DWDM DISTRIBUTION OF PHOTON PAIRS PRODUCED BY SPONTANEOUS PARAMETRIC DOWN CONVERSION

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Summary

We have experimentally implemented the distribution of photon pairs through a telecom DWDM filter. Using the measured counts and coincidences between symmetric channels, the maximum fringe visibility that can be obtained with polarization entangled photons is evaluated.

Introduction

The future quantum communication networks will require a large number of high visibility entangled photon pair sources, in order to be really useful. One way to reduce the cost is to use the wideband spectrum produced by spontaneous parametric down conversion (SPDC) and commercial « on the shelf » DWDM filters to distribute non degenerate photon pairs to a large number of users. The problem is to determine whether the filter performances are compatible with high visibility entanglement.

Some previous experiments have been made [1,2, 3], using either tunable filters or wavelength selective switches. Our objective is to compare various DWDM filters as far as the quantum quality of the source is concerned.

Principle of the device

Because of the energy conservation condition of SPDC, $\omega_p = \omega_s + \omega_i$, the frequencies of the signal ω_s and idler ω_i photons are symmetric with respect to $\omega_p / 2$ if ω_p is the pump frequency. The idea is to tune the degeneracy frequency $\omega_p / 2$ to the central frequency of the filter, so that channel pairs can correspond to signal and idler photons. The users that will receive the two photons of an entangled pair can be determined by using a standard telecom switching device. If we wanted each user to receive a given channel permanently, then distributing entanglement to Alice (ω_A) and Bob (ω_B) would mean tuning the pump frequency to $\omega_p = \omega_A + \omega_B$.

Experimental setup

The pump is a cw DFB laser at 775 nm, with a 2 mW power, and it is focused in a 2cm long MgO-doped PPLN bulk crystal. After the crystal, all pump photons are filtered, using dichroïc mirrors and colored glass filters. The photon pairs are then coupled into a single-mode fiber and go through the DWDM flat-top filter with a channel width of 100 GHz and a channel width of 100 GHz (see Fig.1). AsGa avalanche diode single photon detectors are then added on two of the filter channels in order to measure counts and coincidences between the two channels. The detectors are triggered at 2MHz. Detector noise is 500 counts/s and detector dead time is 100 μs.

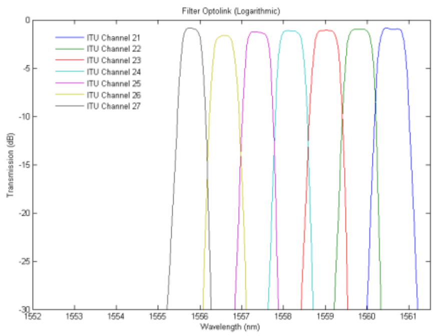

Fig. 1 : Filter transmission

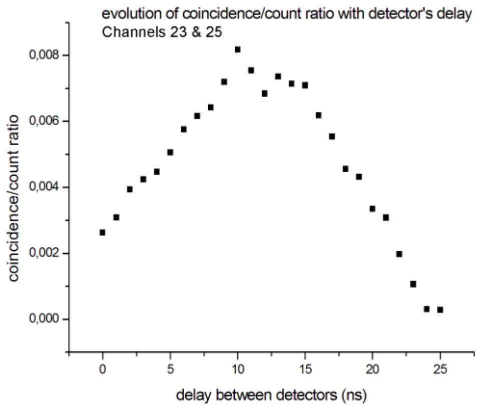

Fig. 2 : coincidence/counts ratio between channels 23 and 25 as a function of detectors delay

Discussion

It has been shown [4] that, using only count and coincidence measurements, we can predict the maximum fringe visibiity that can be obtained when entanglement is implemented with this source. The caculation takes into account the visibility degradation due to double pair generation in SPDC. It shows how the visibility decreases with increasing channel insertion losses and how it also depends on the shape of the filter transmission.

Our measurement results show that the filter induces a delay between the two photons of the pairs. We have measured the coincidence over counts ratio as a function of time delay between the two detectors (see Fig. 2) and found that the curve exhibits a maximum, depending on the channel pair considered. From this ratio, the maximum possible visibility is derived. It can be as high as 87% for the considered channel pair, and also dependent on pump power.

Conclusion

We have shown experimentally that a commercial DWDM filter can be used to distribute photon pairs to a large number of users. The maximum visibility that can be expected from an entangled photon pair source based on this experiment strongly depends on the filter performances and as we show here on the filter technology. The observed variable time delay induced between the two photons of a pair could be a problem for quantum key distribution applications. A systematic investigation of various filters is being made.

Références

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