Quantum Lecture 5.8

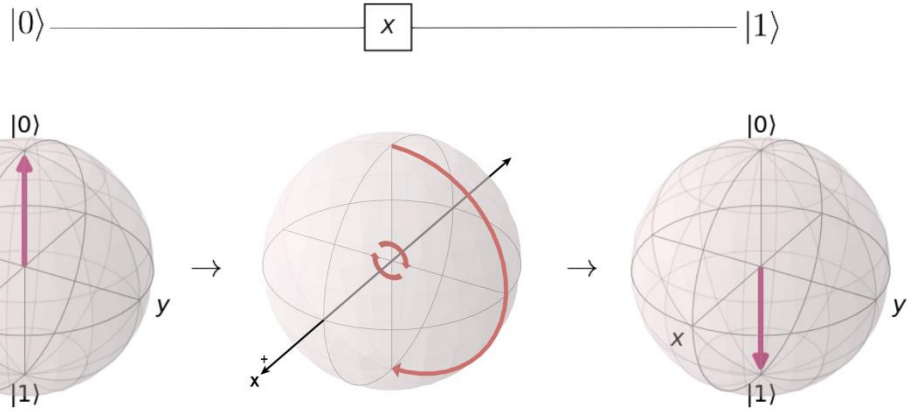
Time Evolution
Two Qubits
And
Tensor products

Agenda for Lecture 3

- 8:30 – 9:00 RECAP Status of Reports
- 9:15 – 10:00 Video 5.1 Rotation Matrix
- 10:15 – 11:00 Video 5.2 Unitary Transform
- 11:00 – 11:45 Video 5.3,4 ”Single Qubit Gates” and ”Two Qubits and Tensor products”
- 11:45 – 12:30 Lunch
- 12:30 – 13:15 Free according to last lect.
- 13:30 – 14:00 Free according to last lect.

Exercise recaps

- What is measurement about
- What does the X,Y and Z do as ***OPERATORS***



13:30 – 14:00 Coderanch

- **Try it out - RSA with 5 bit factorization**

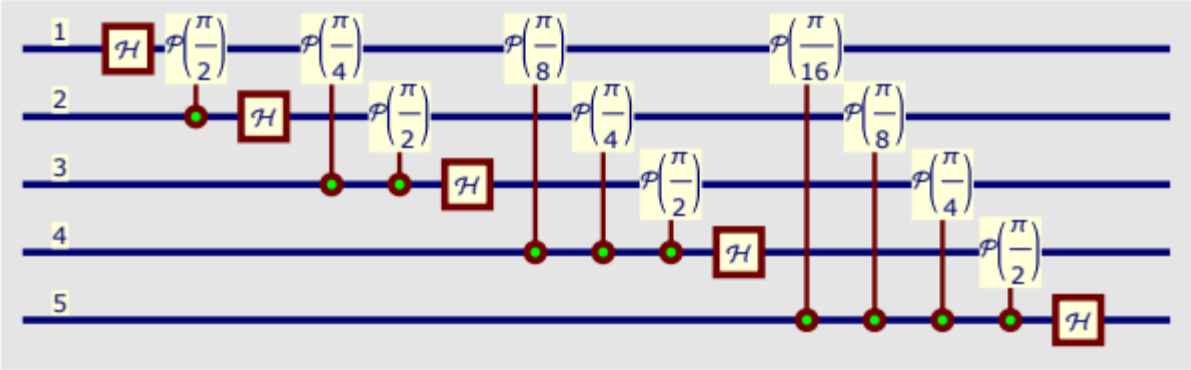


FIG. 7: A Quantum Fourier Transform circuit for five qubits ($n = 5$).

8:30 – 9:00 RECAP

1. Your Report of Your Own choice Status
2. Your CHSH Report Status
3. Your Qiskit Teleportation from last lecture ?
4. Please describe the most simple difference between an Inner products vs Outer product
5. Questions so far including the Mandatory Exercise at DTU
6. During the Gates video remember how You can combine gates

9:15 – 11:45 4 Videos

- The Main topic of today is clearly to understand the meaning and power of a Tensor product on two Qubits
- We are in general running through the 4 Videos and disquss the content and maybe find some Qiskit samples as examples as time goes by

Transform matrix into a combination of simple quantum gates

- I am trying to transform this matrix into a combination of quantum gates but I cannot find any such functionality on Qiskit or anywhere else. I have tried to use Quirk but I do not understand it.

$$\begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

- quantum-gate qiskit gate-synthesis

Matrix Con't

- If you are familiar with tensor products, observe that I⊗XI⊗X gives the desired matrix. Showing the steps of this computation,

$$I \otimes X = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \otimes \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \begin{pmatrix} 1\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} & 0\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \\ 0\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} & 1\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

To obtain the corresponding circuit, note that this tensor represents two gates applied at the same circuit depth on two qubits. That is, you would have an identity gate applied to the top qubit (equivalently, not applying any gate), and you would have the X gate applied on the bottom qubit.

Exercise in Tensor product

A⊗B

1. Evaluate or find a qiskit sample that makes a Tensor product of two Pauli gates and shows the result.
2. Then Try to decompose above to get to the place where You started with two gates
3. Start with I⊗X
4. Then Z⊗X, Y⊗X , H⊗X and H⊗CNOT
5. Try to decompose an entangled state of a Hadamard and CNOT gate like , H⊗CNOT
6. What happens or maybe *Shit happens !!*

11:45 – 12:30 Lunch &/or Free for the rest of the day