Q 17: Integrated Photonics I (joint session Q/QI)

Time: Tuesday 11:00–13:00 Location: E001

Invited Talk Q 17.1 Tue 11:00 E001

Thin-film lithium niobate waveguides for integrated quantum photonic technologies — •Francesco Lenzini[1], Emma Lomonte[1], and Wolfram Pernice[1,2] — [1]University of Muenster, 48149 Muenster, Germany — [2]Heidelberg University, 69120 Heidelberg, Germany

Lithium-Niobate-On-Insulator (LNOI) has emerged in recent years as a promising platform for integrated quantum photonic technologies because of its high-index contrast, enabling the realization of waveguides with a compact footprint, large second-order optical nonlinearity, and high electro-optic coefficient. In the first part of my talk I will give a general overview about our fabrication process for the realization of low-loss LNOI waveguide circuits, with a special focus on the development of efficient fiber-to-chip interconnects based on the use of grating couplers with a metal back-reflector. In the second part of my talk, I will instead discuss some applications in integrated quantum photonic technologies of the developed LNOI circuits. Specifically, I will present the first demonstration of an electro-optically tunable LNOI waveguide network integrated on-chip with superconducting nanowire single-photon detectors (SNSPDs), as well as the realization of high-speed programmable circuits specially designed for operation with single photons emitted by a Quantum Dot source.

Q 17.2 Tue 11:30 E001

Duty cycle errors in periodically poled $LiNbO_3$ waveguides — •Sebastian Brauner, Christof Eigner, Harald Herrmann, Lara Padberg, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics,Institute for Photonic Quantum Systems (PhoQS), Warburgerstr. 100, 33098 Paderborn, Germany

Photon pair generation and quantum frequency conversion are fundamental in quantum communication. Waveguides and specifically tailored quasi-phase matching have shown an amazing potential for future quantum communication technologies, which established material platforms as $LiNbO_3$ are about to explore. However, one often observes deviations from the expected performance, i.e. a low efficiency and distorted spectral phase-matching curves. We attribute these distortions to imperfections of the period poling. To gather a profound understanding, how such imperfections impact on the device performance, we conduct theoretical and experimental studies how duty cycle errors affect the conversion characteristic.

Q 17.3 Tue 11:45 E001

Ultrabright and narrowband intra-fiber biphoton source at ultralow pump power — •Alexander Bruns[1], Chia-Yu Hsu[1,3], Sergiy Stryzhenko[1,2], Enno Giese[1], Leonid Yatsenko[2], Ite Yu[3,4], Thomas Halfmann[1], and Thorsten Peters[1] — [1]TU Darmstadt, Germany — [2]National Academy of Science of Ukraine, Kyiv, Ukraine — [3]National Tsing Hua University, Hsinchu, Taiwan — [4]Center for Quantum Technology, Hsinchu, Taiwan

Nonclassical photon sources of high brightness are key components of quantum communication technologies. We here demonstrate the generation of narrowband, nonclassical photon pairs by employing spontaneous four-wave mixing in an optically-dense ensemble of cold atoms within a hollow-core fiber.

The brightness of our source approaches the limit of achievable generated spectral brightness at which successive photon pairs start to overlap in time. For a generated spectral brightness per pump power of up to 2×10^9 pairs/(s MHz mW) we observe nonclassical correlations at pump powers below 100 nW and a narrow bandwidth of $2\pi \times 6.5$ MHz. In this regime we demonstrate that our source can be used as a heralded single-photon source. By further increasing the brightness we enter the regime where successive photon pairs start to overlap in time and the cross-correlation approaches a limit corresponding to thermal statistics.

Our approach of combining the advantages of atomic ensembles and waveguide environments is an important step toward photonic quantum networks of ensemble-based elements.

Q 17.4 Tue 12:00 E001

Realisation of an integrated source for Gaussian boson sampling — Laura Padberg, •Simone Atzeni, Michael Stefszky, Kai Hong Luo, Harald Herrmann, Benjamin Brecht, Christof Eigner, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Photonic quantum computing based on Gaussian Boson Sampling (GBS) is a quickly emerging research field, whose first implementations have demonstrated the role of single-mode squeezed states at telecom wavelength as key resources. Generally, the generation of these states relies on the process of parametric down-conversion in a nonlinear crystal, where care has to be taken to ensure that spectral correlations in the source do not lead to the generation of undesired multi-mode squeezed states. Due to its unique dispersion properties, bulk potassium titanyl phosphate (KTP) is typically employed for the generation of single-spectral-mode squeezed states at telecom wavelength. However, the performance of KTP sources will benefit from the enhanced light-matter interaction of a waveguide approach.

Here, we present the modelling, characterisation, and fabrication of a waveguide in periodically poled rubidium-doped KTP (ppRb:KTP). This system can act as a high-quality integrated source of single-mode squeezed states at telecom wavelength and can be readily employed in a GBS photonic processor.

Q 17.5 Tue 12:15 E001

Development of micro-integrated optical systems for atom-based quantum sensors — •Conrad Zimmermann, Marc Christ, and Markus Krutzik — Ferdinand-Braun-Institut (FBH), Berlin, Germany

Compact and mobile quantum sensors enable a broad range of applications in e.g. navigation and field-sensing with high sensitivity. The size and weight requirements derived from these applications place high demands on the degree of miniaturization, integration and robustness of all subsystems of such a device. Working on the physics package, we develop and qualify necessary integration technologies to realize miniaturized, ultra-stable optical systems and increase their functionality. Using these techniques, we set up a micro-integrated optical distribution system with a volume of ∼25 ml to generate a crossed beam optical dipole trap. The two high-power laser beams precisely overlap in their focal points ($\omega_0 = 32$ μm), and the system exhibits a high mechanical and thermal alignment stability. We present initial results from its operation in a cold atom experiment.

One approach to further reduce the overall size of a cold-atom based quantum sensor is to integrate optical setups within the vacuum system. We show development and qualification efforts for future in-UHV optical systems for atom trapping and manipulation.

This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Climate Action (BMWK) due to an enactment of the German Bundestag under grant numbers 50RK1978 and 50WM1949.

Q 17.6 Tue 12:30 E001

Design and Simulation of Photonic Integrated Ion Traps — •Guochun Du[1], Elena Jordan[1], Carl-Frederik Grimpe[1], Anastasiia Sorokina[2,3], Steffen Sauer[2,3], Pascal Gehrmann[2,3], Stefanie Kroker[2,3], and Tanja E. Mehlstäubler[1,4,5] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Halbleitertechnik, Technische Universität Braunschweig, Braunschweig, Germany — [3]Laboratory for Emerging Nanometrology, Braunschweig, Germany — [4]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [5]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, Hannover, Germany

Ion traps are a promising platform for realizing high-performance quantum computers and atomic clocks. To make these systems scalable, integrated photonic components for guiding and manipulating laser light on a chip scale are important. We will report on finite element simulations of our integrated ion traps. In the simulations, we examined the distortion of the potential at the position of the ion due to the openings in the electrodes for the outcouplers. Our simulations indicate that a transparent conductive coating can help to smoothen the potential. Further, we study how our traps can benefit from grating outcouplers designed with shallow angles.

Q 17.7 Tue 12:45 E001

Integrated photonics for the ATIQ quantum computer demonstrator — •Carl-Frederik Grimpe[1], Guochun Du[1], Anastasiia Sorokina[2,3], Pascal Gehrmann[2,3], Steffen Sauer[2,3], Elena Jordan[1], Tunahan Gök[4,5], Radhakant Singh[4,5], Maxim Lipkin[4,5], Pragya Sah[4,5], Stephan Suckow[4], Babita Negi[5], Stefanie Kroker[1,2,3], and Tanja E. Mehlstäubler[1,6,7] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Halbleitertechnik, Technische Universität Braunschweig, Braunschweig, Germany — [3]Laboratory for Emerging Nanometrology, Braunschweig, Germany — [4]AMO GmbH, Advanced Microelectronic Center Aachen, Aachen, Germany — [5]Chair of Electronic Devices, RWTH Aachen University, Aachen, Germany — [6]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [7]Laboratorium für Nano- und Quantenengineering, Hannover, Germany

The BMBF project "ATIQ" aims to develop reliable trapped-ion quantum computer demonstrators with more than 40 qubits and with multi-qubit gate fidelities larger than 99.5%. To make the trapped ion systems scalable, we are developing integrated photonic systems for guiding and manipulating the laser light at the chip level. In this talk, we will discuss some design considerations to make when integrating photonics in surface ion traps. Furthermore, we will discuss the characterization of the photonic elements and benchmarking of the ion trap performance.