Q 39: Poster V

Time: Wednesday 17:00–19:00 Location: Aula Foyer

Q 39.1 Wed 17:00 Aula Foyer

Simulations of Anti-Resonant Waveguiding In Hollow Core Fibers — •Lucas Kirchbach, Andreas Stute, Manfred Kottcke, and Bernd Braun — Technische Hochschule Nürnberg Georg Simon Ohm

Standard optical fibers guide light through total internal reflection in high refractive index material such as glass or polymers surrounded by low index material. Guiding light in optically dense matter however has some major disadvantages: Absorption, dispersion and Rayleigh-scattering place a lower bound to attenuation. In this work, a photonic crystal structure based on interference was studied, where light is guided in air surrounded by optical dense media. An attenuation of sub 0.1 db/km has been simulated numerically by optimizing the geometry of the fiber cross section.

Ultra low-loss optical waveguides open up many possibilities for the design of laser resonators on the one hand and optical interfaces between atoms, quantum dots, NV-centers and light sources and detectors on the other hand. Those technologies require highly efficient light-coupling that can be directed at will.

Q 39.2 Wed 17:00 Aula Foyer

Application of an integrated optical Mach-Zehnder interferometer for chemical sensing — •Johannes Schnegas[1], Karo Becker[2], Alexander Szameit[2], and Udo Kragl[1] — [1]Universität Rostock, Institut für Chemie, Rostock, Deutschland — [2]Universität Rostock, Institut für Physik, Rostock, Deutschland

Integrated optics offers a great advantage in the field of analytical chemistry to produce miniaturised optical sensors for the selective detection of analytes. An interesting sensor application are integrated optical interferometers, such as the Mach-Zehnder interferometer. This approach has been tested successfully for the concentration measurement and selective detection of proteins, gases, and DNA fragments. Real-time detection of small changes in the surrounding refractive index is possible. Most publications describe integrated optical MZI fabricated by photolithography, where the optical waveguides are made of silicon nitride or polymers. These waveguides were placed directly on a support such as silicon. In this work, an integrated optical MZI made of femtosecond laser-written near-surface waveguides is tested as a chemical sensor. The concept of near-surface waveguides as chemical sensor such as oils has already been tested. In this study, integrated optical Mach-Zehnder interferometers were tested for their ability to detect different types of analytes, with the intention of using the integrated optical interferometer for concentration measurement.

Q 39.3 Wed 17:00 Aula Foyer

Ultra high throughput single photon detection — •Sebastian Karl[1], Verena Leopold[1,2], Stefan Richter[1,2], Yury Prokazov[2], Evgeny Turbin[2], Gennady Sintotskiy[2], Dimitry Orl[3], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, FAU Erlangen Nürnberg, Germany — [2]Photonscore GmbH, Magdeburg, Germany — [3]Photonis Netherlands BV, Roden, Netherlands

Although recently there has been a tremendous push towards detectors with near unity quantum efficiencies and high timing resolution [1], the dead time of most single photon detection systems remains on the order of 30 ns. Avoiding unwanted pile-up effects this dead time limits the photon detection rate to less than 15 MHz.

We present tests of a novel single photon counting system able to detect single photons at rates exceeding 100 MHz on one single point detector. Photon detection is achieved using a multichannel-plate and a 8 mm diameter Photonis Hi-QE photocathode, reaching quantum efficiencies above 30%. A custom time to digital converter (TDC), Photonscore LINTag, is used to digitise the photon arrival times. It allows the data transfer of event rates exceeding 400 MHz per TDC via standard 10G ethernet fibre cables. At sustained photon detection rates of 100 MHz we measure a jitter of < 70 ps FWHM. Using a spinning disk optical chopper we show reliable single photon detection and timing at instantaneous rates exceeding 500 MHz.

[1] I. E. Zadeh et al., Appl. Phys Lett. 188, 190502 (2021)

Q 39.4 Wed 17:00 Aula Foyer

Towards spatial correlations of A-type stars in the blue — •Verena Leopold[1,2], Sebastian Karl[1], Jean-Pierre Rivet[3], Stefan Richter[1,2], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, FAU Erlangen, Germany — [2]Photonscore GmbH, Magdeburg, Germany — [3]Observatoire de la Côte d'Azur, Nice, France

Intensity interferometry is a reemerging astronomical imaging technique, benefiting immensely from the recent improvements in (single) photon detection instrumentation. Our goal is to perform spatial correlations of A-type stars in the blue using ultra high-rate single photon detectors. We present a setup for the C2PU telescope at the Calern observatory, Nice, France, featuring hybrid single photon counting detectors (HPDs) with which we measured successfully temporal correlations of three different stars - Vega, Altair and Deneb. In all cases the observed coherence time fits well to both the pre-calculated expectations as well as the value measured in preceding laboratory tests. The best signal to noise ratio (SNR) with a value of 10.72 is obtained for Vega for an observation time of 12.1 h. The setup showed remarkable stability and very efficient coupling of the starlight to the photo detectors, owed mainly to the large active area of the HPDs. Utilizing a new class of large area single photon detectors based on multichannel plate amplification, we estimate that high resolution spatial intensity interferometry experiments are within reach at 1 m diameter class telescopes within one night of observation time for bright stars.

Q 39.5 Wed 17:00 Aula Foyer

Effects of Pyroelectricity on the Fabrication Yield of Integrated Superconducting Detectors on Lithium Niobate — •Johanna Biendl[1], Felix Dreher[1], Maximilian Protte[1], Jan Philipp Höpker[1], Varun B. Verma[2], and Tim J. Bartley[1] — [1]Institute for Photonic Quantum Systems, Department of Physics, Paderborn University, Warburger Str. 100, 33098 Paderborn — [2]National Institute of Standards and Technology, CO 80305 Boulder, USA

Reconfigurable photonic quantum systems require a combination of integrated photon sources, modulators and detectors. The best candidates for the realization of on-chip detection are superconducting detectors due to their high efficiency, low dark count rate and good timing accuracy. For the integration of photonic devices, z-cut lithium niobate has proven as an excellent material because of its strong second-order nonlinearity and electro-optic effect. However, the pyroelectric effect causes irreversible damage to integrated superconducting detectors when cooling them down to cryogenic temperatures due to sudden discharges of fields generated by pyroelectric charges. This limits detector fabrication yield to less than 5%. To overcome this limitation we investigate different methods including coating materials, detector dimensions and shorting schemes to compensate the generated charges without constraining the functionality of integrated devices and optical waveguides.

Q 39.6 Wed 17:00 Aula Foyer

Spectral purification of spontaneous parametric down-conversion photons via spatial filtering — •Michael Schlosser[1], Ria G. Krämer[2], Julian Münzberg[1], Daniel Richter[2], Stefan Nolte[2,3], Gregor Weihs[1], and Robert Keil[1] — [1]Institut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University Jena, Albert-Einstein-Str. 15, D-07745 Jena, Germany — [3]Fraunhofer Institute for Applied optics and Precision Engineering IOF, Center of Excellence in Photonics, Albert-Einstein-Str. 7, D-07745 Jena, Germany

The application of photonic quantum technologies on a larger scale typically requires photons from independent sources to be indistinguishable. We report on a spontaneous parametric down-conversion (SPDC) source, which can simultaneously emit two photon pairs with a wavelength of 795nm. The joint spectral intensity of the pairs is measured via time-of-flight spectroscopy utilising femtosecond-laser inscribed fiber Bragg gratings as dispersive elements. The spectral purity extracted from this substantially exceeds the measured Hong-Ou-Mandel (HOM) interference visibility of 39(2)%, which suggests the presence of spatial-spectral correlations in the pump. To counter these, spatial filtering is investigated. A short single-mode fiber inserted into the pump indeed removes these correlations, increasing the

HOM visibility to 79(15)%. Alternatively, inserting a 15μm-diameter pinhole in the Fourier plane of a telescope increases the indistinguishability to 48(2)%, while providing a steady power transmission.

Q 39.7 Wed 17:00 Aula Foyer

Enhancing atom-photon interaction with integrated nanophotonic resonators — •Xiaoyu Cheng[1] and Shnirman Benyamin[1,2] — [1]5. Physikalisches Institut, Universität Stuttgart — [2]Institut für Mikroelektronik Stuttgart (IMS-Chips)

We study hybrid devices consisting of thermal atomic vapor and nanophotonic structures for manipulating the interaction between atoms and photons.

We exploit cooperative effects to develop a compact, on-demand and highly efficient single-photon-source using the Rydberg blockade effect. In order to excite Rb atoms to the Rydberg states efficiently, the corresponding light field is locally enhanced by ultralow-loss microring resonators. Due to the large spatial extent of Rydberg atoms, we carefully design the ring resonators to realize sufficient interactions between Rydberg atoms and the evanescent field from the resonator. In order to create individual photons deterministically, we use the Four-Wave-Mixing (FWM) process in the Rydberg blockade regime inside a thermal vapor cell to develop a single-photon-source at room temperature.

To realize this goal, it is necessary to study Rydberg excitation in photonic integrated vapor cells. We excite and detect Rydberg excited Rb atoms with tapered, freestanding waveguides. Tapered narrow waveguides push out evanescent field that enables the excitation of Rydberg atoms. A specially designed, electric circuit patterned vapour cell and a transimpedance amplifier enables electric read out of single Rydberg excitation.

Q 39.8 Wed 17:00 Aula Foyer

Fabrication of polymer multimode-waveguides with maskless lithography for quantum sensing applications. — •Lena Middel, Tjorven Annika Husmann, Sreelakshmi Sathyan Kizhekayil, Jonas Homrighausen, and Markus Gregor — Department of Engineering Physics, University of Applied Sciences, Muenster

In the world of integrated quantum optics, multimode waveguides usually represent a niche, as singlemode waveguides enable on-chip processing of light. As the production of single mode waveguides is challenging in amounts of time, equipment and cost, our approach is to use multimode waveguides on applications that do not nessecarily require single mode waveguides. One such applications is quantum sensing using solid-state defects, such as the NV-center in diamond, which can be embedded in the waveguide to read out the spin dependent fluorescence [1]. Consequently, the aim of our work is the fabrication of dielectric ridge waveguides for structuring of SU-8. This epoxy-based negative photoresist is an excellent material with high and broadband optical transmission, high aspect ratio and good mechanical, thermal and chemical stability. For prototyping, we use a maskless lithography system, that is equipped with a digital micromirror device to project the image, leaving room for adjustment of exposed structures. This work paves the way for a more efficient and scalable production of waveguides for quantum sensing applications without the need for highly sophisticated equipment.

[1] P. P. Schrinner et al., (2020). Nano Letters, 20(11), 8170-8177.

Q 39.9 Wed 17:00 Aula Foyer

Higher Order Mode Supercontinuum Generation Through Nano-Printed Meta-Fiber — •Shahrzad Hosseinabadi, Mohammadhossein Khosravi, Matthias Zeisberger, Torsten Wieduwilt, and Markus Schmidt — Leibniz IPHT, Jena, Germany

Optical fibers, with their unique light guiding properties, have transformed modern society. Besides the common fundamental mode, fibers also support higher-order modes (HOMs), gaining attention for different applications. In nonlinear frequency conversion research, HOMs play a crucial role, offering access to unique dispersion landscapes. This enables applications such as broadband supercontinuum generation and exploration of novel nonlinear effects. However, efficiently exciting or converting HOMs poses a challenge due to the need for precise matching of modal properties, especially in nonlinear photonics. Current approaches, like spatial light modulators and waveplates, have limitations such as being costly, poorly integrated, and require extensive computer control and additional alignment. A promising solution involves dielectric nanostructures, specifically holograms and metasurfaces, offering unprecedented beam shaping capabilities with minimal losses. These approaches, based on well-designed flat elements, successfully modify intensity, phase distributions, and polarization, opening up possibilities for various applications. Our study focuses on investigating the potential of efficiently HOMs in nonlinear optical fibers. By leveraging technology of diffractive lenses, we aim to enhance the performance of HOMs, by proposing a highly integrated device for nonlinear photonics applications.

Q 39.10 Wed 17:00 Aula Foyer

Temperature Adaptable Supercontinuum Generation in Liquid-filled Fibers by Using Particle Swarm Optimization — •Johannes Hofmann, Ramona Scheibinger, and Markus A. Schmidt — Leibniz-Institute of Photonic Technology, Jena, Germany

Light sources in the IR regime with high spectral density and coherence are of great interest for e.g. spectroscopic approaches in life and environmental science. Supercontinuum (SC) generation due to nonlinear broadening of laser pulses in optical fibers with suitable dispersion profiles can meet the requirement of application specific spectral properties. Liquid-filled fibers offer the opportunity to modify the output spectra by temperature changes due to their large thermo-optic coefficient. Higher-order modes excited in CS2-filled step index fibers exhibit two zero-dispersion wavelengths (ZDW) which strongly shift with temperature. Pumping within the anomalous dispersion regime, the soliton dynamics can be modified and dispersive waves shift. In contrast to other methods of dispersion variation, such as varying the fiber geometry, controlling the temperature is not static, but highly variable. In addition, using a suitable optimization algorithm, such as Particle Swarm Optimization (PSO) the spectral output features can be tuned to desired SC properties, e.g., maximizing the spectral intensity at one or more targeted wavelengths. Here, we investigate and shape the spectral evolution along a liquid-core fiber by applying a PSO to numerical SC generation simulations. Additionally, we present a automated experimental concept to achieve thermodynamic control of the fiber, leading to an adaptable output spectrum.

Q 39.11 Wed 17:00 Aula Foyer

Higher Order Mode Supercontinuum Generation Through Nano-Printed Meta-Fiber — •Shahrzad Hosseinabadi, Mohammadhossein Khosravi, Matthias Zeisberger, Torsten Wieduwilt, and Markus Schmidt — Leibniz Institute of Photonic Technology, Jena, Germany

Optical fibers, with their unique light guiding properties, have transformed modern society. Besides the common fundamental mode, fibers also support higher-order modes (HOMs), gaining attention for different applications. In nonlinear frequency conversion research, HOMs play a crucial role, offering access to unique dispersion landscapes. This enables applications such as broadband supercontinuum generation and exploration of novel nonlinear effects. However, efficiently exciting or converting HOMs poses a challenge due to the need for precise matching of modal properties, especially in nonlinear photonics. Current approaches, like spatial light modulators and waveplates, have limitations such as being costly, poorly integrated, and require extensive computer control and additional alignment. We explore the use of dielectric nanostructures specifically holograms and metasurfaces for advanced beam shaping with minimal losses. Our study specifically investigates the efficient utilization of HOMs in nonlinear optical fibers. Leveraging diffractive lenses technology, we aim to enhance HOMs' performance, proposing a compact integrated device for nonlinear photonics applications.

Q 39.12 Wed 17:00 Aula Foyer

TOWARDS CRYOGENICALLY COMPATIBLE MICROPHOTONIC QUANTUM INTERFACES — •Tuncay Ulas[1,2,3], Lasse Irrgang[1,2,3], and Ralf Riedinger[1,2,3] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Deutschland — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany — [3]Institut für Quantenphysik, Universität Hamburg, 22761 Hamburg, Deutschland

Quantum technologies are increasingly capturing the interest of researchers. These technologies rely on quantum physical operations applied to qubits. In our research group, we develop interfaces between cryogenic ion traps and optical fibers. Specifically, we are working on a cryogenic test station to assess the compatibility of the interface architectures.

Q 39.13 Wed 17:00 Aula Foyer

Sub-20ps-Jitter synchronisation of remote Time-to-Digital-

Converters (TDC) — •Stefan Richter[1,2], Verena Leopold[1,2], Sebastian karl[1], and Joachim von Zanthier[1] — [1]Quantum Optics and Quantum Information, FAU Erlangen Nürnberg, Germany — [2]Photonscore GmbH, Brenneckestr. 20, 39118 Magdeburg

With the emergence of various scientific applications of single-photon counting, such as intensity interferometry or quantum key distribution, measuring photons with high temporal precision at spatially distributed locations has become essential. To achieve this goal, signal capture must be executed using distributed time-to-digital converters (TDCs) that are synchronized to share a common time base with a constant offset to the TAI time. Ideally, the jitter of the synchronization should be on the order of the TDC jitter or lower. In our presentation, we demonstrate test measurements using a White Rabbit LEN system that employs PTP over standard telecommunication fibers along with self-developed TDCs. These tests show a synchronization RMS jitter of less than 20 ps for a link length of 50m. Although this value is larger than the jitter of the TDCs themselves, it does not exacerbate the overall jitter of the single photon detection system, as the MCP-based detectors have an RMS jitter of around 30 ps. Additionally, we have recorded temporal correlation measurements of single photons using White Rabbit synchronized TDCs, proving the high accuracy and precision of this approach for intensity interferometry use cases.

Q 39.14 Wed 17:00 Aula Foyer

Sensitivity optimization of diamond infrared-absorption based magnetometry — •Anil Palaci[1], Julian M. Bopp[1,2], Jonas Wollenberg[1], Felipe Perona[2], and Tim Schröder[1,2] — [1]Department of Physics, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Ferdinand-Braun-Institut gGmbH, Leibniz-Institut für Höchstfrequenztechnik, 12489 Berlin, Germany

Negatively charged nitrogen vacancy (NV) color centers in diamond serve as excellent sensors for magnetic fields, electric fields, and temperature. By utilizing their spin-state dependent photoluminescence or absorption, NV centers enable the precise measurement of various physical and biological signatures under ambient conditions.

In this work, we exploit the NV center's infrared (IR) ${}^1E \leftrightarrow {}^1A_1$ transition for absorption-based magnetometry. Using a 1042 nm laser to probe the IR transition allows for magnetic field-dependent absorption. The high saturation intensity of the IR transition enables the use of high-intensity probe light, improving sensitivity limited by shot noise. However, due to the IR transition's low absorption crosssection, the implementation of a lock-in amplifier becomes necessary. To further enhance sensitivity, we optimize experimental parameters and settings of the lock-in amplifier. With the achieved sensitivity improvement, integration into highly sensitive compact systems becomes feasible without bulky optical setups.

Q 39.15 Wed 17:00 Aula Foyer

Microcontroller-optimized measurement electronics for NV-centers — •Dennis Stiegekötter[1], Jens Pogorzelski[1], Ludwig Horsthemke[1], Markus Gregor[2], and Peter Glösekötter[1] — [1]Department of Electrical Engineering and Computer Science, FH Münster University of Applied Sciences, Stegerwaldstraße 39, 48565 Steinfurt, Germany — [2]Department of Engineering Physics, FH Münster University of Applied Sciences, Stegerwaldstraße 39, 48565 Steinfurt, Germany

The integration and miniaturization of magnetic sensors based on diamonds with nitrogen vacancy centers is largely focused on the sensor tip. This means that the underlying electronics for excitation and readout of the spin states still offers great potential for further innovations. In this work the electronics adjust the power of the microwave. This makes it possible to tune the Rabi oscillation so that the time for a pi pulse is adapted to the microcontroller's limited temporal pulse resolution of Tp,min = 53.3 ns. This allows coherent control to be achieved even with a simple microcontroller. For this purpose, laboratory devices such as lock-in amplifier, photodetector and microwave source are broken down to their relevant functions and integrated on a (82 x 167) mm2 PCB with a STM32G491. Only two Rabi oscillations at different microwave powers need to be recorded in order to extract the Rabi frequency using the fast fourier transformation and calibrate the system. This allows the time of a pi pulse to be synchronized to the pulse length of the microcontroller.

Q 39.16 Wed 17:00 Aula Foyer

Diamond-based quantum sensing for neurosurgery — •Wickenbrock Arne — Johannes Gutenberg University Mainz, Germany

The DIAQNOS (Diamond-based quantum sensing for neurosurgery) project aims to develop a novel Quantum-Neuro Analyzer (QNA) to provide continuous and crucial information for tumor detection and functional diagnostics during neurosurgical procedures. The project utilizes diamond-based quantum sensors for preclinical studies on living human brain tissue. The goal is to implement a clinically deployable DIAQNOS-QNA, an imaging, magnetically sensitive quantum endoscope at the end of a multimodal light guide. This technology is intended to enhance the safety, precision, and efficiency of neurosurgical cancer therapy.