Generating and teleporting entanglement for quantum networks

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Contents

Introduction

Motivation

- Bright source of entanglement

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- Bright source of entanglement
- Training in quantum technologies in Slovenia

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- Training in quantum technologies in Slovenia
- Quantum Network for Slovenia

Motivation

- Bright source of entanglement
- Training in quantum technologies in Slovenia
- Quantum Network for Slovenia
- Testbed for industrialized version

Theory

1. SPDC
2. Entanglement swapping

- Spontaneous Parametric Downconversion

Theory
SPDC

- Spontaneous Parametric Downconversion

$$\omega_p = \omega_s + \omega_i$$

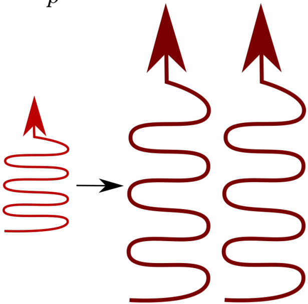


Figure: Illustration of SPDC

- Spontaneous Parametric Downconversion

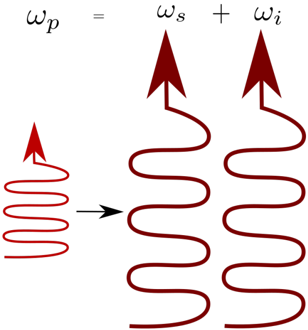


Figure: Illustration of SPDC

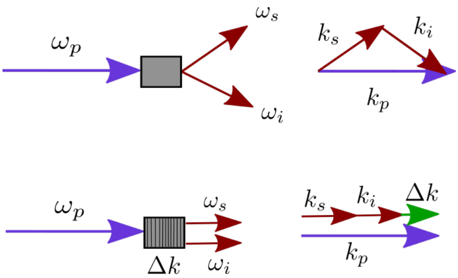
- Non-degenerate

Table: Comparison of different sources

Who	[?]	[?]	[?]	[?]	[?]
Type	0	II	II	II	0
Pairs (s mW nm)	$2.5\ 10^6$	$87.5\ 10^3$	$273\ 10^3$	$5\ 10^3$	$278\ 10^3$
Bandwidth/nm	106	0.3	0.3	1	2.3

Figure

- Phase Matching, Quasi Phase Matching



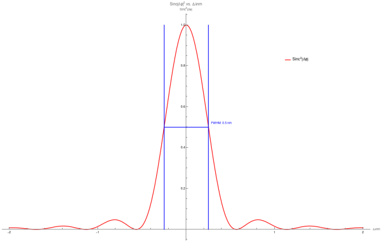
(a)

Figure: Illustration of Phase Matching and Quasi Phase Matching.

Type-II vs Type-0

Bandwidth

Figure: Wavelength bandwidth of a) Type-2 crystal with a polling period of 9,12 um Type-0 crystals with polling periods of b) 19,25 um



(a)

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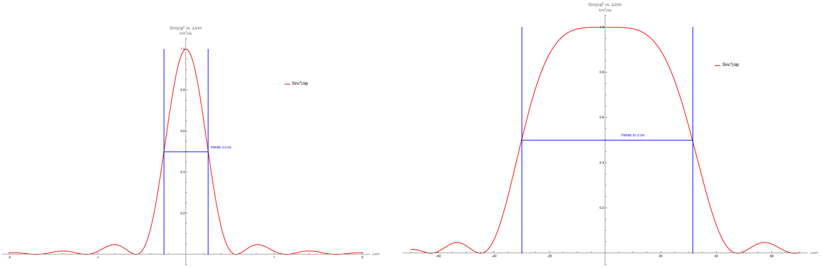
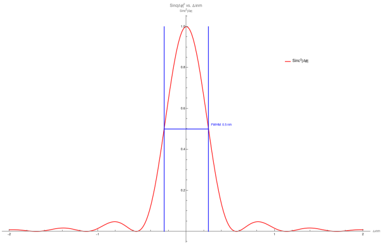
Figure: Wavelength bandwidth of a) Type-2 crystal with a polling period of 9,12 um Type-0 crystals with polling periods of b) 19,25 um

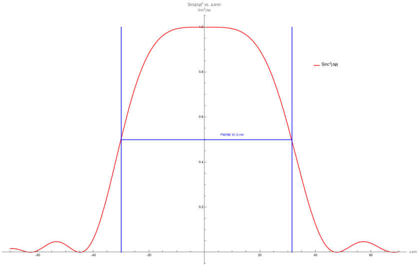


(a) (b)

Figure: Wavelength bandwidth of a) Type-2 crystal with a polling period of 9,12 um Type-0 crystals with polling periods of b) 19,25 um



(a)



(b)

SPDC wavefunction

$$
\begin{aligned}
\Psi_p &= \\
\Psi_{Type-2} &= \\
\Psi_{Type-0} &=
\end{aligned} \tag{1}
$$

Table: Brightness comparison

$Hz/mW/nm$

FMF		IJS
Type-II	**Type-0**	**Type-II**
7,8 $\times 10^6$	2,6 $\times 10^7$	0,05 $\times 10^6$

Fiorentino Expected efficiency Might not be important

Most important Dead-time dependency

Entanglement swapping

- FMF/IJS
- Quantum Repeaters
    1. Quantum Memory - wrong wl for now, have to figure out

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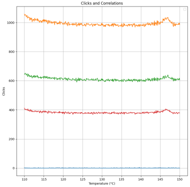
Present state
Building a linear test setup

- Focusing parameters

$$\xi = \frac{L}{kw^2} \tag{2}$$

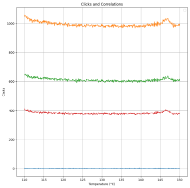
- Heralding

Figure: Temperature scans of Type-0 crystals with different polling periods, a) misaligned 19,25 μm, b) 19,25 μm, c) 19,45 μm, d) 19,65 μm

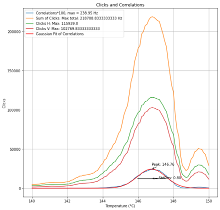


(a)

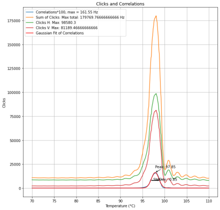
Figure: Temperature scans of Type-0 crystals with different polling periods, a) misaligned 19,25 μm, b) 19,25 μm, c) 19,45 μm, d) 19,65 μm



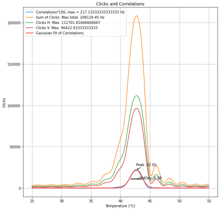
(a)



(b)



(c)



(d)

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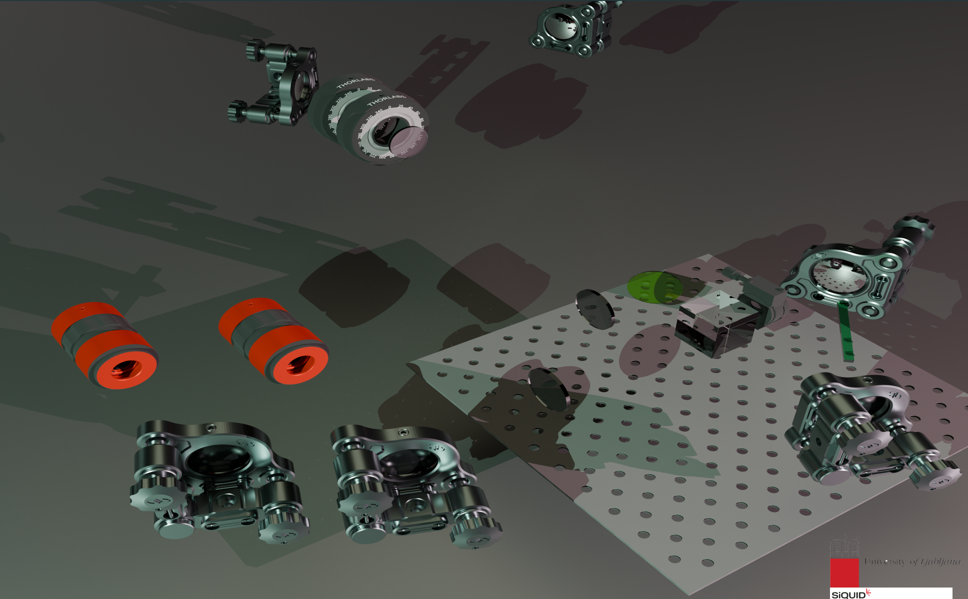
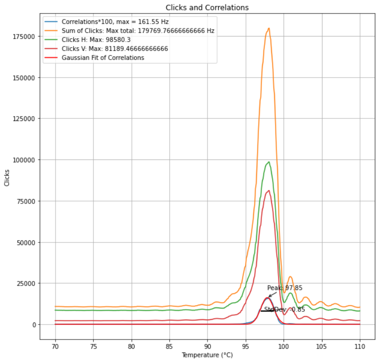
Present state

Building a Sagnac Interferometer





(a)

Figure: Photograph of the current state of the Sagnac Interferometer.

Outlook

- SiQUID
- Entanglement swapping between FMF and IJS
- Building quantum internet
- Free space link to reactor

Testing, calculating various properties of the system, limitations, Thank you

References

- [Online]. Available: http://dx.doi.org/10.22331/q-2022-09-29-822
- [Online]. Available: http://dx.doi.org/10.1038/nature09175
- "A wavelength-tunable fiber-coupled source of narrowband entangled photons." [Online]. Available: http://dx.doi.org/10.1364/OE.15.015377
- [Online]. Available: https://opg.optica.org/abstract.cfm?URI=QELS-2006-JTuH5
- [Online]. Available: http://dx.doi.org/10.1364/OE.20.009640