Towards tailored single-photon sources using continuously-tapered waveguides

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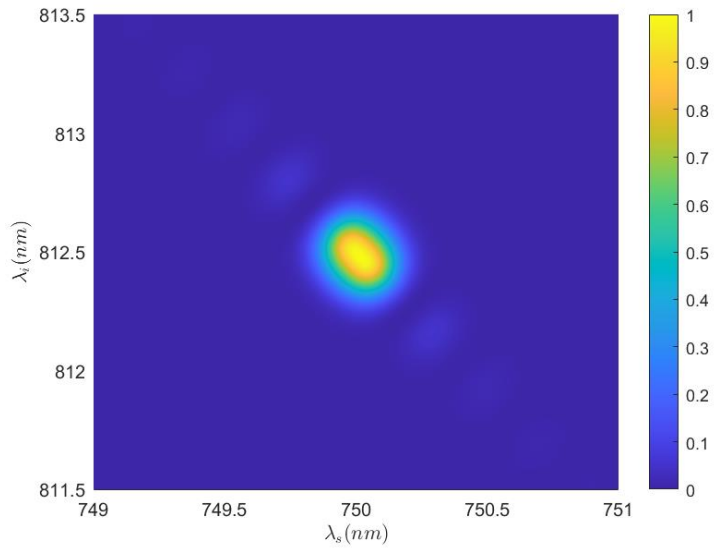
Funder(s): EPSRC

Abstract
We have recently conducted a numerical analysis investigating spontaneous parametric four-wave mixing in third-order nonlinear waveguides with different tapering patterns. We find that these devices could lead to efficient highly-pure single-photon sources.

Joint spectral intensity obtained when a Gaussian pulse is fired into a photonic crystal fibre with a periodic Gaussian tapering pattern. This is equivalent to the dependence of the expected number of photons at the fibre output on the signal and idler wavelengths



Periodically tapered waveguides have been proposed as a means to quasi-phase-match nonlinear processes in third-order materials [1,2]. These structures are analogous to periodically-poled crystals where the nonlinear coefficient is flipped at discrete intervals enabling power to flow from the pump into the generated field.

In third-order nonlinear media the variation of the nonlinear coefficient can be achieved by modulating the waveguide width. We found that by carefully choosing values of the tapering period and modulation depth high conversion efficiency can be achieved [2].

The prospect exists to implement this scheme to generate single-photons at on-demand frequencies [3].

- Continuously tapered devices show promise as a QPM scheme in third-order nonlinear materials, greatly enhancing conversion efficiency
- This lends itself to the production of high-purity single-photons at on-demand frequencies and enables the tailoring of spectral properties such by finely tuning the tapering parameters
- More complex and non-periodic patterning profiles offer many exciting avenues of research

1. D. D. Hickstein, et al. Quasi-Phase-Matched Supercontinuum Generation in Photonic Waveguides. Physical Review Letters, 120(5):53903, 2018.
2. M. F. Saleh. Quasi-phase-matchedχ(3) -parametric interactions in sinusoidally tapered waveguides. Physical Review A, 97(1):1–7, 2018.
3. M. F. Saleh. Modelling spontaneous four-wave mixing in periodically-tapered waveguides. Optics Express,27(9):11979–11990, 2019.