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Quasi-Phase-Matched Parametric Fluorescence in Poled Silica Fibres

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Abstract

We report the first observation of parametric fluorescence from a periodically-poled silica fibre. The achieved pair-photon production rate resulted in more than 100 MHz at 1532 nm for 300 mW of pump power at 766 nm.

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Summary

Recently the demonstration of highly efficient Second-Harmonic Generation (SHG) in periodically poled silica fibres (PPSF) [1], has opened new prospects for the realisation of second-order nonlinear optical processes in all-fibre devices . In particular the achieved high SHG efficiencies, show PPSF are now mature for the implementation of Parametric Fluorescence (PF), a special case of Difference Frequency Generation (DFG). PF is at the heart of optical parametric oscillators and represents a unique source of correlated photon pairs, whose peculiar characteristics make them extremely useful for the study of quantum interference [2], quantum cryptography [3] and for metrology applications (e.g. absolute measurement of the quantum efficiency of photon counting detectors [4]).

The fabrication of the PPSF samples is fully described in [5]. The period of the patterned aluminium anode, $\Lambda = 56.5$ μm, prodeuced QPM-SHG around 1532 nm, with a conversion efficiency $\eta_{SH} \simeq 4 \cdot 10^{-3}$ %/W (see Ref.1).

The setup for the parametric fluorescence generation is illustrated in Fig.1. Up to 300 mW of pump power were coupled into the sample in the fundamental mode, without exciting higher orders. For the coincidence measurement two InGaAs APDs operated in photon counting mode, were spliced to a 3 dB fibre splitter into which we launched the output from the sample.

The coincidence curve was collected with a Modulation Domain Analyser (MDA) attached to Nuclear Instrumentation Module (NIM) discriminators connected to the APDs.

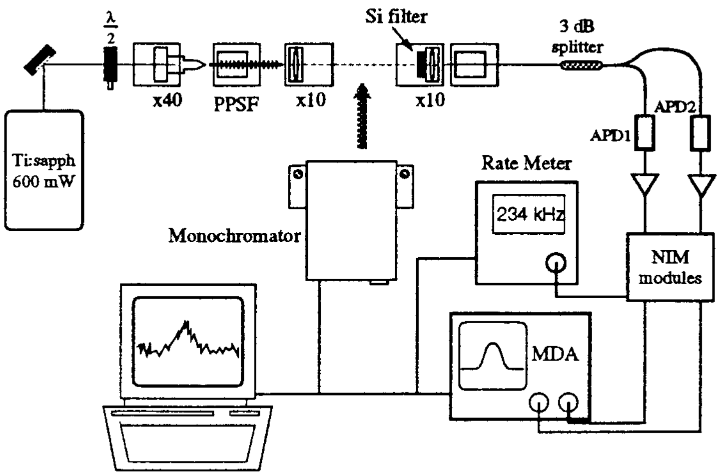

Fig. 1: Setup for parametric fluorescence generation and coincidence measurement. APD: Avalanche Photodiode, PPSF: Periodically Poled Silica Fibre, MDA: Modulation Domain Analyser, NIM: Nuclear Instrumentation Module.

The QPM curve was collected detecting with a single APD the output from the fibre, passed through a monochromator.

Fig.2 illustrates the coincidence curves for vertical (top) and horizontal (bottom) polarisation of the pump, its wavelength being 766 nm. The large background in is due to the high dark counts rate ($\sim$ 200 kHz) of the detectors. The larger signal for vertical pump is due both to the tensorial nature of the nonlinear coefficient and the fibre birefringence.

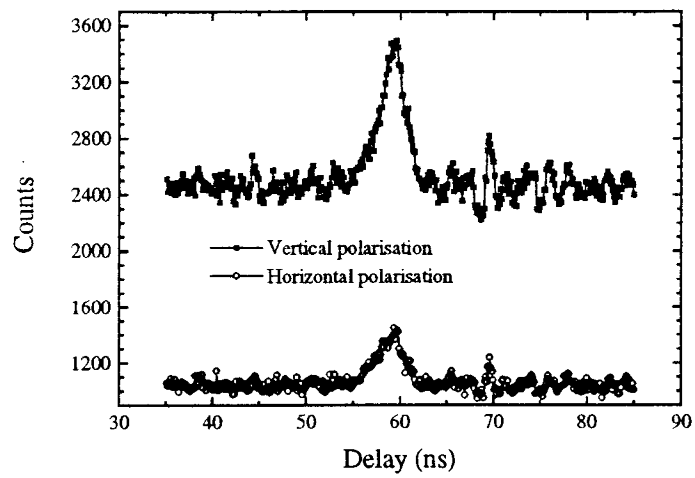

Fig. 2: Coincidence curves for vertical (top) and horizontal (bottom) pump polarisation. Each point corresponds to 0.09 ns interval

Given the coincidence rate $\sim$ 500 Hz, we estimated the quantum efficiencies of the two APDs to be $1.4 \pm 0.4\%$ and $1.7 \pm 0.4\%$, and the photon pairs production rate to be $\sim$ 150 MHz, in good agreement with the expected 156 MHz.

Fig.3 shows the collected QPM tuning curve. We measured the signal branch, while, due to the roll-off in the detector sensitivity and the significant losses for long wavelengths in the sample, only three idler points could be identified experimentally. The bars correspond to the bandwidth for the process.

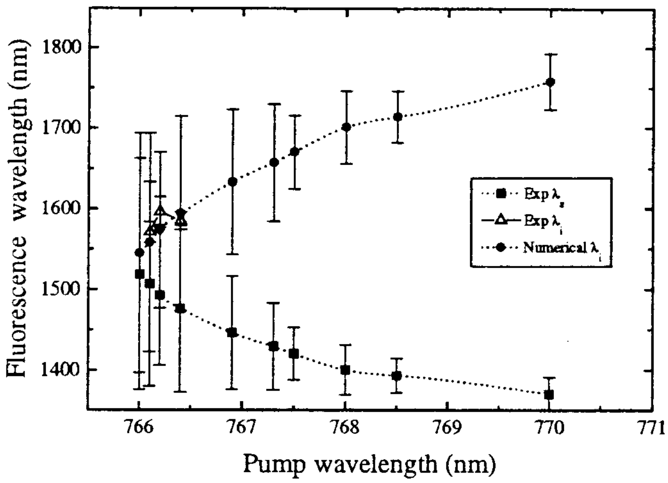

Fig. 3: QPM tuning curve. The bars show the measured signal bandwidth.

We have reported on the observation of quasi-phase matched parametric fluorescence from periodically poled silica fibres. The photon pair production resulted in 150 MHz for 300 mW of pump power at 766 nm. These results clearly show the large potential of periodically poled silica fibres as nonlinear media in all-fibre single photon sources, which are going to play a major role in the future for the implementation of quantum cryptography systems and as absolute metrology standards.

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