Demonstration of Nonlocal Dispersion Cancelled Two-Photon Bessel Interference in Frequency Domain

B. Galmes, J.-P. Decurey, I. Mbodji, L. Furfaro, K. Phan Huy, L. Larger, J. M. Dudley, J.-M. Merolla

Département d'Optique, Institut FEMTO—ST, Centre National de la Recherche Scientifique, Unité Mixte de Recherche 6174, Université de Franche-Comté,16 Route de Gray 16, F-25030 Besançon, France

Entangled photons have appeared to be a promising way both for fundamental tests of physical principles and for quantum information applications such as Quantum Key Distribution. In particular, using entangled photons could potentially allow the realization of key distribution protocols over distances greater than a few hundreds of kilometers [1] and security certification without *a priori* trust in the devices employed [2]. Recently we reported experiments [3] in which entanglement is manipulated in the frequency domain using electro-optic phase modulators driven by radio-frequency signals. Such method allows observation of an accurate and stable high-visibility (better than 99%) two-photon Bessel interference patterns. However in long distance fibre implementation this scheme remains sensitive to chromatic dispersion effect. We report a simple non local dispersion cancellation method built entirely from off-the-shelf components. The figure 1 a) depicts a setup allowing a realization of a non local dispersion cancellation in frequency domain. Pairs of photon are created by parametric down conversion in a Periodically Poled Lithium Niobate (PPLN) waveguide symmetrically around the 1550 nm wavelength (pulsation ω_0). A 3dB coupler separates photon pairs. One of the photons is launched in a fibre spool. The second is launched in equivalent fibre spool following by a commercial programmable optical filter based on solid-state Liquid Crystal on Silicon switching element (Waveshaper 4000S). This equipment allows introducing a negative dispersion necessary to cancel the positive dispersion effect experienced by the photons propagating in the fiber spools. Both photons are then modulated by independent electro-optic phase modulators (EOPM) at 25 GHz. The relative phases between the 25 GHz signals are independently controlled by two phase shifters PS1 and PS2. After modulation, the photons are sent through narrowband tunable filters (F1,2) centred on angular frequency ω_0. The photons are detected by two Avalanche Photodiodes (D1, 2). The phase modulators perform Bessel-type interference between photons separately detected on D1 and D2 (see [3] for details). The figure 1 b) and 1c) shows respectively the theoretical evolution of the interference patterns versus the distance when the phase shift is varying between 0 and 2π without (b) and with (c) negative dispersion (the normalized amplitude of modulation is 2.74). The introduction of negative dispersion allows cancelling the dispersion effect on the observed interference patterns.

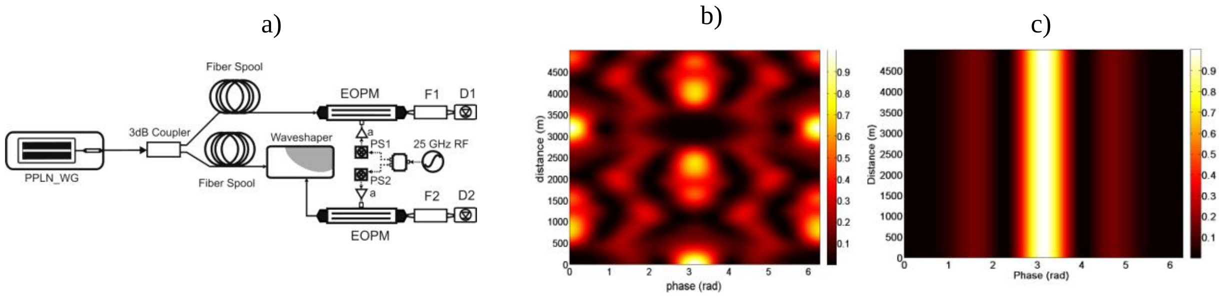

Fig. 1 a) Scheme of the non local dispersion cancellation system. Variation of the interference patterns versus the distance for phase shifts varying between 0 and 2π , b) without and c) with negative dispersion.

In conclusion, we have proposed a simple non local dispersion cancellation method allowing implementation of long distance two photon interference systems in frequency domain. The simulations described here readily guide experimental design and preliminary experimental results support the results obtained above. Full experimental results and performance characterisation will be presented at the meeting.

References

[1] A. Scherer, B. C. Sanders, and W. Tittel, "Long-distance practical quantum key distribution by entanglement swapping", Opt. Express **19**,4, 3004 (2011).

[2] A. Acin, N. Brunner, N. Gisin, S. Massar, S. Pironio and V. Scarani, "Device-Independent Security of Quantum Cryptography against Collective Attacks", Phys. Rev. Lett. **98**, 230501(2007).

[3] L. Olislager, I. Mbodji, E. Woodhead, J. Cussey, L. Furfaro, P. Emplit, S. Massar, K. Phan Huy, J.-M. Merolla " Implementing two-photon interference in the frequency domain with electro-optic phase modulators", New J. Phys. **14,** 043015 (2012)

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