Quantum Interference from a High-Flux Collinear PPKTP Parametric Downconverter

Christopher E. Kuklewicz, Gaetan Messin, Franco N. C. Wong, and Jeffrey H. Shapiro
Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139

Abstract: We have observed quantum interference of polarization-entangled photon pairs from a type-II phase-matched periodically poled KTP parametric downconverter with a pair production of $5 \times 10^4$/s/mW of pump power.

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In a recently proposed singlet-based quantum communication system [1], a high-brightness narrowband source [2] of polarization-entangled photon pairs at 795 nm is required for loading trapped-Rb quantum memory units that allow nondestructive loading verification and measurements of all four Bell-states [3]. Here we report a high-flux source of polarization-entangled photons using a type-II phase-matched periodically poled potassium titanyl phosphate (PPKTP) optical parametric downconverter.

A 10-mW diode laser at 397.2 nm was used to pump a 10-mm flux-grown PPKTP crystal that had a 8.9 $\mu$m periodic grating for quasi-phase matched operation. When the PPKTP downconverter was operated at frequency degeneracy, the orthogonally polarized outputs were in polarization-entangled triplet states [4, 5]. As shown in Fig. 1, the outputs were sent through a 5-mm-long KTP compensating crystal to symmetrize the time delay caused by the crystal’s birefringence. A half-wave plate was used to rotate the output polarizations by 0 or $\pi/4$, after which the resultant outputs were analyzed with a polarizer and coincidences were measured. At zero rotation, we measured an inferred pair production rate of $5 \times 10^5$/s, assuming an overall detection quantum efficiency of 16%. The detector efficiency is estimated to be 50% and the interference filter has a 49% transmission at 795 nm. At $\pi/4$ rotation, the coincidence count rate dropped by 88% because of quantum interference between the entangled photons.

By detuning the pump laser, we made the signal and idler nondegenerate in frequency, and hence distinguishable. In this case there was no quantum interference, and we observed a 50% drop in the coincidence count rate because of the classical beam splitter effect. A similar 50% drop at frequency degeneracy was observed when the KTP compensating crystal was removed.

We will report a Gaussian-state theory for single-pass downconversion that accounts for these experimental results. If the PPKTP crystal is embedded in an optical cavity — to further narrow its output bandwidth — our theory predicts that the need for the compensating crystal is mitigated. Evidence of this mitigation was seen in our previous work with a KTP optical parametric amplifier [4].

![Fig. 1. PPKTP quantum interference measurement apparatus: IF interference filter, HWP half-wave plate, PBS polarizing beam splitter.](image-url)
References