TRR 142
Tailored Nonlinear Photonics

TRR Guest Scientist Lecture / Seminar

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Quantum properties of backward parametric down-conversion

Abstract:

Backward parametric down-conversion, in which one of the twin beams is generated in the opposite direction with respect to the pump laser source (Fig.1a), was theoretically predicted fifty years ago, but only recently became experimentally accessible [1], due the challenges involved in the fabrication of the required submicrometer poling period. A peculiarity of this geometry is the presence of distributed feedback, responsible for the appearance of a threshold pump intensity, beyond which the system has a transition to coherent oscillations, i.e. it behaves as a *Mirrorless Optical Parametric Oscillator* (MOPO) [1]. This seminar focuses on the quantum properties of the counter-propagating twin beams/twin photons generated below the MOPO threshold. The first part describes the coherence and correlation of the twin beams in the threshold region, where stimulated pair production is the dominant mechanism. In this regime the feedback plays a fundamental role, and we predict [2] a progressive shrinking of the emission spectra and a critical slowing down of the temporal coherence and correlation as threshold is approached.

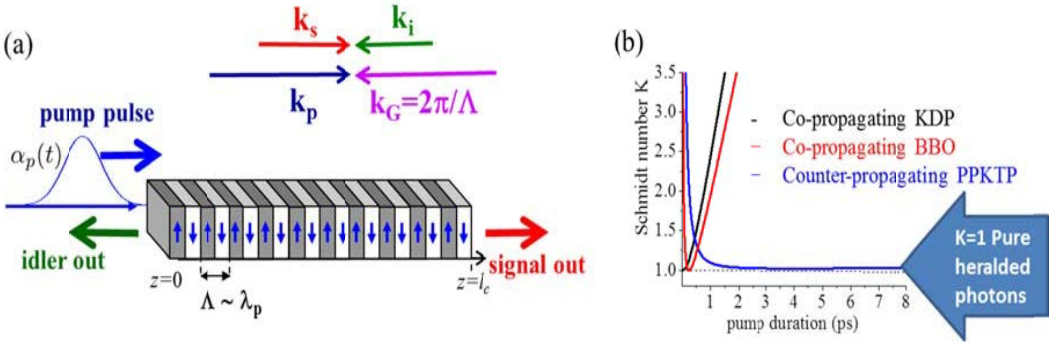

Fig1.
(a) Schematics of the backward parametric down-conversion process
(b) Schmidt number characterizing the degree of entanglement of the state in the spontaneous regime. Comparison between the counter-propagating and co-propagating geometries

The second part concentrates on the regime of spontaneous pair production, and describes the effects of the spectral properties of the pump on the degree of entanglement of the quantum state of twin photons. We show [3] that under very general and accessible conditions the state becomes almost separable, with the possibility of generating high purity heralded single-photons, characterized by a narrow frequency bandwidth (the backward propagating photon may be even more monochromatic than the pump), for a wide range of pump durations and phase matching conditions. We offer a physical interpretation of such a behavior, and a comparison with the more conventional co-propagating geometry, where separability can be achieved only at very special matching points, by using ultrashort pump pulses [4].

[1] C. Canalias, V. Pasiskevicius, Mirrorless optical parametric oscillator, Nature Photonics 1, 459 (2007)
[2] T.Corti, A. Gatti and E. Brambilla, Phys. Rev. A 93, 023837 (2016).
[3] Alessandra Gatti, Tommaso Corti, Enrico Brambilla, Phys. Rev. A 92, 053809 (2015).
[4] P. J. Mosley et al., Phys.Rev. Lett. 100, 133601 (2008);W. P. Grice, A. B. U'Ren, and I. A. Walmsley, Phys.Rev. A 64, 063815 (2001)

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