Q 4: Photonics I

Time: Monday 11:00–12:45 Location: f342

Q 4.1 Mon 11:00 f342

High-power mid-infrared high repetition-rate supercontinuum source based on a chalcogenide step-index fiber — •Stefan Kedenburg, Tobias Steinle, Florian Mörz, Andy Steinmann, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

We demonstrate a tunable and robust femtosecond supercontinuum source with a maximum output power of 550 mW and a maximum spectral width of up to 2.0 μm which can cover the mid-infrared region from 2.3 μm up to 4.9 μm by tuning the pump wavelength. As light source we use a synchronously pumped fiber-feedback OPO and a subsequent OPA which delivers femtosecond, Watt-level idler pulses tunable between 2.5 μm and 4.1 μm. These pulses are launched into As2S3 chalcogenide step-index fibers with core diameters of 7 and 9 μm. The spectral behavior of the supercontinuum is investigated by changing the pump wavelength, core diameter, fiber length, and pump power. Self-phase modulation is identified as the main broadening mechanism in the normal dispersion regime. This source promises to be an excellent laboratory tool for infrared spectroscopy owing to its high brilliance as demonstrated for the CS2-absorption bands around 3.5 μm.

Q 4.2 Mon 11:15 f342

Ultrafast all-optical mode conversion in graded-index fibers — •Martin Schnack, Tim Hellwig, and Carsten Fallnich — Institute of Applied Physics, University of Münster, Corrensstraße 2, 48149 Münster

We present experimental results on all-optical transverse mode conversion in graded-index multi-mode fibers. Ultrashort probe pulses are converted from the fundamental mode to the next higher-order modes by optically induced transient long-period gratings[1]. Temporally synchronized, high-power subpicosecond control pulses are used to excite a combination of transverse modes in the fiber. By exploiting the Kerr-effect the periodic spatial intensity pattern emerging from multi-mode interference is translated into a spatial refractive index modulation, transiently inducing the necessary long period grating.

The graded refractive index profile of the fiber allows for the first time to achieve efficient mode conversion using control and probe pulses at separate wavelengths[2]. The probe pulses are thus easily distinguishable by spectral filtering and can be directly visualized. Furthermore, numerical simulations are presented, exhibiting excellent agreement with the experimental results.

[1] Walbaum T., Fallnich C., *Appl. Phys. B* **115**, 225 (2014)
[2] Schnack M., et. al., *Opt. Lett.* **40**, 4675 (2015)

Q 4.3 Mon 11:30 f342

Investigation of higher-order mode content in Si_3N_4 integrated optical waveguides via spatially and spectrally resolved imaging — •Niklas M. Lüpken[1], Tim Hellwig[1], Martin Schnack[1], Klaus-J. Boller[2], and Carsten Fallnich[1,2] — [1]Institute of Applied Physics, University of Münster — [2]MESA+ Institute for Nanotechnology, University of Twente

High-confinement Si_3N_4 integrated optical waveguides have been shown to be highly suitable for ultra-broadband supercontinuum generation[1]. Thick waveguides (800 nm × 1000 nm), which are inherently multi-mode, have been identified to feature suitable dispersion for efficient supercontinuum generation. We present a detailed experimental investigation of the excitation of transverse modes in these integrated optical waveguides by characterizing the modal distribution at the output of the waveguide. In our experiment a lensed fiber is scanned transversally over the input facet of the waveguide, giving a position-dependent higher-order mode excitation. The modal content was measured by spatially and spectrally resolved imaging (S^2 imaging)[2], being an interferometrically based method and, therefore, sensitive enough to detect even very weak higher-order modes.

The presented measurement system can be used for modal decomposition and optimization of fundamental mode content in integrated optical waveguides. Furthermore, our results show that the higher-order mode content is negligible in the studied waveguides.

[1] Epping JP, et al., *Opt. Express* **23**, 19596 (2015).
[2] Nicholson JW, et al., *Opt. Express* **16**, 7233 (2008).

Q 4.4 Mon 11:45 f342

A hybrid photonic crystal fibre suitable for photon triplet generation — •Andrea Cavanna[1], Felix Just[1], Xin Jiang[1], Maria V. Chekhova[1,2,3], Gerd Leuchs[1,2], Nicolas Y. Joly[2,1], and Philip St.J. Russell[1,2] — [1]Max Planck Institute for the Science of Light Günther-Scharowsky-Str. 1 Building 24, 91058 Erlangen, Germany — [2]University of Erlangen-Nürnberg, Staudtstr. 7/B2, 91058 Erlangen, Germany — [3]Department of Physics, M.V.Lomonosov Moscow State University, Leninskie Gory, 119991 Moscow, Russia

Here we present a hybrid photonic crystal fibre that allows phase-matching for third-harmonic generation, and therefore for triplet photon generation, between fundamental modes only. The fibre features an inner all-solid band-gap microstructure made of high refractive-index glass rod (SF6) embedded in a lower refractive index host (LLF1). This microstructure is part of a larger step-index PCF, where the longer wavelength radiation propagates by total internal reflection, without being perturbed by the all-solid microstructure. Combined with the difference in modal diameters, phase-matching is achieved between fundamental modes. Experimentally, we have observed third harmonic generation between 1521 nm and 507 nm.

Q 4.5 Mon 12:00 f342

Characterising linear optical circuits via phaseless estimation techniques — •Daniel Suess[1], Richard Kueng[1], Chris Sparrow[2], Christopher Harold[2], Jacques Carolan[2], Anthony Laing[2], and David Gross[1] — [1]Institute for Theoretical Physics, University of Cologne, Germany — [2]Centre for Quantum Photonics, University of Bristol

Linear-optical circuits may become important elementary building blocks of quantum computers in the future. Especially integrated photonics has the prospect of being scaleable by using technology from chip manufacturing. Here, we present an efficient, robust, and conceptually simple technique for characterising such a chip based on recent advances in low-rank matrix recovery. We also report on a successful experimental implementation using a universal six-mode linear optics chip.

Q 4.6 Mon 12:15 f342

Coherent single photon frequency conversion for long distance quantum networks — •Tim Kroh[1], Andreas Ahlrichs[1], Otto Dietz[1], Andreas W. Schell[2], Benjamin Sprenger[1], and Oliver Benson[1] — [1]1Department of Physics, Humboldt-Universität zu Berlin, Germany — [2]Department of Electronic Science and Engineering, Kyoto University, Japan

For long-distance quantum cryptographic communication it is convenient to use the existing fiber optical network to transmit single flying quantum bits - that are photons. The concept of a quantum repeater enables the establishment of a quantum communication channel even beyond the absorption limit of less than 100 km for single photon transmission by the successive transfer of entanglement over the whole distance while the participating photons will only travel a small fraction.

To set up a quantum information network using quantum repeaters different building blocks such as quantum gates, memories and sources of entangled photons are required. Bright sources of high quality indistinguishable photons only exist so far at shorter wavelengths, e.g. single quantum dots or a spontaneous parametric process in a nonlinear crystal. We tackle that problem by coherently converting the frequency of single photons emitted by these two sources into the telecom band. Recent results will be presented that demonstrate the preservation of non-classical temporal properties of quantum correlated photon pairs.

Q 4.7 Mon 12:30 f342

Nonlinear metamaterials with amplification and absorption — •Sebastian Erfort, Sascha Böhrkircher, Holger Cartarius, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart, Germany

Although originally discussed in the context of non-Hermitian quantum mechanics, $\mathcal{PT}$ symmetry has been demonstrated experimentally in optics and other areas. Recently, PT symmetry has also entered the experimental field of metamaterials [1]. The investigation of polarization eigenstates of metasurfaces with anisotropic absorption has

revealed $\mathcal{PT}$ symmetry breaking at a critical coupling strength of the two orthogonal orientations of the dipoles. Investigations so far have been restricted to linear wave propagation in metasurfaces. In our work we extend this to nonlinear metamaterials and investigate this extension with examples composed of split ring resonators or optical breather setups. We will study the influence of the nonlinearity in both cases.

[1] M. Lawrence, et al., Phys. Rev. Lett. **113**, 093901 (2014)