Squeezing in Lithium Niobate Waveguides

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ABSTRACT

Lithium niobate is widely used in photonics applications because of its large second order nonlinearity and the possibility of integrating nonlinear parametric processes and fast electro-optical reconfigurability. Here we show how these properties can be used for continuous variable quantum optics experiments including the generation, manipulation and characterization and detection of squeezed light.

Keywords: Integrated optics, quantum optics, squeezed light, lithium niobate

1. INTRODUCTION

Integrated quantum photonics has emerged as a promising platform for large scale optical quantum technology¹. Confining light inside miniaturized waveguide circuits enables the generation, manipulation, and detection of quantum photonics states in a scalable way². In particular lithium niobate has a great potential for realizing all basic operations in a single platform. Here we show the generation, manipulation, and the interferometric stage of homodyne detection of non-classical light on a single device, a key step towards a fully integrated approach to optical quantum technology with continuous variables³. Furthermore, the lithium niobate platform can be used for classical characterization of squeezing and the generation of ultrashort squeezing pulses which are essential for time multiplexed cluster state quantum computation⁸.

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2. THE LITHIUM NIOBATE PLATFORM

We fabricated a device to realize a reconfigurable lithium niobate waveguide network (see Fig. 1). The goal was to demonstrate the potential of this platform in generating and manipulating multiple quantum states. The sources of squeezed vacuum are two nonlinear periodically poled waveguides are pumped by a 777 nm laser, generating photons at 1554 nm through spontaneous parametric down conversion, and the two modes interfere in an electro-optically reconfigurable directional coupler. Two integrated frequency filters separate the pump from the signal while the output modes are characterized by two integrated homodyne detectors where signal and local oscillator (LO) are mixed and the phase of the LOs are scanned. Free space photodiodes are used for the measurements since they provide a detection efficiency $>99\%$. This device can generate and characterizing squeezed vacuum and two-mode entangled states, essential resources for several optical quantum computation and communication protocols. We measure a squeezing level of -1.38 ± 0.04 dB and demonstrate two-mode entanglement from quadrature correlations and by verifying an inseparability criterion $I=0.77 \pm 0.02 < 1^3$. Our platform can implement all the processes required for optical quantum technology and its high nonlinearity and fast reconfigurability makes it ideal for the realization of quantum computation with time encoded continuous variable cluster states⁴. Future development of this technology will enable the integration of several quantum photonic applications, including fast photon routing and frequency conversion for hybrid quantum networks.

Figure 1. Schematic of the chip for the generation and manipulation of CV quantum states.

In separate experiments we characterized the bandwidth of the generated squeezed vacua using classical technique⁷. Finally we will report on the generation of ultrashort squeezed vacuum pulses using these integrated, broadband, single pass squeezers.

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