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Photon pair source characterization for two photon entangled absorption experiments

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Abstract

In this study, we focus on the characterization of a source of entangled photon pairs. We begin by characterizing the pump beam, followed by an analysis of the spatial profile of the photon pairs through the second-order temporal correlation function and the start-stop histograms. Finally, this characterization is applied to detect an Entangled Two Photon Absorption(ETPA) signal in Rhodamine B molecules.

Motivation: ETPA

MOTIVATION

- Linear dependence with the photon flux: Enhancement of the TPA process.
- Possible applications in biological samples.
- New spectroscopic techniques.
- Measurements sensitive to single photon losses.
- Relation between ETPA cross-section and classical TPA cross-section:

$$\sigma_e^{(2)} \sim \frac{\sigma^{(2)}}{A_E T_E}$$

$$R_{TPA} = \sigma^{(2)}\phi^2 + \sigma_e^{(2)}\phi$$

Spontaneous downward parametric conversion

SPDC

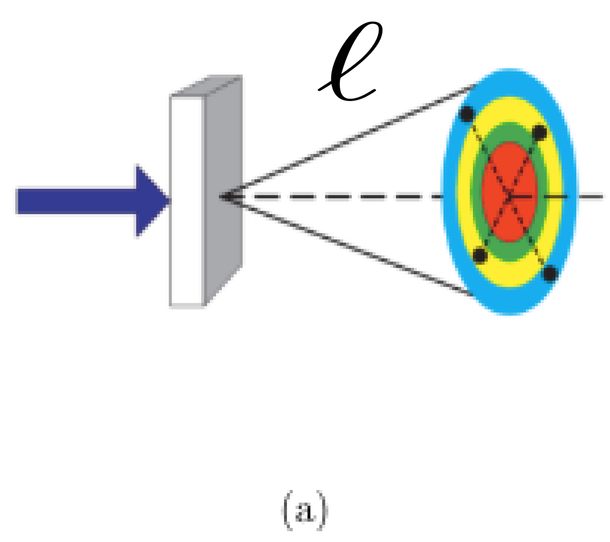


Figure 1. SPDC rings.
(a) Non-collinear SPDC type

$$k_s \cos\theta_s + k_i \cos\theta_i = k_p$$

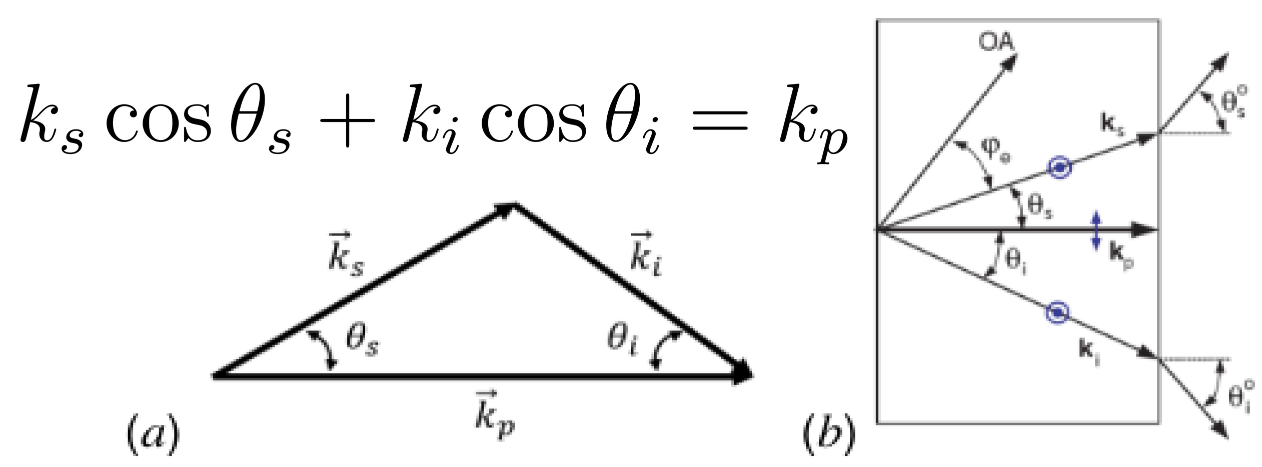
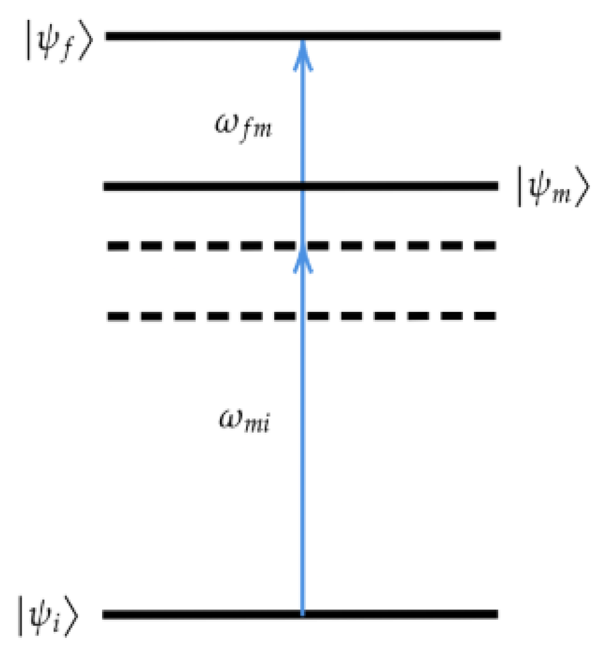


Figure 2. Wave vectors of the incident photon kp and of the final photons ks and ki.



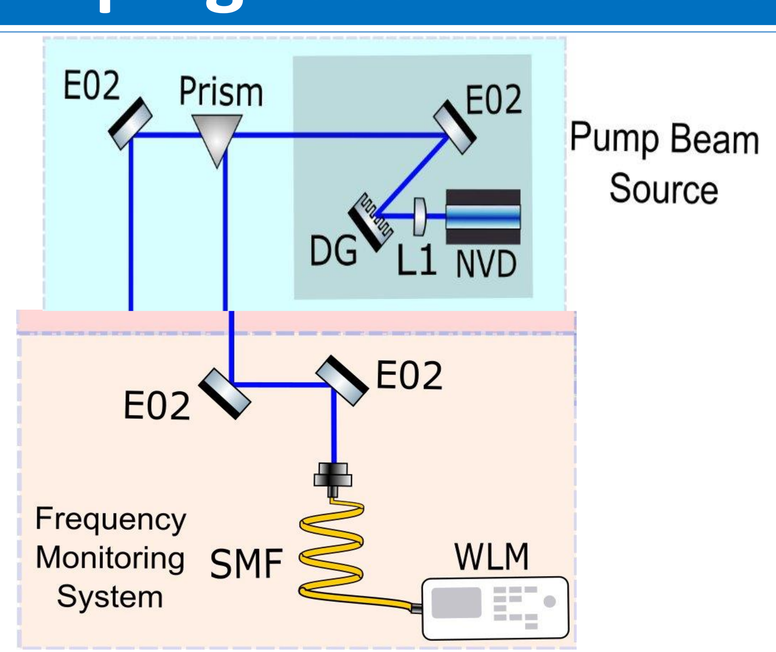
Phase matching conditions

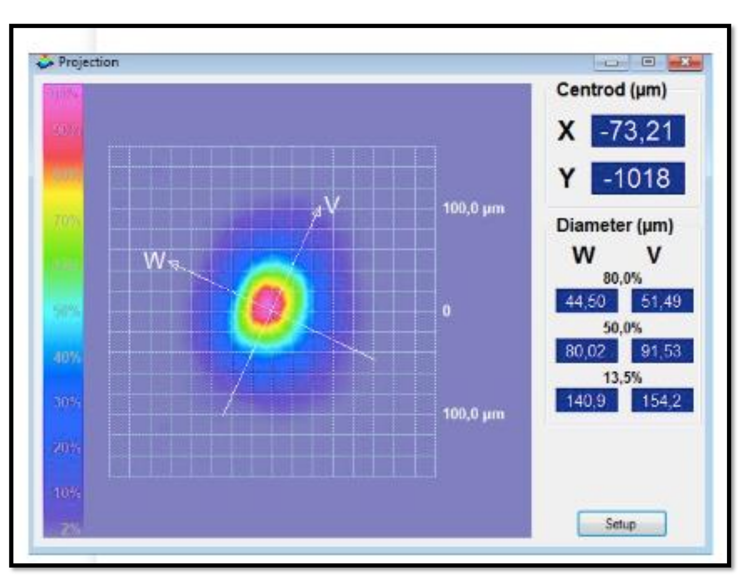
$$\omega_p = \omega_s + \omega_i$$
$$k_p = k_s + k_i$$

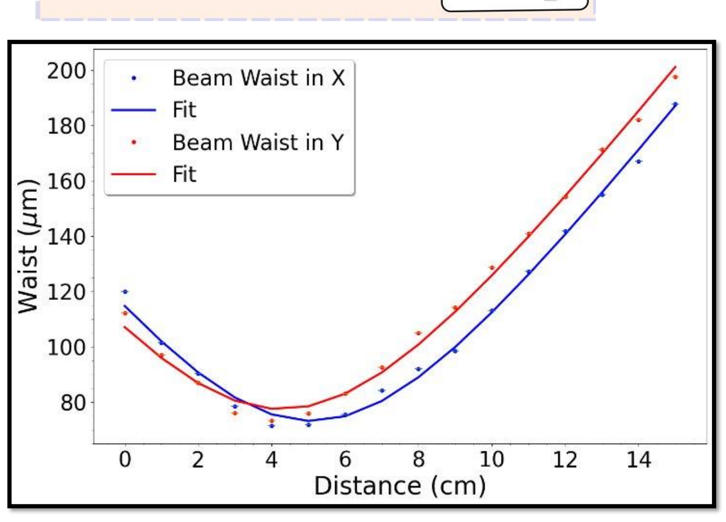
Degenerate case

$$\omega_s = \omega_i = \frac{1}{2}\omega_p$$

Pumping Laser Characterization



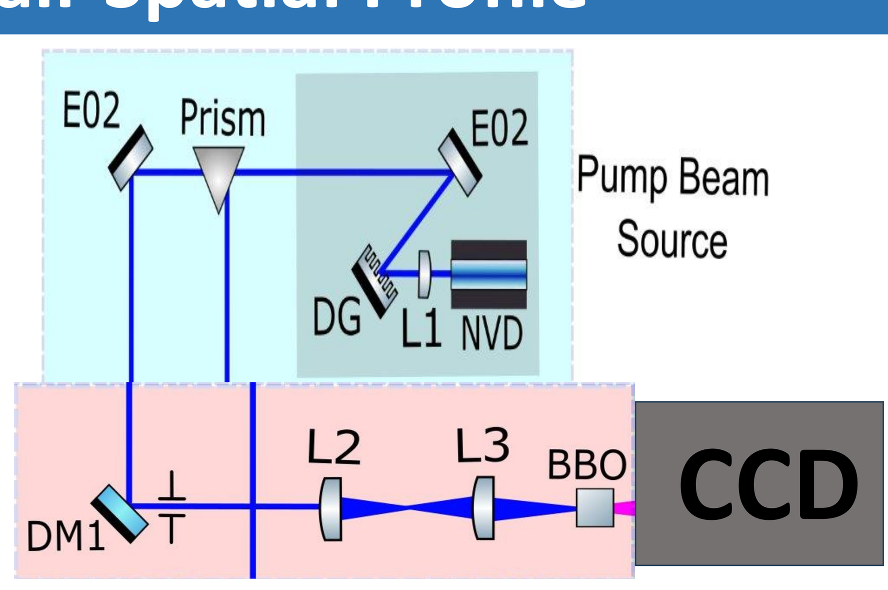




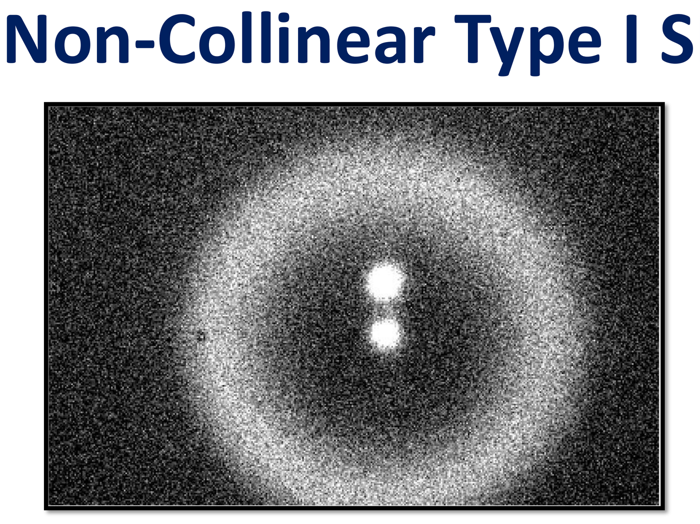
$$W_{0x} = (73 \pm 1)\mu m \quad Z_R = (4,2 \pm 0,1)cm$$

$$W_{0y} = (77 \pm 1)\mu m \quad Z_R = (4,5 \pm 0,1)cm$$

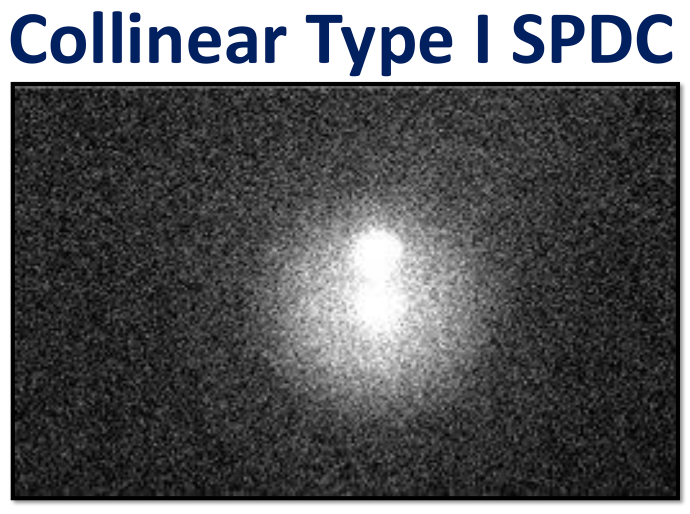
Photon Pair Spatial Profile



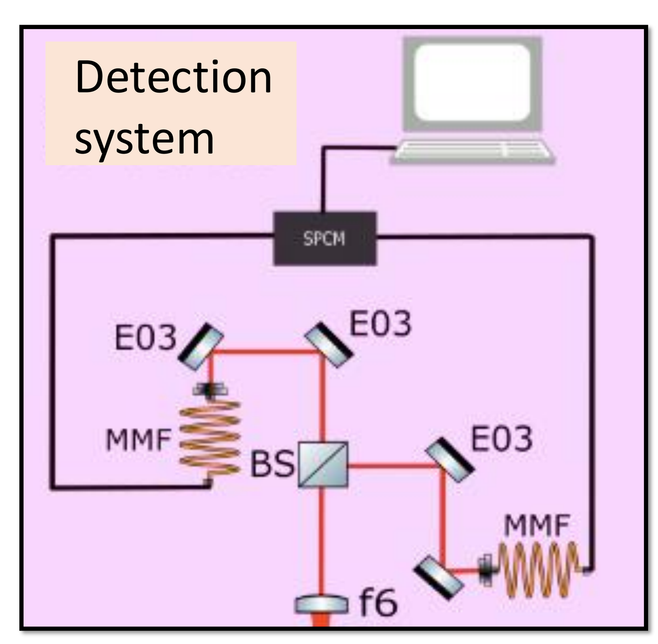
Non-Collinear Type I SPDC

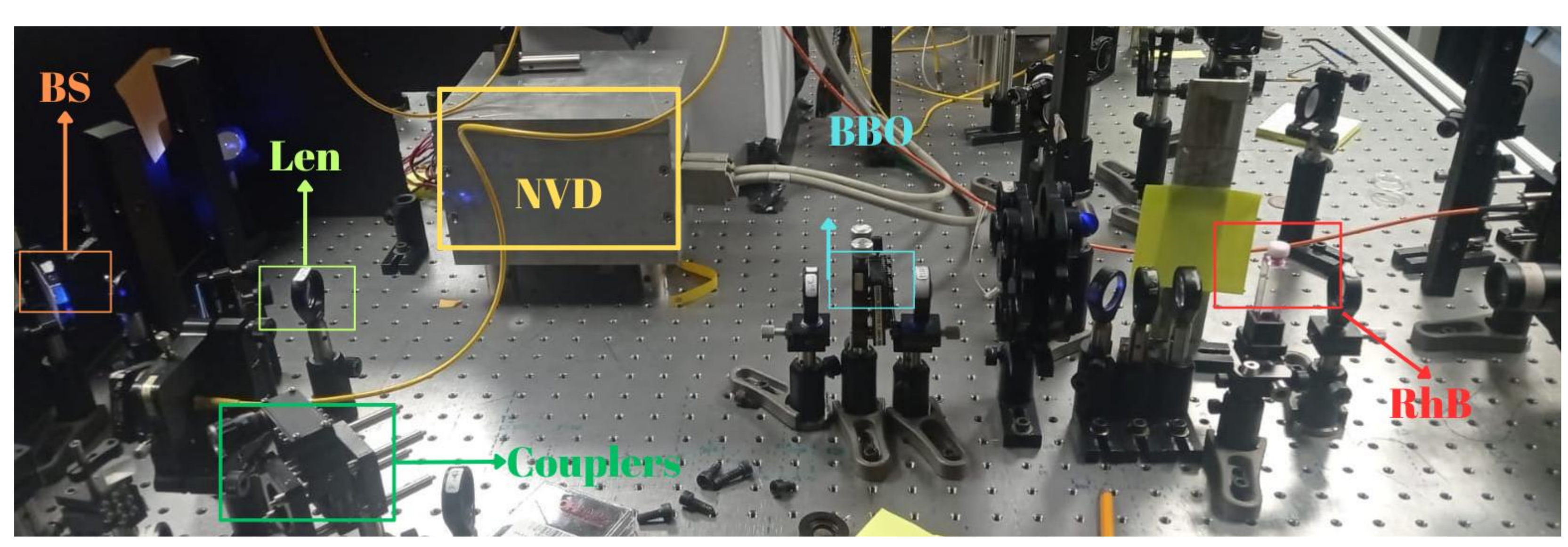


Collinear Type I SPDC



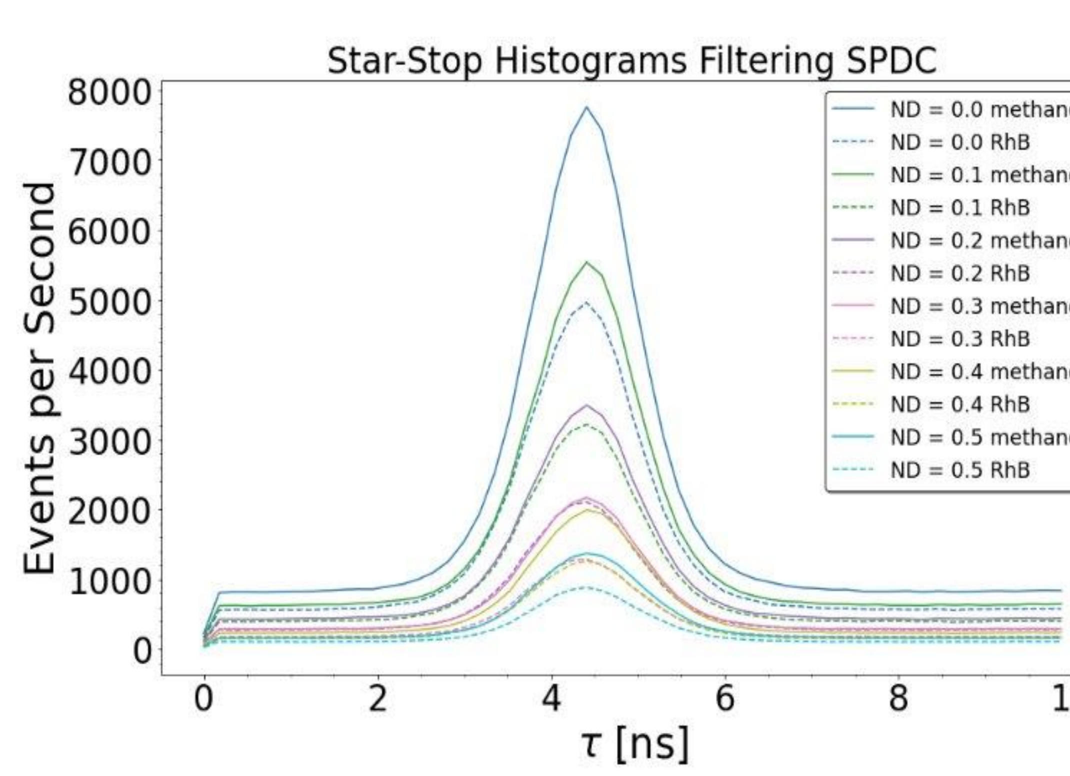
Coincidence Detection





Experimental Setup

Start Stop Histogram and ETPA Signal



$$R_c \sim \int_0^{T_{coin}} d\tau S(\tau - t_0) G^2(\tau)$$

Conclusions

- The experimental conditions are ensured to perform an optimal calculation of the ETPA cross section in RhB.
- We were able to witness ETPA in RhB molecules using a coincidence detection scheme.
- New experiments regarding ETPA in Cesium atoms are planned for the future.

Referencias

- Yu et al., Opt. Express **26,** 17254 (2018).
- M. Caracas et al., Opt. Express **31** (Sept. 2023)
- Couteau Christophe et al., SPDC (2018)