CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Jennifer J. Choi

Project Number
S1805

Project Title
Entangling Time-bin Qubits Using an Optical Switch: Source Alignment and Mach-Zehnder Interferometer Construction

Abstract

Objectives/Goals
Quantum mechanics is an extremely relevant topic of the day as it is being used in technology to increase the speed of information processing and to improve the security of cryptographic systems. These advancements largely involve the process of entangling qubits, which are basic units of quantum information (quantum bits). While polarization entanglement has been utilized frequently in current optics research, time-bin entanglement remains more in theory and has not been as thoroughly explored. 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.

Methods/Materials
Single photon detector, fiber laser, fiber cutter/splicer, light attenuators, optical fibers, nonlinear crystal, polarizing beam splitters, couplers, mirrors, iris diaphragm, function generator, phase modulator, MXA signal analyzer

The stages of the experiment included photon pair generation, time-bin qubit preparation, time-bin qubit entanglement with a switch, and measurement. Because of previous inefficiencies, the first stage is being reconstructed and retested to more efficiently generate photon pairs using a dual-Sagnac interferometer. The source is being built using free space components and aligned to maximize efficiency. An M-Z interferometer was built to test the functionality of the phase modulator, which is to be used in the third stage.

Results
The ideal laser settings to maximize efficiency were found. The M-Z interferometer was constructed and used to verify the functionality of the phase modulator. Some previous results suggested high loss, which is why the first stage is being reformulated to more efficiently generate photon pairs.

Conclusions/Discussion
Though various stages of the experiment were verified, the low efficiency of initial photon pair generation hinders the set-up from being fully assembled. Once the dual-Sagnac interferometer source is successfully aligned, all the components can be linked to generate time-bin qubits.

Summary Statement
My goal was to entangle time-bin qubits by creating a multi-stage experiment involving an optical switch.

Help Received
I would like to thank my research mentors, Professor Chee Wei Wong and Alvin Peizhe Li 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 am also grateful to the Southern California