Distribution of photon pairs in a WDM environment

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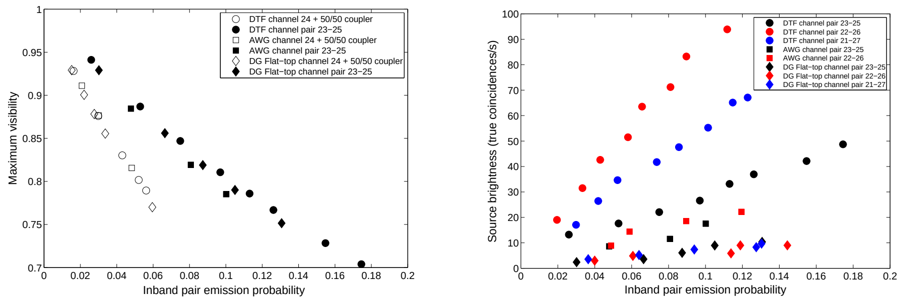
Entanglement based quantum communications require high visibility entangled photon pair sources. Several applications that use entanglement as a ressource, such as Quantum Key Distribution and Quantum Secret Sharing can be interesting to implement in a quantum network, in order to allow a multiparty distribution. Multiuser distribution is however costly due to the high amount of needed ressources. An alternative to reduce this cost is to set up a broadband photon pair source and make use of the whole generated photon pair spectrum [1].

We present a broadband source of photon pairs based on spontaneous parametric down-conversion (SPDC). A deterministic splitting of the photon pairs, is made, using wavelength-division demultiplexing (WDM) techniques, so that a channel pair can be attributed to a pair of users. In order to determine the filter properties (insertion loss, stability and uniformity of the channel bandwidth, precision of the channel wavelength) that are compatible with a good visibility of the entangled photons, we report our results using different WDM demultiplexer technologies. Visibility and brightness are used as figures of merit.

The tested demultiplexers are based on Fabry-Perot etalons, using dielectric thin-film (DTF) and acting as bandpass filters, arrayed waveguide gratings (AWG) that are planar lightwave circuits, based on multi-beam interference or diffraction gratings (DG) where the beam separation occurs in free space, and allows specific wavelengths to be coupled in different output fiber. In the case of DG demultiplexers, we have tested two different transmission shapes : gaussian or flat top.



Using a laser diode (DFB) operating at 779 nm, we focus our laser beam into a PPLN crystal to generate photon pairs. True coincidences have been observed only when delaying the detection on one of the two channels. Depending on the filters, the delay can either be the same (DG) or exhibit a large variation between all channel pairs (AWG and DTF).

Maximum source visibility (left) is calculated from the ratio of true to accidental coincidences [2] and brightness (right) is the number of true coincidences in the considered bandwidth (here 100 GHz channels). They are plotted as a function of the inband pair emission probability, depending on the pump power. The visibility corresponding to a statistical splitting (using a 50/50 beamsplitter on the central channel) has also been plotted for comparison purposes. The necessary visibility/ brightness compromise appears very clearly here when comparing the two plots. The visibility curve does not show very significant differences between the various tested filters in the deterministic splitting configuration, where as the brightness shows very distinctive features of the filter technologies : higher values for the DTF demultiplexers, but also much higher dispersion beween different channel pairs than for the other demultiplexers. Depending on the considered application, the required filter performances can be determined using these experimental results.

[1] H.C.Lim, A. Yoshizawa, H. Tsuchida and K. Kikuchi, "Wavelength-multiplexed entanglement distribution", Optical Fiber Technology **16**, 225-235 (2010).

[2] J.L. Smirr, S. Guilbaud, J. Ghalbouni, R. Frey, E. Diamanti, R. Alléaume and I. Zaquine, "Simple performance evaluation of pulsed spontaneous parametric down-conversion sources for quantum communications", Optics Express **616**, Vol. 19, No 2 (2011).