CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
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Project Number
36846

Project Title
Entangling Time Bin Qubits Using an Optical Switch

Abstract

Objectives/Goals
Quantum mechanics is a very relevant topic of the day as it is being used extensively in technology. These advancements largely involve the process of entangling qubits, which are basic units of quantum information (quantum bits). A long-term, multi-stage experiment was planned out with the purpose of verifying the theoretical set-up by attempting to generate entangled time-bin qubits in real-time. The stages of the experiment included laser attenuation, photon pair generation, time-bin qubit preparation, time-bin qubit entanglement with a switch, and measurement.

Methods/Materials
In the first stage of the experiment, data was collected to attenuate the laser down to a single photon. The discriminator of the single photon detector was kept at 0.53 while the bias was varied in increments of 0.5 volts from 61.94 to 44.84 volts. A high-power fiber laser was also attenuated using ten light attenuators with loss of 8 dB each. In the second portion of the experiment, a Mach-Zehnder interferometer was constructed using fiber and two 50-50 couplers. Measurements of input and output power were taken from 1520 to 1560 nm. The structure was then used to test the functionality of the phase modulator, and MXA signal analyzer was used to find the peak intensity for each frequency and wavelength.

Results
The dark count (DC) and bias displayed an exponential relationship, while the DC and power displayed a linear relationship. The optimal bias amount was calculated to be around 54.94 volts. The optimal power to attenuate the laser was not found because the data did not include large enough DC values. The ratio of the output power to the input power versus the wavelength for the M-Z interferometer did not display the expected cosine or sine function. The functionality of the phase modulator was verified through recorded data.

Conclusions/Discussion
In order to find the optimal power input to obtain one photon per pulse, further must be done with a different number of attenuators. The results furthermore suggest that there is high loss, likely at the 50-50 coupler sites. DC variation also likely contributes to the discrepancy between theory and experimental results. In future work, a pump laser may be used rather than a fiber laser to decrease the loss from using fiber elements. We are also working on a setup to generate photon pairs through spontaneous parametric down conversion.

Summary Statement
I planned and carried out parts of a multi-step, long-term experiment to generate time-bin entangled qubits in real time and verify the entanglement.

Help Received
I would like to thank my research mentors, Dr. Yongnan Li and Professor Chee Wei Wong of the UCLA Mesoscopic Optics and Quantum Electronics Laboratory, for working closely with me and providing insightful discussions to help me carry out this experiment. I would also like to thank Alvin Li for the