Towards correcting atmospheric turbulence via pump control in a down conversion process

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Adaptive optics has been used to correct wavefront errors in light travelling through the atmosphere for astronomical imaging [1] for many years. It has also been used to increase the efficiency of communication based on laser beams through the atmosphere to satellites [2]. Currently, there is a large field of interest in performing quantum communication to satellites [3, 4]. This can be done using single photons generated in a process of spontaneous parametric down conversion (SPDC), which can provide information carriers capable for secure quantum communication. The temporal and spatial modes of the photons can be adjusted according to specific requirements of a transmission link. This possibility, in conjunction with adaptive optics, can enhance a link quality beyond classical methods.

The correlations, which are an important feature for quality of transmission to the satellite, have been already studied in a context of aberration cancellation [5, 6]. The technique we use is based on and array of single photon avalanche diodes (SPAD) [7], which are devices similar to CCD camera, however they offer temporal and spatial resolution on a single photon level. Here we investigate the possibility to control the spatial characteristics of one of the photons by altering the direction of the pump beam (ultimately to be modified by means of adaptive optics).

The experimental setup is depicted in Fig. 1 (a). It consists of a 404 nm pumping laser, where the beam is directed by a mirror through a piece of NBK7 glass used to alter the incidence angle in the nonlinear BBO crystal. The lens L2 together with the CCD camera allows us to measure the direction of the pump beam. The idler photon spatial mode is collimated by a lens L4 and passes through a bandpass filter (Thorlabs FB810-10, 810 nm, FWHM 10 nm), and is coupled by a lens L5 into a multi mode fibre (SMF-28e+ supporting 7 modes at 810 nm). Finally it is detected by a SPCM (Perkin Elemer). The signal photon is collimated by the lens L3 and passes through a longpass filter LF (Thorlabs, FEL0750). Next it is focused in a horizontal direction by a cylindrical lens CL onto the line of 32x1 single photon avalanche diode (SPAD) array [7]. The detections from the SPAD array and Perkin Elemer SPCM are registered by the time tagging FPGA device (UQdevices).

Fig. 1(b) shows a measured statistics of counts at the SPAD array, which followed a coincidental count on the SPCM. The data acquisition was set to 1 min and the coincidence window wa 2 ns. The pump beam direction was set to $\alpha_p = 0$. The best fit of a gaussian function allows one to estimate the central direction of signal photon propagation for a given direction of a pump. The blue dots in Fig. 1 show the measured signal photon's propagation direction as a function of the pump beam direction. The red line represents the theoretical prediction.

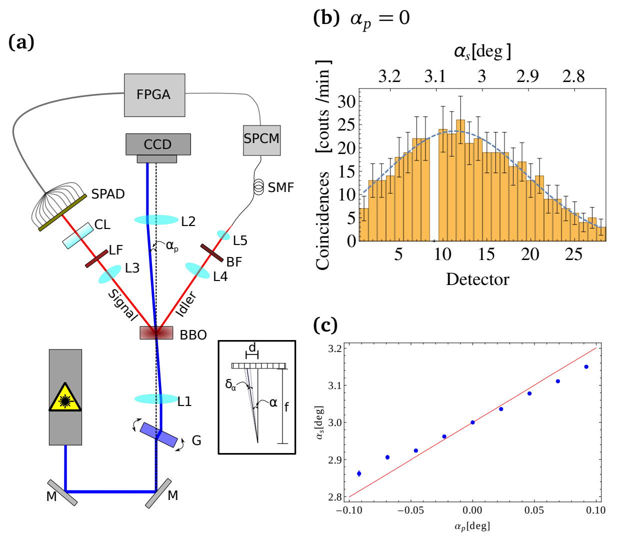

FIG. 1. (a) Experimental Setup. (b) A measured statistics of counts at the SPAD array, which followed a coincidental count on SPCM. (c) Signal photon's direction dependence on the pump beam direction.

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