Q 10: Quantum Technologies – Photon Detectors and Sources

Time: Monday 17:00–19:00 Location: P 5

Q 10.1 Mon 17:00 P 5

Photon-number resolved characterization of a type-II SPDC light source — •Umair A. Mir[1,2], Oskar Kohout[1,2], Carlos Sevilla[1,2], and Fabian Steinlechner[1,2] — [1]Institute of Applied Physics IAP, Friedrich Schiller University, Jena, Germany — [2]Fraunhofer Institute of Applied Optics and Precision Engineering IOF, Jena, Germany

Squeezed light sources have become important resources for applications in quantum information processing areas. Spontaneous parametric down conversion (SPDC) is the most widely used method to generate squeezed states of light. In a type-II SPDC process, the signal and idler photons are orthogonally polarized, and when they are of the same wavelength, the output state corresponds to a two-mode squeezed vacuum (TMSV) state. The signal and idler modes are then perfectly correlated and entangled in the photon-number basis, which can be directly probed via joint photon statistics (JPS) measurements using a photon-number-resolving (PNR) detector. In this work, we measure JPS of type-II apktp and ppktp crystals serving as SPDC sources using a commercially available PNR detector with up to four photon resolution. From the measured statistics, we estimate the overall squeezing gain and transmission losses via a loss model that minimizes the deviation between simulated and experimental JPS, providing an alternative characterization method to conventional homodyne detection. Furthermore, we discuss how JPS measurements can offer insights into the spectral composition of more general SPDC-generated light, where each spectral mode corresponds to an independent TMSV state.

Q 10.2 Mon 17:15 P 5

Spectro-Temporal Study of Photon Pairs from a Lithium Niobate Waveguide Resonator — •Stefan Kazmaier and Kaisa Laiho — Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Quantentechnologien, Wilhelm-Runge-Straße 10, 89081 Ulm

Lithium niobate is one of the most widely used platforms for generating photon pairs, usually called signal and idler, via parametric down-conversion (PDC). Here we characterize a commercially available type-II periodically-poled lithium niobate waveguide (PPLN-WG) with highly reflecting end-facets forming a resonator at the PDC wavelengths. We measure conventional key figures of merit of our PDC source, including the coincidence-to-accidentals ratio (CAR), Klyshko efficiencies, and the temporal profile of signal and idler. Furthermore, by independently measuring the optical path length difference of signal and idler, we additionally extract the phasematching bandwidth, the group delay, and the resonators cluster spacing [1]. These results provide a comprehensive performance assessment of the device and support its use in quantum optics and integrated photonics applications.

[1] Kazmaier and Laiho, Phys. Scr. 100, 081502 (2025).

Q 10.3 Mon 17:30 P 5

Extracting pairs of time-bin entangled photons from resonance fluorescence — •Xinxin Hu, Gabriele Maron, Luke Masters, Arno Rauschenbeutel, and Jürgen Volz — Department of Physics, Humboldt Universität zu Berlin, 10099 Berlin, Germany

Photon-photon entanglement and photon antibunching are fundamental manifestations of the quantum nature of optical light fields, but are typically regarded as distinct phenomena. Here, we experimentally demonstrate that pairs of narrow-band time-bin entangled photons can be naturally extracted from resonance fluorescence. We split the collected fluorescence of a single trapped atom on a 50:50 beamsplitter, resulting in strong temporal correlations between photons at the beamsplitter outputs. A time-bin coincidence between the two output modes then projects their state onto a maximally entangled Bell state. This entanglement is evidenced by violating the CHSH-Bell inequality as well as by reconstructing the density matrix of the photon pair. Importantly, we show that the entanglement persists both for weak and strong excitation of the emitter. Our results establish resonance fluorescence as an efficient source of time-bin entangled photon pairs, i.e., a practical and scalable resource for quantum communication and photonic quantum technologies.

Q 10.4 Mon 17:45 P 5

Deterministic single ion implantation of Er into thin film lithium niobate — •Maranatha Andalis, Reiner Schneider, and Klaus D. Jöns — Institute for Photonic Quantum Systems (PhoQS), Center for Optoelectronics and Photonics Paderborn (CeOPP) and Department of Physics, Paderborn University, 33098 Paderborn, Germany

Incorporating rare-earth ions (REIs) into lithium niobate-on-insulator (LNOI) is of great interest for scalable photonic integrated circuits (PICs), as it enhances the functionality of LNOI with the unique properties offered by REIs. Erbium ions can be introduced into LNOI through ion implantation, enabling device operation at telecom wavelengths. In our setup, the ion implanter achieves an 85% implantation efficiency using secondary electron emission detection for single ion Er implantation into LNOI. The results presented here provide an overview of the most recent advancements in this topic.

Q 10.5 Mon 18:00 P 5

Narrowband frequency-entangled photon source based on a whispering gallery resonator — •Yen-Ju Chen[1,2], Sheng-Hsuan Huang[1,2], Thomas Dirmeier[1,2], Kaisa Laiho[3], Dmitry V. Strekalov[2], Andrea Aiello[2], Gerd Leuchs[1,2], and Christoph Marquardt[2,1] — [1]Chair of Optical Quantum Technologies, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstrasse 7/A3, 91058, Erlangen, Germany — [2]Max Planck Institute for the Science of Light, Staudtstrasse 2, 91058 Erlangen, Germany — [3]German Aerospace Center (DLR e.V.), Institute of Quantum Technologies, Wihelm-Runge-Str. 10, 89081, Ulm, Germany

Frequency-entangled photons have emerged as a powerful tool for advancing quantum technologies, such as sensing. While the generation of highly-nondegenerate frequency-entangled photons have been achieved using non-resonant parametric down-conversion (PDC), the realization of narrowband frequency-entangled states remains an experimental challenge due to the complexity associated with the optical cavity design and control. In this work, we report the realization of a highly-nondegenerate frequency-entangled photon source based on resonant PDC in a whispering gallery resonator (WGR). This approach overcomes existing limitations by leveraging total internal reflection within spherical geometries. Moreover, this WGR device facilitates the generation of a high-brightness photon source, further enhancing its use for quantum applications.

Q 10.6 Mon 18:15 P 5

Synchronizing the generation of SPDC photons with a storage loop — •Xavier Barcons Planas[1,2], Helen M. Chrzanowski[2], Siavash Qodratipour[2], Fuad Haddad[1,3], Zora Kutz[1,3], and Janik Wolters[1,3,4,5] — [1]German Aerospace Center, Berlin, Germany — [2]Humboldt-Universität zu Berlin, Berlin, Germany — [3]Technische Universität Berlin, Berlin, Germany — [4]Einstein Center Digital Future, Berlin, Germany — [5]AQLS UG (haftungsbeschränkt), Berlin, Germany

Heralded spontaneous parametric down-conversion (SPDC) is one of the most mature techniques for producing pure single photons. Despite the probabilistic nature of SPDC photon-pair generation, parallelization of photon creation events through multiplexing can boost the probability of photon generation [1]. In the temporal degree of freedom, a switchable loop storage cavity has been studied [2,3]. Here, we present a monolithic cavity heralded SPDC single-photon source [4] and demonstrate time-multiplexed photon synchronization using a fiber optical storage loop. The achieved low loop roundtrip loss (<12%) and synchronization across 20 time bins result in substantial enhancements in the n-photon synchronized rates, while the multiphoton contamination increases only slightly. This approach is therefore promising for photonic quantum information processing.

[1] E. Meyer-Scott et al., Rev. Sci. Instrum. **91**, 041101 (2020)
[2] T. Pittman et al., Phys. Rev. A **66**, 042303 (2002)
[3] F. Kaneda et al., Optica **2**, 1010 (2015)
[4] X. B. Planas et al., (in preparation)

Q 10.7 Mon 18:30 P 5

Reducing Dark Counts in SNSPDs through Optical Shielding Designs and an On-Chip SiN Polarisation Beam Splitter within the MultiQomm Project — •César Bertoni Ocampo[1,2,3], Connor A. Graham-Scott[1,2,3], Janis

Averbeck[1,2,3], and Carsten Schuck[1,2,3] — [1]Department for Quantum Technology, University of Münster — [2]Center for NanoTechnology - CeNTech, Münster — [3]Center for Soft Nanoscience - SoN, Münster

Photonic integrated circuits (PIC) hold great potential for realizing scalable architectures for future quantum networks, as they allow for realizing single-photon counting, routing and state discrimination on reproducible chips. However, low-noise detection and polarization management present important practical challenges on otherwise well established nanophotonic platforms, such as silicon nitride (SiN) on insulator. Here we report on the integration of superconducting nanowire single photon detectors (SNSPDs) with SiN-waveguides that approach < 1 cps dark count rate through locally shielding dedicated areas of a PIC. Moreover, we develop nanophotonic devices that allow for distinguishing transverse electric and magnetic polarization with > 15 dB extinction ratio and straightforwardly integrate with SNSPDs and polarization-agnostic 3D-printed fiber-chip interfaces. Making polarization sensitive nanophotonic functionalities and single photon detectors with low dark count rate available on SiN-PICs enables novel realizations of quantum key distribution receivers and quantum communication systems.

Q 10.8 Mon 18:45 P 5

Generation of polarization-entangled Bell states in monolithic photonic waveguides by leveraging intrinsic crystal properties — Trevor Vrckovnik[1,2], Dennis Arslan[1], Falk Eilenberger[1,2], and •Sebastian Schmitt[1,2] — [1]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany — [2]Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, Albert-Einstein-Str. 15, 07745 Jena, Germany

Advanced photonic quantum technologies-from quantum key distribution to quantum computing-require on-chip sources of entangled photons that are both efficient and scalable. This theoretical study demonstrates the generation of polarization-entangled Bell states in structurally simple waveguides by exploiting intrinsic nonlinear-crystal properties, eliminating the need for elaborate phase-matching schemes based on spatial modulation. We derive general criteria for the second-order susceptibility tensor that enable cross-polarized photon-pair generation via spontaneous parametric down-conversion in single-material waveguides and categorize all birefringent, non-centrosymmetric crystal classes accordingly. Using coupled-mode theory, we numerically analyze cuboid waveguides made from lithium niobate and barium titanate. Barium titanate consistently outperforms lithium niobate, offering higher nonlinear efficiency and high concurrence over a much broader spectral range. These findings outline a practical path toward efficient, fabrication-friendly, and scalable sources of polarization-entangled photons for integrated quantum photonic circuits.