Grupo de investigacion de óptica cuántica
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Measurements of correlation in frequency on pairs of photons generated with a Non-linear PPKTP crystal

Miguel Perdomo Luna, Mayerlin Nuñez Portela*

Quantum Optics Laboratory, Universidad de los Andes, A.A. 4976, Bogota, D.C., Colombia

E-mail: m.nunez@uniandes.edu.co

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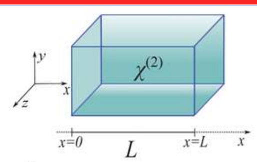
Abstract

Correlated photon pairs present a great area of interest in the optics community since their unique properties allow them to be used in a wide area of fields such as quantum communications, quantum cryptography, quantum computing, and entangled two-photon absorption. Therefore, an efficient source of these pairs of photons is of great significance in modern optics laboratories. With this in mind, we are using a Periodically Poled Potassium Titanyl Phosphate crystal (PPKTP), which is a type of second-order non-linear crystal that serves as a source of production of correlated pairs of photons through a process named Spontaneous Parametric down conversion (SPDC). For a collinear configuration, we study the spectrum of frequencies that can be generated by SPDC for each photon. These results allow us to compare the main characteristics of PPKTP photon pair sources with the ones generated with traditional nonlinear crystals which are 3 orders of magnitude less efficient than the PPKTP on the production of there photons.

Objectives

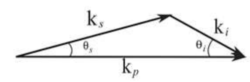
- Characterize the angular dependence of emitted photons with respect to the temperature of the crystal and the wavelength.
- Measure temporal correlations for the generated photon pairs.
- Measure the frequency spectrum of correlated photons generated with the PPKTP crystal.

SPDC and Phase Matching



$$\hat{H}_I = \epsilon_0 \int_v d^3r\ \chi^{(2)} \hat{E}_p^{(+)}(r,t)\hat{E}_s^{(-)}(r,t)\hat{E}_i^{(-)}(r,t)$$

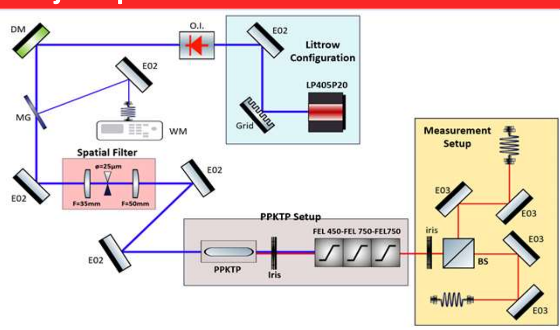
Phase Matching



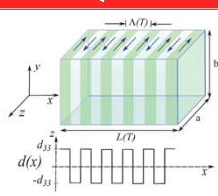
$$\Delta\vec{k} = \vec{k_p} - \vec{k_s} - \vec{k_i} \approx 0$$

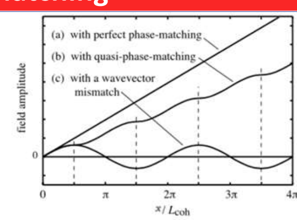
$$w_p = w_s + w_i$$

Montaje Experimental

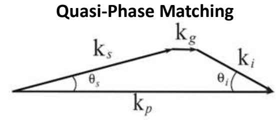


PPKTP and Quasi-Phase Matching





Quasi-Phase Matching

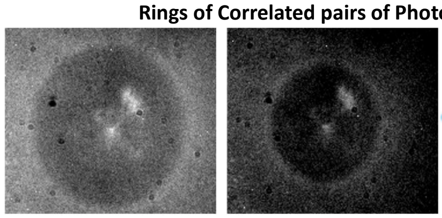


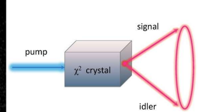
$$\Delta\vec{k} = \vec{k_p} - \vec{k_s} - \vec{k_i} - \vec{k_g} \approx 0$$

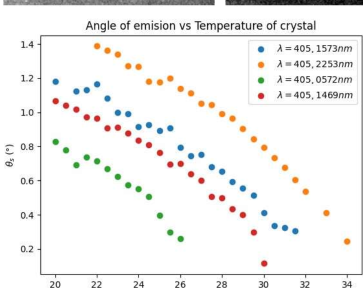
$$|\vec{k_g}| = \frac{2\pi}{\Lambda}$$

Spatial Characterization

Rings of Correlated pairs of Photons



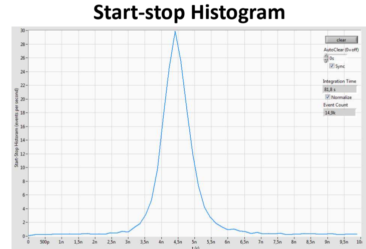




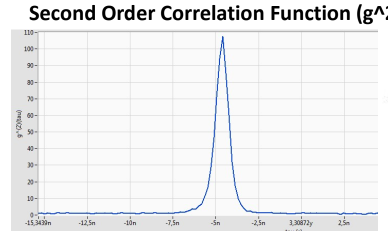
$$\theta_s \approx \pm\sqrt{\frac{2n_{zi}\omega_i}{n_{zs}\omega_s}\left[1+\frac{(2\pi c/\Lambda)-n_{zp}\omega_p}{n_{zs}\omega_s+n_{zi}\omega_i}\right]}.$$

CORRELACIONES TEMPORALES

Start-stop Histogram



Second Order Correlation Function (g^2)



$$g_{si}^{(2)}(\tau) \equiv \frac{\langle \hat{E}_s^\dagger(t+\tau)\hat{E}_i^\dagger(t)\hat{E}_i(t)\hat{E}_s(t+\tau)\rangle}{\langle \hat{E}_s^\dagger(t+\tau)\hat{E}_s(t+\tau)\rangle\langle \hat{E}_i^\dagger(t)\hat{E}_i(t)\rangle}$$

$$g_{si}^{(2)}(\tau) = \frac{\langle n_s(t)n_i(t+\tau)\rangle}{\langle n_s(t)\rangle\langle n_i(t+\tau)\rangle}$$

Conclusions and Future Work

- The dependence on temperature on the angle of emission of the S and I photons was observed and characterized for the PPKTP crystal. This allowed us to find the critical temperature that generates the collinear configuration of photons.
- With the signal and idler photons in a collinear configuration, the second-order correlation function (g^2) and the coincidence count rate of photons were measured. This enabled the observation and confirmation of correlated photons generated in the PPKTP crystal through the SPDC process.
- Using the aforementioned data, the goal is to measure the frequency spectrum of photons generated in the PPKTP crystal for a specific wavelength (joint-spectrum). This is done with the aim of obtaining a reliable characterization of the crystal, making it suitable for use in other experiments where an efficient source of correlated photons is required.

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