Q 60: Photonics IV

Time: Friday 11:00–12:45 Location: A320

Q 60.1 Fri 11:00 A320

stimulated Brillouin scattering in chiral photonic crystal fibre — •Xinglin Zeng[1], Philip Russell[1], and Birgit Stiller[1,2] — [1]Max-Planck institute for the science of light — [2]Department of Physics, Friedrich-Alexander-Universität

Stimulated Brillouin scattering (SBS) in optical fibres, in which guided light is parametrically reflected by coherent acoustic phonons, provides a powerful and flexible mechanism for controlling light. The recent advent of chiral photonic crystal fibres (PCF) has been shown to robustly preserve optical modes carrying circular polarization states and optical vortices over long distances, allowing investigation of nonlinear processes in the presence of chirality. Here, we report the topology-selective SBS effect in chiral PCF, demonstrate an optical vortex Brillouin laser and a reconfigurable nonreciprocal vortex isolator based on this novel effect. This work opens up new perspectives in Brillouin scattering, with potential interest in many areas, for example, quantum information processing, optical tweezers and telecommunications.

Q 60.2 Fri 11:15 A320

Complex aspherical singlet and doublet microoptics by grayscale 3D printing — •Leander Siegle, Simon Ristok, and Harald Giessen — 4th Physics Institute, University of Stuttgart

We demonstrate grayscale 3D printed aspherical singlet and doublet microoptical components and characterize and evaluate their excellent shape accuracy and optical performance. The typical two-photon polymerization (2PP) 3D printing process creates steps in the structure which is undesired for optical surfaces. We utilize two-photon grayscale lithography (2GL) to create step-free lenses. To showcase the 2GL process, the focusing ability of a spherical and aspherical singlet lens are compared. The surface deviations of the aspherical lens are minimized by an iterative design process, and no distinct steps can be measured. We design, print and optimize an air-spaced doublet lens with a diameter of 300 μm. After optimization, the residual shape deviation is less than 100 nm and 20 nm for the two lenses, respectively. We examine the optical performance with an USAF 1951 resolution test chart to find a resolution of 645 lp/mm.

Q 60.3 Fri 11:30 A320

3D lithography for single-photon level spectroscopy with superconducting detectors — •Johanna Biendl, Maximilian Protte, Timon Schapeler, Thomas Hummel, and Tim J. Bartley — Institute for Photonic Quantum Systems, Paderborn University, Germany

Wavelength is a characteristic property of light, the study of which is a crucial technique in many areas of physics. However, measuring wavelength at the single-photon level is a challenging task. Superconducting detectors have shown excellent single photon counting capabilities, however they are typically broadband devices. We aim to combine the advantages of superconducting single-photon detectors with spectrally selective elements at the microscale under cryogenic operating conditions. Using 3D lithography, we fabricated an array of Fabry-Pérot etalons that encodes the spectral information of incident light by generating a unique transmission pattern. By measuring these transmission spectra with superconducting nanowire single-photon detectors, we demonstrated functionality at the single-photon level. The combination of the etalon array with superconducting detectors will therefore enable a reconstructive single-photon spectrometer that can be operated in the near-infrared wavelength range.

Q 60.4 Fri 11:45 A320

Noise characterization of crystalline AlGaAs coatings for ultra-stable optical resonators — •Chun Yu Ma[1], Jialiang Yu[1], Sofia Herbers[1], Thomas Legero[1], Daniele Nicolodi[1], Fritz Riehle[1], Steffen Sauer[2], Dhruv Kedar[3], John M. Robinson[3], Eric Oelker[4], Jun Ye[3], and Uwe Sterr[1] — [1]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany — [2]Institut für Halbleitertechnik and LENA, Technische Universität Braunschweig, Germany — [3]JILA, NIST and University of Colorado, Boulder, Colorado, USA — [4]University of Glasgow, UK

Brownian thermal noise of highly reflective dielectric coatings fundamentally limits the frequency stability of state-of-the-art ultra-stable lasers. Crystalline AlGaAs mirror coating with low mechanical loss is a promising candidate to reduce this limit. However, our recent measurements at cryogenic temperatures have shown novel noise sources in AlGaAs mirrors beyond their thermal noise level [J. Yu et al., arXiv:2210.15671 (2022) and D. Kedar et al., arXiv:2210.14881 (2022)].

In this work, we present a new investigation on the novel noise sources in AlGaAs mirrors in a room temperature ultra-stable resonator and give an update on our measurement at cryogenic temperatures. Our work provides insight into the predicted and actual noise limits set by these coatings.

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Q 60.5 Fri 12:00 A320

Spectral tailoring of quasi-phase-matched nonlinear processes in Ti:LiNbO$_3$ waveguides using microheaters — •Jonas Babai-Hemati, Felix vom Bruch, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Nonlinear optical conversion processes, such as second harmonic generation (SHG) or parametric down-conversion are at the heart of many quantum optic applications. Various efficient devices have been demonstrated using periodically poled Ti-indiffused waveguides in LiNbO$_3$ (PPLN). Their performance, however, is often limited by inhomogeneities induced by an imperfect fabrication. We demonstrate that this problem can be mitigated by counteracting the inhomogeneities by a distinct temperature profile along the waveguide. Here, we theoretically and experimentally investigate a cascade of microheaters, inducing specifically tailored temperature profiles to improve the performance of an SHG-process. With an optimized temperature profile, we could modify the phase-matching resulting from nonuniform domain inversion or varying waveguide cross-section towards ideal spectra. Furthermore, our method also opens new possibilities to tailor spectra of nonlinear optical processes, allowing for highly efficient and tuneable generation of single photons.

Q 60.6 Fri 12:15 A320

Cryogenic Integrated Nonlinear Optics in Lithium Niobate — •Nina Amelie Lange, Jan Philipp Höpker, Maximilian Protte, Dominik Kostiuk, and Tim J. Bartley — Institute for Photonic Quantum Systems, Paderborn University, Germany

We demonstrate the operation of a nonlinear waveguide at cryogenic temperatures. We investigate the cryogenic performance of Second Harmonic Generation (SHG) and Spontaneous Parametric Down-Conversion (SPDC) in a titanium-indiffused periodically poled lithium niobate waveguide. We show that the nonlinear performance behaves as expected and we can describe the temperature dependent changes very well. Although we change the operation temperature by nearly two orders of magnitude, the SHG process and the SPDC single-photon source remain fully functional.

While SHG and SPDC are typically investigated under ambient conditions, we show that our nonlinear waveguide is compatible with the demanding operation conditions of cryogenic integrated components. The realization of the cryogenic nonlinear processes paves the way for developing novel integrated quantum experiments, for example by combining SPDC sources together with superconducting detectors.

Q 60.7 Fri 12:30 A320

Tunable niobium-based plasmonic superconducting photodetectors for the near- and mid-IR — •Sandra Mennle, Philipp Karl, Monika Ubl, Ksenia Weber, Pavel Ruchka, Mario Hentschel, Philipp Flad, and Harald Giessen — 4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

In the last few years, photon-based applications such as quantum technologies have become a growing field of research. In particular, highly sensitive photodetectors in the near- and mid-IR spectral range are of high importance. Superconducting nanowire single photon detectors, utilizing the resistivity change during the transition from the superconducting to the normal conducting phase, have great potential due to their high efficiency and sensitivity.

To enhance the absorption at larger wavelengths in the IR spectral range, a plasmonic perfect absorber geometry can be used, which utilizes an impedance-matched plasmonic resonance in combination with a spacer layer and a reflector.

In this work we present detectors which reach an absorption of over 95% for wavelengths up to 4 μm. In contrast to cavities, our approach exhibits angle independence, thus high-NA optics can be used to decrease the spot size, resulting in even smaller detector areas and therefore faster response.

Another advantage of the plasmonic approach is the large bandwidth. Furthermore, with simple changes of the geometry the resonance can be easily tuned over a wide spectral range.