Efficient, Narrowband PPKTP based Source for Polarization Entangled Photons

By,
Siddartha Koduru Joshi
Chen Ming Chia,
Felix Anger,
Antia Lamas-Linares,
Christian Kurtsiefer.
Phasematching

Type II => Signal and Idler of Opposite Polarizations
Efficiency = Pairs to Singles Ratio = Heralding Efficiency
Sagnac Geometry for Entangled Pairs

Generates $|\psi^\pm\rangle = 1/\sqrt{2} \left( |HV\rangle \pm |VH\rangle \right)$

Experimental Setup
Continuous wave external cavity diode laser as pump

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405 nm

Detector 1

Detector 2

Single mode fiber

Coincidence Logic

Glan Taylor

PBS

HWP

Temperature control

PPKTP in Oven

Dichroic Mirror

HWP

Singlemode fiber
Focused to a waist of 150 µm
Experimental Setup

- Singlemode fiber
- 405 nm
- Polarization Beam Splitter (PBS)
- Glan Taylor
- HWP
- Dichroic Mirror
- PPKTP in Oven
- Temperature control
- Dichroic Mirror
- Singlemode fiber
- Detector 1
- Detector 2
- Coincidence Logic
- 25mm Long, Type II 10 µm poling period
Experimental Setup

Temperature stabilized to 0.1° C
Experimental Setup

Diagram showing a setup with labeled components such as dichroic mirror, HWP, PPKTP in Oven, temperature control, singlemode fiber, detector 1, detector 2, and Si APDs.
Focusing for Higher Efficiency

Pairs to singles ratio (Efficiency) of > 38%. (No corrections)
Focusing for Higher Efficiency

System efficiency > 38%
APD detection efficiency ~55%
=> Source efficiency > 69%
> Eberhard limit for loop hole free Bell test (66.7%)

System Efficiency Improvements

- Better detectors
- Improve focusing conditions
- Reduce reflection losses
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  APD ~50 to 55%

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System Efficiency Improvements

- Better detectors
  APD \( \sim 50 \text{ to } 55 \% \)  
  TES \( \sim 95 \text{ to } > 99 \% \)

- Improve focusing conditions

- Reduce reflection losses

System Efficiency Improvements

- Better detectors
  APD ~50 to 55 %  TES ~95 to > 99 %
- Improve focusing conditions
- Reduce reflection losses
  14 surfaces => ~5 % loss

Entanglement Quality

Polarization correlations in the $\pm 45^\circ$ basis = 98.4%
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Polarization correlations in the $\pm 45^\circ$ basis = 98.4%
Bandwidth of down-converted light at $145^\circ$ C is 0.18nm (82GHz). Bandwidth at room temperature is 0.12nm (55GHz).
Bandwidth Constraints

Theoretically \( \sim 18 \) GHz

\[
\Delta \lambda = \frac{\lambda^2}{(n_s - n_i) \cdot L}
\]
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Theoretically ~18 GHz

\[ \Delta \lambda = \frac{\lambda^2}{(n_s - n_i) \cdot L} \]

* Temperature inhomogeneity
  
  82 GHz @ 145°C
  
  55 GHz @ 25°C

* Imperfections in the crystal poling period
Summery

✓ High efficiency (pairs to singles ratio) > 38 %
✓ ~8,000 pairs/s/mW
✓ 82 GHz Bandwidth
✓ 98.4% Polarization Correlations in the ± 45º basis
✓ No spectral filtering
✓ Collected using Singlemode Fibers
Questions?
What is walk off
Refractive Index of KTP

- Wavelength nm
- Pump
- Downconverted light

Graph showing the refractive index of KTP across different wavelengths.
Bandwidth measured using a solid etalon

Blue curve: expected signal with 0.04nm (18 GHz) bandwidth
Purple curve: expected signal with 0.4nm (183GHz) bandwidth

Resolution $\sim 0.04$nm(18GHz)
Tunable

- Polarization 1
- Polarization 2
- Theoretical

Slope
- 0.27 nm/°C
- 121 GHz/°C
Efficiency Vs. pump power

Corrected
Uncorrected
For dark counts

Efficiency (%)

Counts /s/mW

Singles
Pairs

Pump power (mW)
Focusing for high pairs to singles ratio (efficiency).