Q 64: Quantum Optics and Photonics IV

Time: Friday 10:30–12:30 Location: K 0.016

Q 64.1 Fri 10:30 K 0.016

Quantum noise enhanced through nonlinear effects: extreme events and extreme bunching — •Kirill Spasibko[1,2], Mathieu Manceau[1], Gerd Leuchs[1,2], Radim Filip[3], and Maria Chekhova[1,2,4] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]University of Erlangen-Nürnberg, 91058 Erlangen, Germany — [3]Department of Optics, Palacky University, 77146 Olomouc, Czech Republic — [4]Department of Physics, M. V. Lomonosov Moscow State University, 119991 Moscow, Russia

Extreme events and rogue waves are observed for different physical systems. They are especially fascinating because they can lead to catastrophic changes in the system despite being quite rare. However, their probability is still much higher than one expects from Gaussian random processes, i.e. the probability distribution has a 'heavy tail'.

In optics such distributions are obtained mainly from supercontinuum generation using laser light with faint (shot-noise-limited) fluctuations to pump a nonlinear medium. If a 'noisy' pump is used, one expects to have even more pronounced heavy tails.

In this work we used 'noisy' pump, obtained via parametric down-conversion, to produce tremendously fluctuating light from two different nonlinear processes: optical harmonics and supercontinuum generation. The generated light shows heavy-tailed statistics with extreme bunching (the bunching parameter g(2) being as high as 170) and extreme events (with photon numbers exceeding the mean values by three orders of magnitude).

Q 64.2 Fri 10:45 K 0.016

frequency-tripled photon generation in argon gas far beyond the paraxial regime — •rojiar penjweini[1,2], markus weber[1,2], markus sondermann[1,2], and gerd leuchs[1,2,3] — [1]Max-Planck-Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Erlangen, Germany — [3]Department of Physics, University of Ottawa, Ottawa, Canada

We investigate the generation of frequency-tripled photons under the condition of extremely tight focusing, which has not been explored in experiments before. As non-linear medium we use argon gas in the regime of normal dispersion. Our experiments show that the number of frequency-tripled photons under such conditions exhibits a fifth order dependence on the intensity of the fundamental beam. We argue that the observed frequency-tripled photons are generated through six-wave-mixing. We compare our experimental results to simulations, finding a good agreement between the simulation and experiments on the number of frequency-tripled photons as a function of focus size and pressure.

Q 64.3 Fri 11:00 K 0.016

A new definition for the Kerr nonlinearity parameter — •Izzatjon Allayarov[1], Swaathi Upendar[1], Markus A. Schmidt[2,3], and Thomas Weiss[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]Leibniz Institute of Photonic Technology, Germany — [3]Otto Schott Institute of Material Research, Friedrich Schiller University of Jena, Germany

Gas filled hollow-core photonic crystal fibers outperform conventional fibers in terms of their tuning capabilities. For instance, the linear dispersion and the nonlinear optical properties can be controlled through changing the temperature and the pressure [1]. Due to the finite cladding, the modes in such fibers are leaky, i.e., they radiate perpendicular to the fiber axis. Therefore, the electromagnetic fields of the modes grow exponentially with distance to the fiber center. Hence, the derivation of the Kerr nonlinearity parameter becomes questionable, since existing approaches rely on an arbitrary spatial truncation of the electromagnetic fields [2]. We present a new and more general derivation of the Kerr nonlinearity parameter that is based on the resonant state expansion [3]. Our approach provides the correct Kerr nonlinearity parameter independent of the spatial truncation. For leaky modes, we obtain a nonzero imaginary part of the Kerr nonlinearity parameter, providing nonlinear gain or loss. We will discuss about the impact of this novel result on the nonlinear pulse propagation.

[1] P. St. J. Russell et al., Nat. Photon. **8**, 278 (2014).
[2] S. Afshar V. and T. M. Monro, Opt. Express **17**, 2298 (2009).
[3] T. Weiss et al., Phys. Rev. B **96**, 045129 (2017).

Q 64.4 Fri 11:15 K 0.016

Generation of third harmonic and photon triplets in gas-filled hollow core photonic crystal fibre — •Andrea Cavanna[1], Cameron Okoth[1], Michael H. Frosz[1], Maria V. Chekhova[1,2,3], Gerd Leuchs[1,2], Nicolas Y. Joly[1,2], and Philip St.J. Russell[1,2] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]University of Erlangen-Nuremberg, Staudtstr. 7/B2, 91058 Erlangen, Germany — [3]Department of Physics, Moscow State University, 119991 Moscow, Russia

We present a single-ring photonic crystal fibre designed for phase-matched third harmonic generation from pump light at 1596 nm, as well as generation of photon triplets when pumped at 532 nm. The core region is surrounded by 12 capillaries with inner diameter approximately 6.7 μm and wall thickness 350 nm. The fiber guides, with losses below 1 dB/m, both broadband NIR radiation and visible light within a narrow spectral region around 532 nm. The 38 μm diameter core is filled with xenon gas, and the fibre offers convenient pressure-tunable dispersion and phase-matching for conversion from 532 to 1596 nm and vice-versa. We report generation of tunable third harmonic from an LP01-like pump mode to an LP03-like third harmonic mode as well as measurements of the luminescence at the single photon level for the reverse process.

Q 64.5 Fri 11:30 K 0.016

Coherent Raman gain suppression in gas-filled broadband-guiding photonic crystal fibres — •Manoj K. Mridha, Pooria Hosseini, David Novoa, and Philip St.J. Russell — Max Planck Institute for the Science of Light, Erlangen, Germany

The gain for stimulated Raman scattering (SRS) gets strongly suppressed when the rate of phonon creation (via pump-to-Stokes conversion) is equally compensated by the rate of phonon annihilation (via pump-to-anti-Stokes conversion). This occurs when the Raman coherence waves–synchronous oscillations of a large population of molecules–have identical propagation constants for both processes; i.e., they are phase-velocity matched. This phenomenon, first predicted more than half a century ago, has recently been demonstrated in the collinear geometry provided by a hydrogen-filled photonic crystal fibre pumped in the vicinity of its zero-dispersion wavelength. Here we report that Raman gain suppression is a universal feature of SRS in gas-filled hollow-core fibres and that it can strongly weaken SRS even under conditions of large phase mismatch, especially at high pump powers when it is normally assumed that nonlinear processes become more (not less) efficient. This counterintuitive behavior at high pump power implies the domination of Stokes growth in a different core mode compared to the pump (for example LP01/pump to LP11/ Stokes). These results have important implications for fibre-based Raman amplifiers, shifters, or frequency combs, especially for operation in the ultraviolet, where the Raman gain is very high.

Q 64.6 Fri 11:45 K 0.016

Transient Raman scattering in hollow-core photonic crystal fibers filled with gas mixtures — •Pooria Hosseini, David Novoa, and Philip St.J. Russell — Max Planck Institute for the Science of Light, Erlangen, Germany

Previous reports on stimulated Raman scattering (SRS) in mixtures of Raman-active and noble gases indicate that the addition of a dispersive buffer gas increases the phase-mismatch to higher-order Stokes/anti-Stokes sidebands, resulting in preferential conversion to the first few Stokes lines, accompanied by a significant reduction in Raman gain. Gas-filled hollow-core photonic crystal fibers (HC-PCFs) permit, however, operation in the so-called transient SRS regime, where the Raman gain is marginally reduced owing to the high pump intensities and long interaction lengths attainable. We report the generation of a dense cluster of Raman sidebands in the ultraviolet-visible region using a mixture of hydrogen-deuterium-xenon with 1-ns-long laser pulses of only 5 μJ energy at 532 nm. In addition, we show that, provided the dispersion can be precisely controlled, the effective Raman gain in gas-filled HC-PCF can actually be significantly enhanced when a buffer gas is added. This counterintuitive behavior occurs when the nonlinear coupling between the interacting fields is strong and can result in a performance similar to that of a pure Raman-active gas, but at much lower total gas pressure, allowing competing effects such as

Raman backscattering to be suppressed.

Q 64.7 Fri 12:00 K 0.016

Waveguide-integrated single photon spectrometer based on tailored disorder — •Wladick Hartmann[1,2], Paris Varytis[3,4], Kurt Busch[3,4], and Wolfram Pernice[1,2] — [1]University of Münster, Institute of Physics, 48149 Münster, Germany — [2]University of Münster, CeNTech - Center for Nanotechnology, 48149 Münster, Germany — [3]Humboldt-University Berlin, Institute of Physics, Berlin, Germany — [4]Max-Born Institute, 12489 Berlin, Germany

Integrated nanophotonic circuits allow for realizing complex optical functionality in a compact and reproducible fashion through high-yield nanofabrication. Typically configured for single-mode operation in a single path, the optical propagation direction in such devices is determined by the waveguide layout which inherently requires smooth surfaces without scattering and restricts the device footprint to the limits of total internal reflection. Yet intentionally introducing disorder and scattering can be beneficial for the realization of novel nanophotonic components to overcome fabrication imperfections. In particular on-chip spectrometers may benefit from random disorder.

Here, as part of the priority program "Tailored Disorder" (SPP 1839), we utilize multi-path interference and the interaction of light with randomly oriented scatterers to realize broadband and narrow linewidth on-chip integrated spectrometers with small footprint. In combination with integrated superconducting nanowire single-photon detectors such devices allow for resolving optical spectra on the single photon level which is of interest for single-photon spectroscopy or quantum wavelength division multiplexing.

Q 64.8 Fri 12:15 K 0.016

Towards Integrated High-T$_c$ Superconducting Nanowire Hot Electron Bolometers — •Martin A. Wolff[1,2], Matvey Lyatti[1,2], Simone Ferrari[1,2], Carsten Schuck[1,2], and Wolfram H. P. Pernice[1,2] — [1]University of Münster, Physics Institute, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]CeNTech - Center for NanoTechnology, Heisenbergstr. 11, 48149 Münster, Germany

The idea of exploiting the optical response of superconductors for nanophotonic applications such as bolometers, transition edge sensors and single-photon detectors is an active and rapidly growing field of research. Hot-electron bolometers (HEBs) feature very attractive performance such as low-noise and high-speed photon detection with applications in astronomy and quantum communication. However, cryogenic environments at temperatures below 4 K are inevitable for conventional low-temperature superconducting materials. Hence, there is an increasing interest for exploring the potential of high-T_c superconductors for this kind of application, thus significantly reducing the cryogenic requirements for operating HEBs.

Here we present the characterization of high-T$_c$ $YBa_2Cu_3O_{7-x}$ (YBCO) nanowires on a transparent $SrTiO_3$ (STO) substrate realized by a focused ion beam (FIB) milling technique. The fabricated nanowires are then used as bolometers to demonstrate their potential for photon detection.