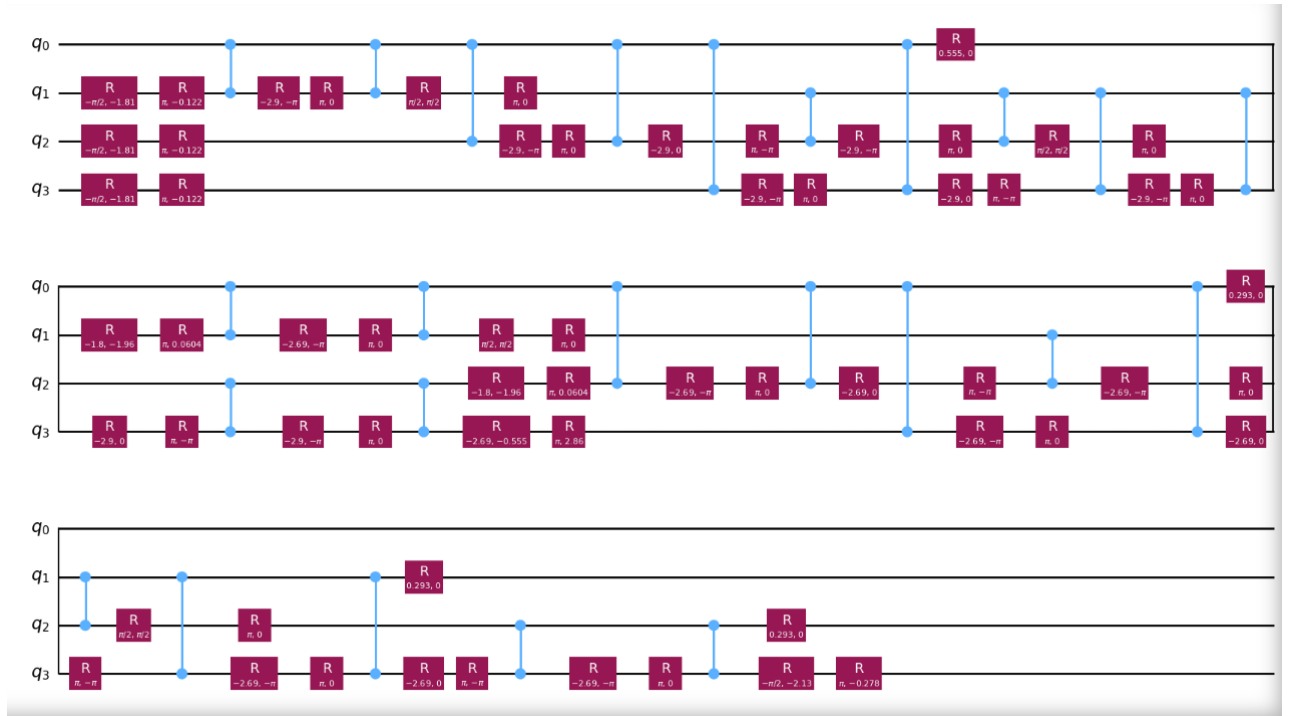
2. Reduce the number of moves and travel distance of the neutral atoms. We were able to optimize this circuit in 6 moves with an overall cost of 21.22.

## Problem 3.

We need to optimize the QAOA circuit.

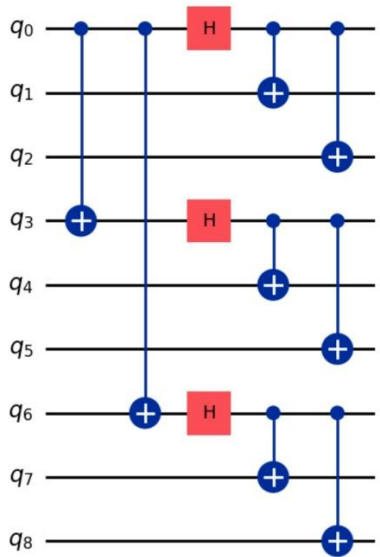


### 1. Transpile the circuit

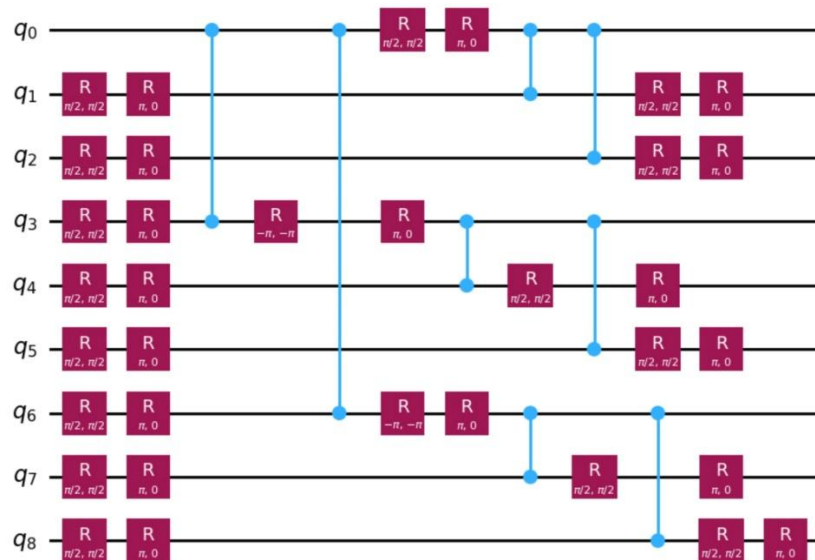


2. We further optimize the circuit using the optimization algorithm. We optimized the circuit with 48 moves and a score of 111.63.

Problem 4.

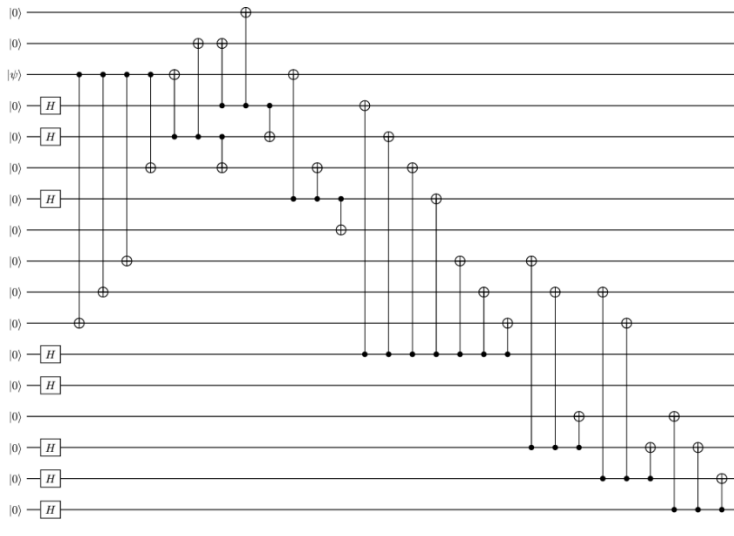


### 1. Transpile the Circuit



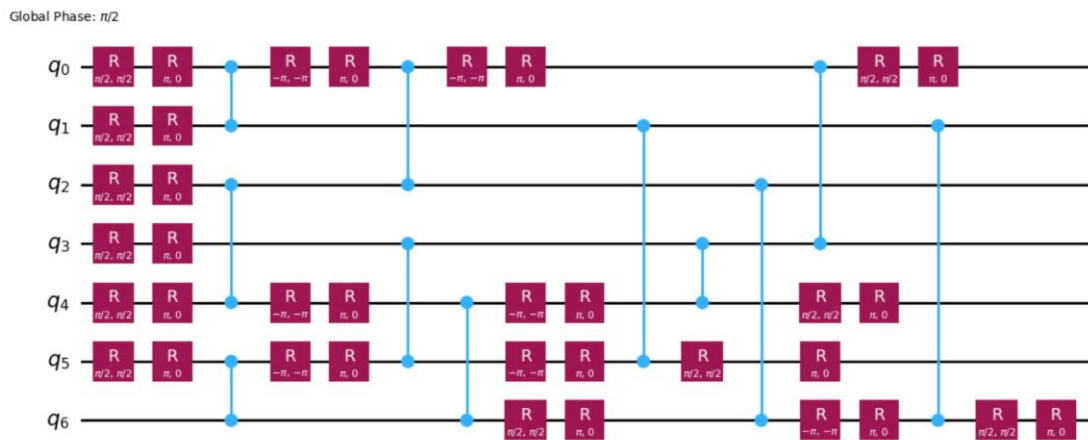
1. We optimize the circuit by parallelizing Cz gates and increasing the usage of global gates.
2. We optimized the circuit with 7 moves and a cost of 32.56

## Problem 5.



## Solution-

### 1. Transpile the Circuit



2. Reduced the number of moves and travel distance of the neutral atoms. We were able to optimize this circuit in 6 moves with an overall cost of 21.22