Dispersion tailoring of a silicon strip waveguide employing Titania-Alumina thin-film coating
We numerically demonstrate dispersion tailoring of a silicon strip waveguide employing Titania-Alumina thin-film coating using a finite-difference mode solver. The proposed structure exhibits spectrally-flattened near-zero anomalous dispersion within the telecom wavelength range. We also numerically predict the wavelength conversion efficiency for degenerate four-wave mixing, and obtain a 3 dB bandwidth of 80 nm.

Effects of noninstantaneous nonlinear processes on photon-pair generation by spontaneous four-wave mixing
We present a general model, based on a Hamiltonian approach, for the joint quantum state of photon pairs generated through pulsed spontaneous four-wave mixing, including nonlinear phase modulation and a finite material response time. For the case of a silica fiber, it is found that the pair-production rate depends weakly on the waveguide temperature, due to higher-order Raman scattering events, and more strongly on pump-pair frequency detuning. From the analytical model, a numerical scheme is derived, based on the well-known split-step method. This scheme allows computation of joint states where nontrivial effects are included, such as group-velocity dispersion and Raman scattering. In this work, the numerical model is used to study the impact of the noninstantaneous response on the prefiltering purity of heralded single photons. We find that for pump pulses shorter than 1 ps, a significant detuning-dependent change in quantum-mechanical purity may be observed in silica. This shows that Raman scattering not only introduces noise, but can also drastically change the spectral correlations in photon pairs when pumped with short pulses.
Full-vectorial propagation model and modified effective mode area of four-wave mixing in straight waveguides

We derive from Maxwell's equations full-vectorial nonlinear propagation equations of four-wave mixing valid in straight semiconductor-on-insulator waveguides. Special attention is given to the resulting effective mode area, which takes a convenient form known from studies in photonic crystal fibers, but has not been introduced in the context of integrated waveguides. We show that the difference between our full-vectorial effective mode area and the scalar equivalent often referred to in the literature may lead to mistakes when evaluating the nonlinear refractive index and optimizing designs of new waveguides. We verify the results of our derivation by comparing it to experimental measurements in a silicon-on-insulator waveguide, taking tolerances on fabrication parameters into account. (C) 2017 Optical Society of America
Generation of two-temporal-mode photon states by vector four-wave mixing

Photon pair states and multiple-photon squeezed states have many applications in quantum information science. In this paper, Green functions are derived for spontaneous four-wave mixing in the low- and high-gain regimes. Nondegenerate four-wave mixing in a strongly-birefringent medium generates signal and idler photons that are associated with only one pair of temporal (Schmidt) modes, for a wide range of pump powers and arbitrary pump shapes. The Schmidt coefficients (expected photon numbers) depend sensitively on the pump powers, and the Schmidt functions (shapes of the photon wavepackets) depend sensitively on the pump powers and shapes, which can be controlled. (C) 2017 Optical Society of America

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High coincidence-to-accidental ratio continuous-wave photon-pair generation in a grating-coupled silicon strip waveguide: Letters

We demonstrate a very high coincidence-to-accidental ratio of 673 using continuous-wave photon-pair generation in a silicon strip waveguide through spontaneous four-wave mixing. This result is obtained by employing on-chip photonic-crystal-based grating couplers for both low-loss fiber-to-chip coupling and on-chip suppression of generated spontaneous Raman scattering noise. We measure a minimum heralded second-order correlation of $g^{(2)}(0) = 0.12$, demonstrating that our source operates in the single-photon regime with low noise. (C) 2017 The Japan Society of Applied Physics
Spectrally pure heralded single photons by spontaneous four-wave mixing in a fiber: reducing impact of dispersion fluctuations

We model the spectral quantum-mechanical purity of heralded single photons from a photon-pair source based on nondegenerate spontaneous four-wave mixing taking the impact of distributed dispersion fluctuations into account. The considered photon-pair-generation scheme utilizes pump-pulse walk-off to produce pure heralded photons and phase matching is achieved through the dispersion properties of distinct spatial modes in a few-mode silica step-index fiber. We show that fiber-core-radius fluctuations in general severely impact the single-photon purity. Furthermore, by optimizing the fiber design we show that generation of single photons with very high spectral purity is feasible even in the presence of large core-radius fluctuations. At the same time, contamination from spontaneous Raman scattering is greatly mitigated by separating the single-photon frequency by more than 32 THz from the pump frequency. (C) 2017 Optical Society of America
Differential phase-time shifting protocol for QKD (DPTS)

We explore the implementation of a novel protocol for fiber-based high-dimensional quantum key distribution (QKD) which improves over the traditional DPS-QKD and COW protocols.

General information
Generation of pure heralded single-photon states by cross-polarized spontaneous four-wave mixing

We propose a novel scheme which employs cross-polarized pumps to generate temporally and spectrally uncorrelated signal-idler photon-pairs through spontaneous four-wave mixing in a birefringent third-order nonlinear waveguide.

Temporally uncorrelated photon-pair generation by dual-pump four-wave mixing

We study the preparation of heralded single-photon states using dual-pump spontaneous four-wave mixing. The dual-pump configuration, which in our case employs cross-polarized pumps, allows for a gradual variation of the nonlinear interaction strength enabled by a birefringence-induced walk-off between the pump pulses. The scheme enables the preparation of highly pure heralded single-photon states, and proves to be extremely robust against the effect of nonlinear phase modulation at the required photon-pair production rates.
Two-dimensional distributed-phase-reference protocol for quantum key distribution

Quantum key distribution (QKD) and quantum communication enable the secure exchange of information between remote parties. Currently, the distributed-phase-reference (DPR) protocols, which are based on weak coherent pulses, are among the most practical solutions for long-range QKD. During the last 10 years, long-distance fiber-based DPR systems have been successfully demonstrated, although fundamental obstacles such as intrinsic channel losses limit their performance. Here, we introduce the first two-dimensional DPR-QKD protocol in which information is encoded in the time and phase of weak coherent pulses. The ability of extracting two bits of information per detection event, enables a higher secret key rate in specific realistic network scenarios. Moreover, despite the use of more dimensions, the proposed protocol remains simple, practical, and fully integrable.
Temporal mode sorting using dual-stage quantum frequency conversion by asymmetric Bragg scattering

The temporal shape of single photons provides a high-dimensional basis of temporal modes, and can therefore support quantum computing schemes that go beyond the qubit. However, the lack of linear optical components to act as quantum gates has made it challenging to efficiently address specific temporal-mode components from an arbitrary superposition. Recent progress towards realizing such a “quantum pulse gate,” has been proposed using nonlinear optical signal processing to add coherently the effect of multiple stages of quantum frequency conversion. This scheme, called temporal-mode interferometry [D. V. Reddy, Phys. Rev. A 91, 012323 (2015)], has been shown in the case of three-wave mixing to promise near-unity mode-sorting efficiency. Here we demonstrate that it is also possible to achieve high mode-sorting efficiency using four-wave mixing, if one pump pulse is long and the other short - a configuration we call asymmetrically-pumped Bragg scattering. (C) 2015 Optical Society of America
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