

Integrated photonic 3D waveguide arrays for quantum random walks on a circle

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December 7, 2009

Submitted in partial fulfilment of the requirements for the Honours
Degree of Bachelor of Science (Physics) in the Faculty of Science
at Macquarie University, 2009.

Abstract

Quantum random walks (QRWs) can be used to perform both quantum simulations and quantum algorithms. In order to exploit this potential, quantum walks on different types of graphs must be physically implemented. To this end this we design, model and experimentally fabricate, using the femtosecond laser direct-write technique, a 3D tubular waveguide array within glass to implement a photonic quantum walk on a circle. The boundary conditions of a QRW on a circle naturally suggests a 3D waveguide implementation - allowing much simpler device design than what could be achieved using a 2D waveguide architecture. We show that, in some cases, three-dimensional photonic circuits can be more suited to the simulation of complex quantum phenomena.

Contributions and Acknowledgements

I want to express my gratitude to my supervisors Jason Twamley, Graham Marshall and Stojan Rebic for their patience, kindness, support and guidance in this project. Thanks to Jonathan Matthews of Bristol University, who wrote the Mathematica scattering QRW code, which generated Fig. 3.5. I also want to express my gratitude to the department in general, as several figures used in this thesis were kindly provided by members of the Department of Physics and Engineering.

The fundamental concept for this project came from my supervisors and arose over the course of several conversations I had with them. The tubular waveguide array concept came up in a discussion between myself, my supervisors and Jonathan Matthews. I subsequently worked with these ideas and made some simulations in two different programs, comparing various configurations of design parameters for the tubular array. Ultimately, I came to what I felt was an optimal compromise between the various constraints for fabrication and the intended function of the tubular array.

As I have not been trained in the femto-second laser direct-write technique and other crucial techniques for these experiments, I could not be primarily responsible for the fabrication and testing of the tubular waveguide array devices. However, while Graham Marshall performed most of the work in device fabrication and characterisation, I assisted at each step experimentally. I also made the decision to spend more time fabricating fewer devices, as this could possibly allow us to explore higher refractive index waveguides. This gamble appears to have paid off, but was risky since it increased the possibility of fabrication errors.

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