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Study of the spectral properties of entangled photons.

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Abstract

Entangled photons pairs have played an important role in quantum applications and in fundamental physics. The most convenient way to produce entangled photon is via spontaneous parametric down-conversion (SPDC) using a non-linear crystal. We produce entangled photons pumping a Type II BBO crystal with a CW laser at 404 nm. The signal and idler photons produced are separated using a polarized beam splitter (PBS). The spectrum of the photons is study using a monochromator and single photon detector. This experiment is the first step to study of spectral properties in atoms and molecules using entangled photons.

1. Spontaneous Parametric Down-Conversion

The spontaneous parametric down-conversion (SPDC) is a quantum process where two entangled photons, signal and idler, are created from a photon pump in a non-linear crystal. The quantum state of the photons created, in the first order approximation of the perturbation theory, is:

$$|\psi\rangle = B_0 \int d^3k_e \int d^3k_o \int_0^L dz\, e^{i(k_p - k_{ez} - k_{oz})z} \ldots$$

$$\ldots \int_A d^2\vec{r}_\perp e^{i(-\vec{k}_{e\perp}.\vec{r}_\perp - \vec{k}_{o\perp}.\vec{r}_\perp)} \int_{-\infty}^{t} dt\, e^{i(\omega_e+\omega_o-\omega_p)t} a^\dagger_{k_e} a^\dagger_{k_o} |0\rangle \qquad (1)$$

where L is the length of the crystal and A is the transversal area of the pump beam. For $L >> \lambda$, $t >> \tau$ and A is much greater than interaction area, the state of the SPDC photons is [1, 2].

$$|\psi\rangle = B_1 \int d^3k_e \int d^3k_o \delta(k_p - k_e - k_o)\delta(\omega_e + \omega_o - \omega_p) a^\dagger_{k_e} a^\dagger_{k_o} |0\rangle \qquad (2)$$

2. Experimental Setup of the SPDC Source

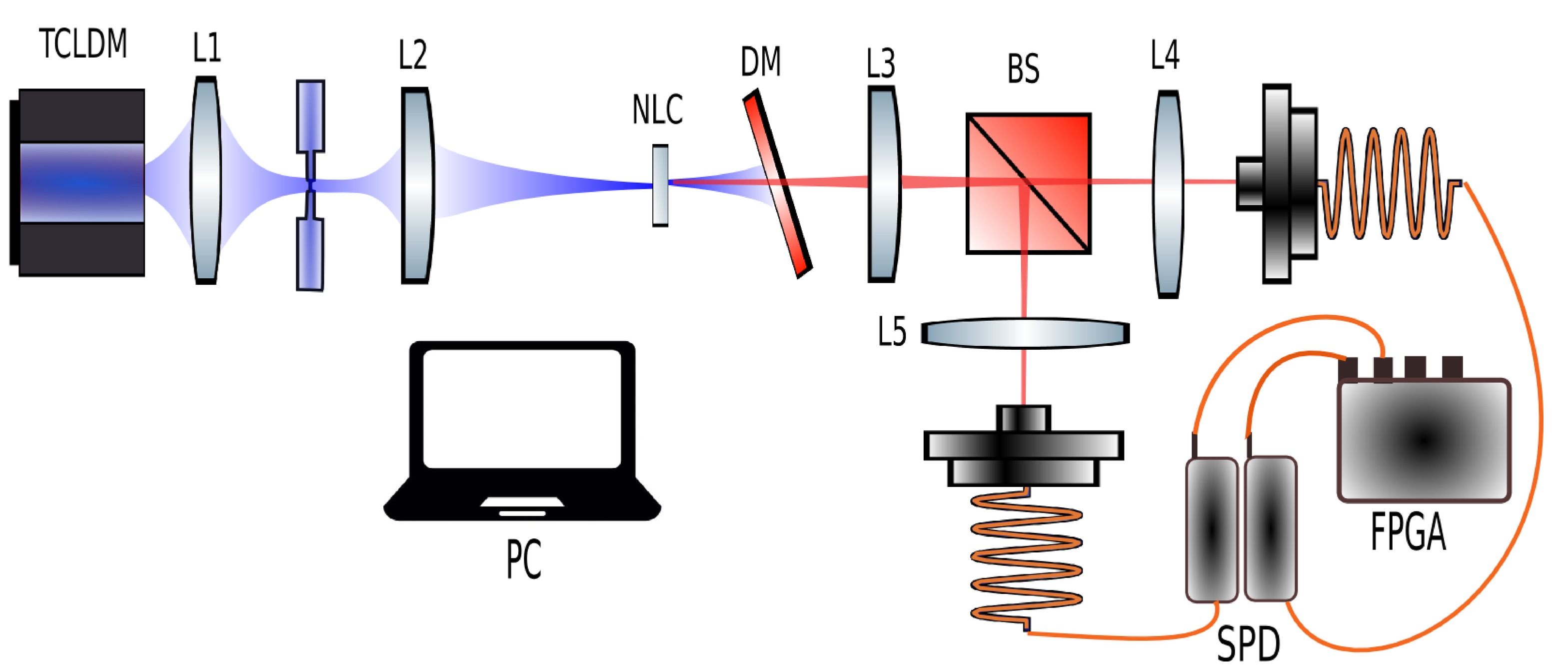
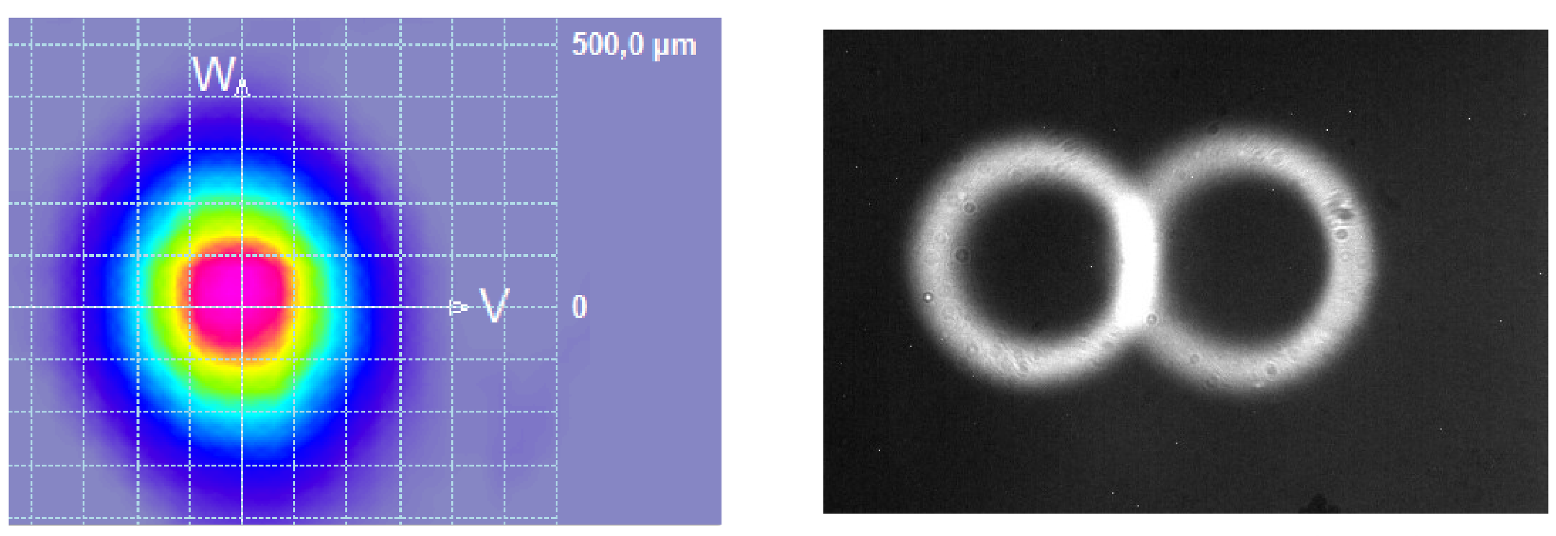


Figure 1: *The UV beam have a spatial filter for obtain a Gaussian beam and pump a BBO crystal to obtain SPDC photons. This photons are detected in a single photon detector.*



(a) Gaussian profile of pump beam. (b) Rings of the SPDC.

Figure 2: *We obtain the profile of the Gaussian pump beam after of the spatial filter. The rings are obtain in a CCD camera.*

References

[1] Yanhua Shih. Entangled biphoton source - property and preparation. *Reports on Progress in Physics*, 66(6):1009, 2003.

[2] Beck M. *Quantum mechanics. Theory and experiment.* Oxford University Press, 2012.

3. Measurement of the spectrum of the photons

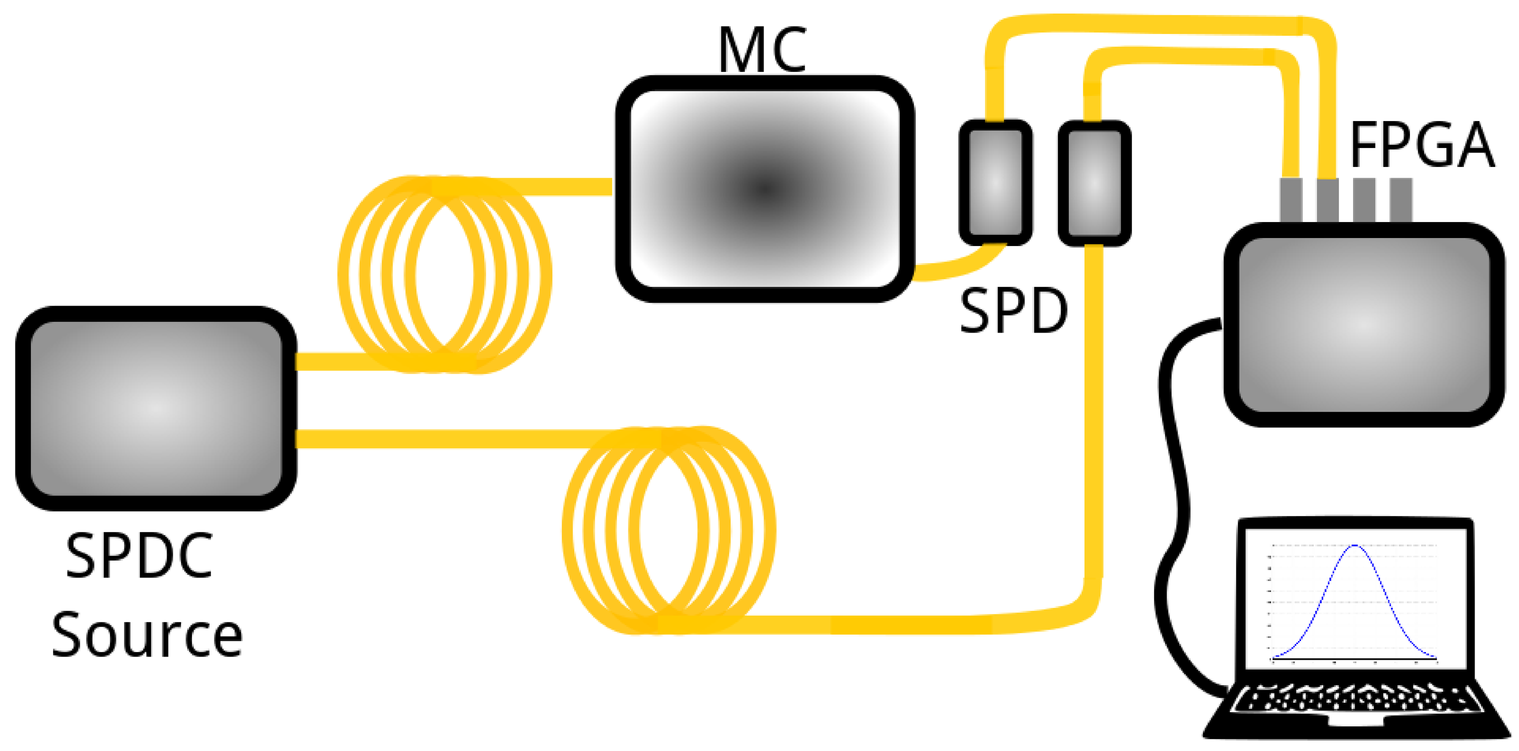
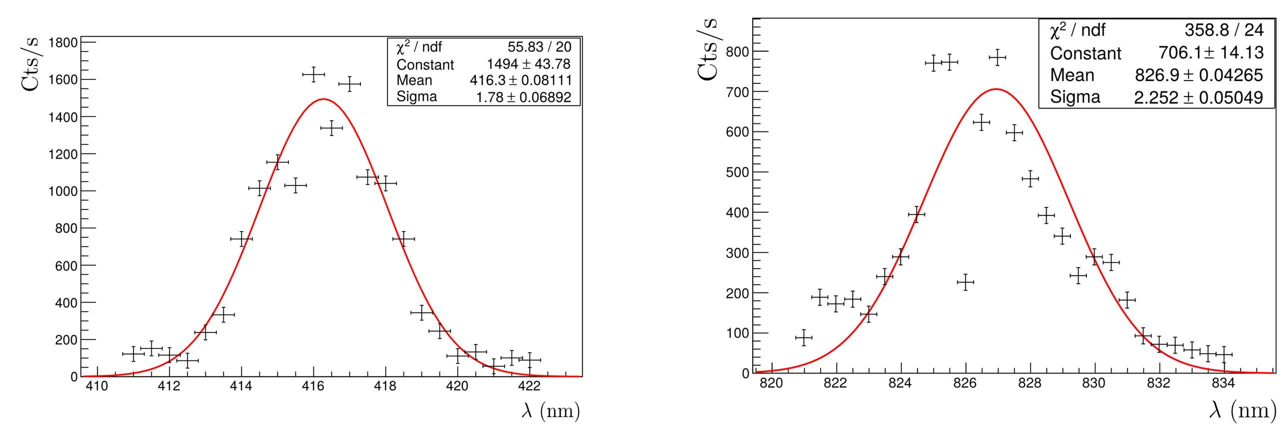


Figure 3: *The light of one arm of the SPDC source is carry througt Monochromator to measure the spectrum of this with the Single Photon Counters (SPD).*



(a) Spectrum of pump beam. (b) Spectrum of idler beam.

4. Measurement of time correlation function

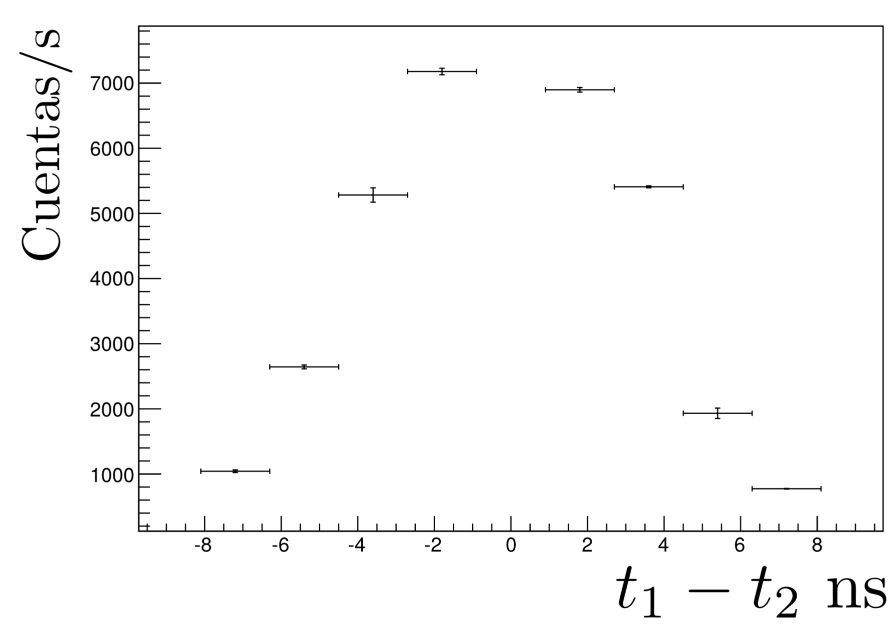


Figure 5: *Correlation function in the presence of delay $\Delta t = t_1 - t_2$ between channels.*

Conclusions

The system laser operation is learned and conditioned for a Gaussian beam mode with an efficiency of 60 %.

The photon detection system is able to measure the order of 7000 matches and established that UV light also generates signals that the system recognizes as matches.

The non-normalized time correlation and spectrum of the SPDC photons with a monochromator was measured . This measurement revealed that there is pump light after of the filter.

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