Photon Pair Generation at 780 and 1560 nm in Periodically Poled Silica Fiber

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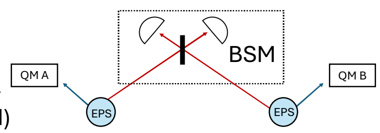
Motivation

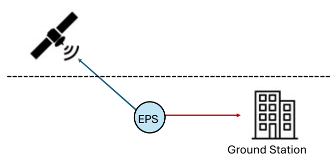
Quantum Repeater Protocols

- Distant Quantum Memory Device (QM) can be entangled via interaction with entangled Photon Source performing a Bell-State Measurement (BSM) at an intermediate node [1].



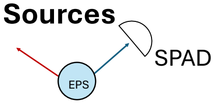
Ground-Satellite Communications

- Non-degenerate sources can establish correlations between satellites and ground-based trusted nodes.[2].



Heralded Single Photon Sources

- Single photons in the C-band can be heralded by detecting 780nm light.



Periodically-Poled Silica Fiber

-An effective $\chi^{(2)}$ is introduced to a step-indexed, Ge-doped fiber via thermal poling.

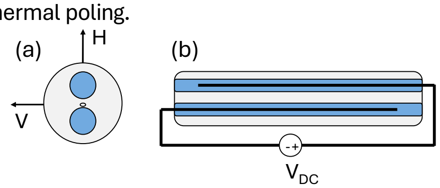
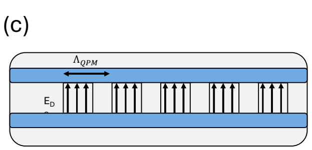


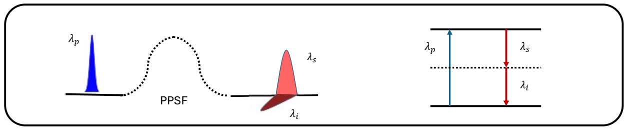
Figure 1:(a) The cross-section of a twin-hole fiber (THF). (b) Two electrodes through the twin hole introduce polarization (c) The polarization can be periodically erased with UV light for Quasi-phase matching condition(QPM).

The effective nonlinearity will depend on the "frozen-in" DC field E_{DC}:
$\chi^{(2)} = 3\chi^{(3)}E_{DC}$.



Entangled Photon Pair in Fiber

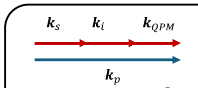
Collinear pairs of photons can be generated in PPSF via spontaneous parametric downconversion.



The state of the biphoton pairs exiting a type-II SPDC source can be decomposed into its spectral components as

$$|\psi\rangle = \int d\omega_s \int d\omega_i \left(f_-(\omega_s,\omega_i)|H,\omega_s\rangle|V,\omega_i\rangle + f_+(\omega_s,\omega_i)|H,\omega_i\rangle|V,\omega_s\rangle \right),$$

where $f_{+/-}(\omega_s,\omega_i)$ are spectral amplitudes determined by the dispersive properties of the medium and the quasi-phase matching conditions [4].



$$k_p = k_s + k_i + \frac{2\pi}{\Lambda_{QPM}}$$

Non-Degenerate Source

- A QPM period of $\boldsymbol{\Lambda = 38.16\ \mu m}$ will yield photon pairs at 780 and 1560 nm when pumped with 520 nm light.

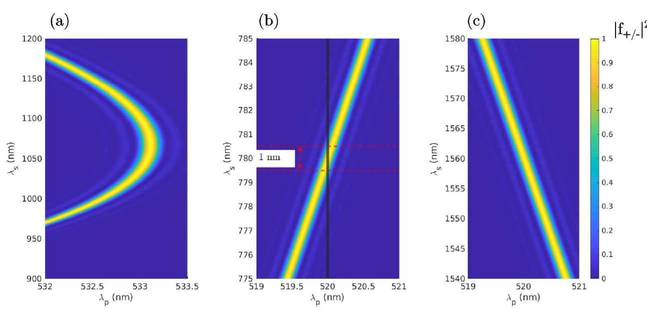
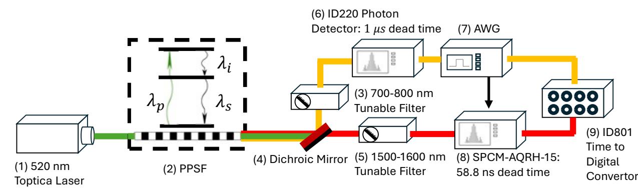


Figure 2: (a) A simulated tuning curve of signal and idler photons emitted from a Type-0 SPDC process near the degeneracy wavelength at ~ 1066 nm. (b) and (c) The SPDC brightness of signal and idler photons for a pump near 520 nm. The single photon bandwidth is reported to be 1 nm ≈ 489 GHz (FWHM) when centered at 780 nm.

Gating Function & Coincidence

-The generated photon pairs are detected by concentrating the detection windows of the detectors near the SPDC signals using the Gating Function



-The ID220 detects 1560nm idler photon to gate the SPCM for 780 nm signal photon detection.

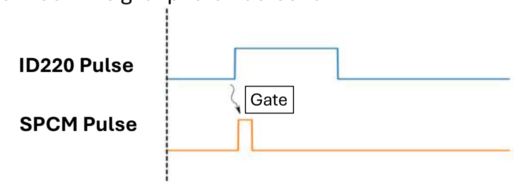


Figure 3: Demonstration of the SPCM detector being gated by the ID220 to concentrate the detection window to the vicinity of the SPDC signals.

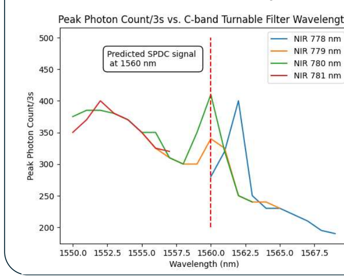


Figure 4: Experimental plot of the peak photon count on the coincidence histogram, obtained by sweeping the wavelengths of the tunable filters to locate the SPDC signals. A peak at 780nm and 1560nm are observed for a 520.002 nm pump laser, matching the simulation

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