LightningQ - Optical Quantum Computer

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1 Introduction

Linear Optics are promising new ways to enable development of Optical Quantum Computers, while being able to overcome the challenge that current Quantum Computers have, like the need to operate at cryogenic temperatures(around 0 Kelvin or Absolute zero), which can make the cooling system much bigger than the computer itself.

By using Universal Linear Optics method [2], the Qubit can easily be build and interconnected with other nearby Qubits, like it is shown in four Qubit example [1]. The interconnection happens after the transformations a photon endures and the end result is affected. Especially if effect such as entanglement occurs.

The approach proposes a scalable and efficient way of achieving easy scaling and controlling of Qubits.

2 Components

This blueprint is making use of the methods proposed in "Universal Linear Optics"[2] paper, which includes the following components:

- Directional Coupler

Directional Coupler is a passive optical device consisting out of two tightly coupled wave guides. When sending a source of photons to just one wave guide, Directional Coupler can transfer a part of its contents to a coupling wave guide. Here you can see an example of Directional Coupler where each line represents a wave guide:

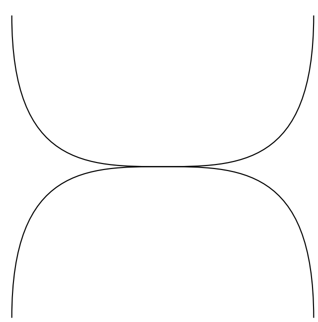

Figure 1: Example of a Direction Coupler, where the top and bottom lines represent top and bottom wave guides.

- Phase Shifter

Phase Shifters are electro-optical types of devices which can transform a state of an incoming photon. The Phase Shifter is controlled electronically. It controls photon's amplitudes as well as phases, which, when manipulated, can be made to do computations.

Phase Shifters are vital part for construction quantum circuits.

3 How it works

The Qubit works by utilizing three Phase Shifters connected to a Directional Coupler. The Phase Shifters are controlling the photon manipulation and are able to make any state which quantum algorithm can demand. It can be controlled externally from a analog electric signals, where the number of connectors grows by six more with each Qubit added. Of course the Qubits are interconnected at the very end of their inner Qubit transformations, so they can entangle with each other.

In order to be as efficient as possible, we need for Qubit to have only single photon source, which is the top wave guide. The photon are introduced into bottom wave guide by coupling effect Directional Coupler achieves.

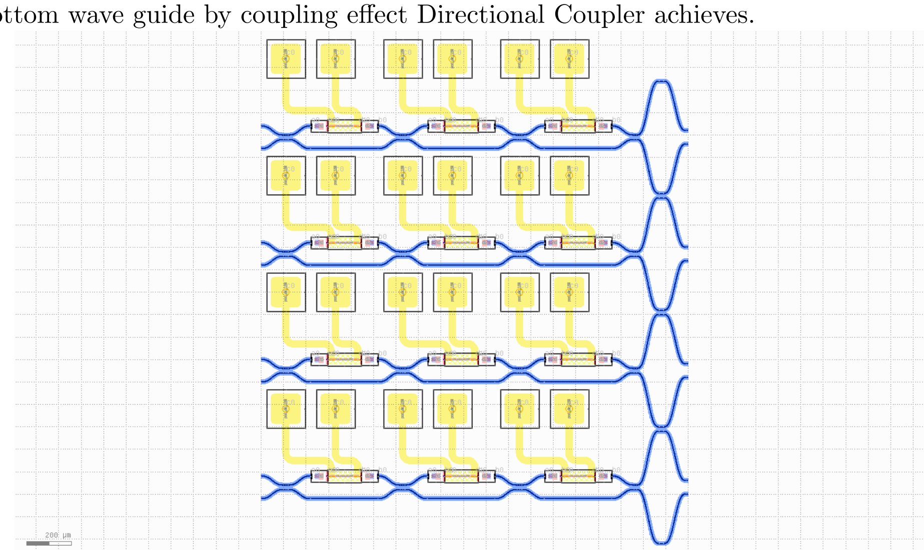

Figure 2: Example of a four Qubit chip, consisting of Direction Couplers and Phase Shifters

3.1 Off Chip Equipment

In order to introduce stimulus to a chip, we need a laser that is capable of firing only one photon per one cycle. Such lasers are however harder to find and require more investment. To measure the final state of a photon that already went under manipulation on chip, a good photo detector like Photon Number Resolver, Homodyne Detector or Heterodyne Detector is needed.

To control Phase Shifters, off chip analog electronics are needed, like the one presented in Universal Linear Optics paper [2]. The digital signal from user gets translated to analog with ADC devices, than analog signals control the Phase Shifter. End result is a fully functional Quantum Computer, using Linear Optics.

References

[1] https://github.com/AleksandarKostovic/LightningQ

[2] Universal Linear Optics - arXiv:1505.01182v1 [quant-ph] 5 May 2015