Spatio-Spectral Characteristics of Biphotons in Structured Nonlinear Waveguides

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One of the challenges in the field of quantum optics is engineering of new sources of non-classical light with controllable spectral and temporal properties. An efficient approach in this direction based on the process of spontaneous parametric down-conversion (SPDC) in nonlinear crystals, nonlinear waveguides and fibers leading to generation of correlated two photons. In this report, we study production of biphotons in definite spatial modes with controlled spectral properties in multimode layered waveguides. In the waveguide configurations wavelengths of the signal and idler photons are governed only by the quasi-phase-matching (QPM) of the longitudinal components of wave vectors while transverse components determine the spatial modes. Thus, we take into account the correlations between three spatial modes of pump, signal, and idler waves with specific distributions of wavelengths.Two models of layered structure are considered as a core of the waveguide: spatially chirped photonic-like crystals and chirped aperiodically poled crystals. These structures are considered as definite assembles of nonlinear layers that leads to a detailed description of SPDC processes through the discrete Gauss sums. On the whole, it becomes possible to control the frequencies and bandwidths of the signal and idler photons also by varying the number of layers equally with the QPM condition. We present the results of SPDC for the following modal configurations: all the three photons (pump, signal and idler) are in the same fundamental spatial mode (0 mode); the pump wave is in (0)-mode, and the two generated waves are in (1)-mode. These configurations also give an opportunity to study modal entanglement of biphotons with different polarization, i.e. for the signal (idler) field being in mode (0) and the idler (signal) field in mode (1). We demonstrate that the structured waveguides bring to the controlled entanglement of biphotons by obtaining the spectral regions of entanglement in dependence on the waveguide structure.

Acknowledgements: The work is supported by the EC for the RISE Project CoExAN GA644076 and the Armenian State Committee of Science, Project No.15T-1C052.