Q 39: Quantum Optics & Nano-Optics

Time: Wednesday 14:30–16:30 Location: F342

Q 39.1 Wed 14:30 F342

Ultra-small superconducting Nb-based plasmonic perfect absorbers single mode fiber coupled photodetectors — •Philipp Karl[1], Sandra Mennle[1], Monika Ubl[1], Ksenia Weber[1], Pavel Ruchka[1], Mario Hentschel[1], Philipp Flad[1], Jing-Wei Yang[2,3], Tzu-Yu Peng[2,3], Yu-Jung Lu[2,3], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan — [3]Department of Physics, National Taiwan University, Taipei 10617, Taiwan

Quantum technologies require high-quality and efficient photodetectors and the ability to detect single photons, which can be provided by superconducting nanowire single photon detectors.

In this work, we present a superconducting niobium-based plasmonic perfect absorber detector and utilize the tunable plasmonic resonance to create a photodetector with near-100% absorption efficiency in the near-infrared spectral range. To reach the near-100% absorption, we take advantage of resonant plasmonic perfect absorber effects. This leads to an angle insensitivity and a high resonant absorption cross-section, which enable ultra-small active areas and short recovery times.

The ultra-small active areas are aided by a directly coupled single mode fiber in combination with high NA micro optics, which are printed onto the fiber.

Q 39.2 Wed 14:45 F342

Frequency Conversion in pressurized Hydrogen — •Alireza Aghababaei — Nussallee 12, 53115 Bonn, Deutschland

State-preserving frequency conversion in the optical domain is a necessary component in many configurations of quantum information processing and communication. Thus far, nonlinear crystals are used for this purpose. Here, we report on a new approach based on coherent anti-Stokes Raman scattering (CARS) in dense molecular hydrogen gas. This four-wave mixing process sidesteps the limitations imposed by crystal properties, it is intrinsically broadband and does not generate an undesired background. We demonstrate this method by converting photons from 434 nm to 370 nm and show that their polarization is preserved.

Q 39.3 Wed 15:00 F342

Low-noise quantum frequency conversion of single photons from silicon-vacancy centers in diamond to the telecom C-band — •Marlon Schäfer, Benjamin Kambs, Tobias Bauer, Dennis Herrmann, David Lindler, and Christoph Becher — Universität des Saarlandes, Fachrichtung Physik, Campus E2 6, 66123 Saarbrücken

The vast majority of systems suitable as a quantum emitter for quantum communications show optical transitions in the visible or near infrared spectral region. Therefore, quantum frequency conversion (QFC) into low-loss telecom bands is the key enabling technology for long-range fiber-based quantum networks. Here, in addition to achieving high conversion efficiencies, the key issue is to minimize the conversion-induced noise photons in the target band. Especially conversion schemes that require a mixing wavelength in the vicinity of the target wavelength lead to high noise counts. A promising quantum emitter affected by this is the silicon-vacancy (SiV) center in diamond, where direct conversion to 1550 nm implies a mixing wavelength at 1405 nm, thus resulting in strong Raman and SPDC noise.

We present an efficient and low-noise QFC device converting SiV photons into telecom C-band. In a two-stage conversion process, the photons are first converted to an intermediate wavelength and then transduced to the target wavelength. This greatly increases the spectral distance between the mixing and the target wavelength, leading to very low noise rates of less than 1 photon/s/GHz. We discuss current limitations and applicability to other platforms such as SnV centers.

Q 39.4 Wed 15:15 F342

Towards interfacing a multiplexed warm vapor quantum memory with single photons from cavity enhanced spontaneous parametric down-conversion — •Leon Messner[1,2], Elizabeth Robertson[2,3], Luisa Esguerra[2,3], Helen Chrzanowski[2], and Janik Wolters[2,3] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institute of Optical Sensor Systems, Berlin, Germany — [3]Technische Universität Berlin, Institut für Optik und Atomare Physik, Berlin, Germany

Recent investigation [1] shows that a significant speed-up in intercontinental quantum key distribution is achievable by having quantum memories with on the order of 10^3 randomly accessible storage modes. We present our latest results on a spatially multiplexed warm vapor EIT memory [2] with the ability to scale beyond this number, while having modest technological requirements. In future, this will allow isolated deployment away from laboratory infrastructure and facilitate remote operation on satellites and similarly insular locations. To gain a deeper understanding of the challenges presented by integrating these memories into quantum networks, we are planning to interface them with single photons generated by spontaneous parametric down-conversion inside a monolithic cavity [3,4].

[1] Wallnöfer, J. et al., Commun Phys **5**, 169 (2022)
[2] Esguerra, L. et al., arXiv:2203.06151 **[quant-ph]** (2022)
[3] Mottola, R. et al., Optics Express **28**, 3159-3170 (2020)
[4] Buser, G. et al., PRX Quantum **3**, 020349 (2022)

Q 39.5 Wed 15:30 F342

Two-Step Frequency Conversion from 637nm to telecom wavelengths in a PPLN waveguide — •Joscha Hanel — AG Nanooptik, Humboldt-Universität zu Berlin — AG Ding, ATMOS, Leibniz Universität Hannover

In the future, the reliable on-demand generation of single photons at telecommunication wavelengths will be an essential tool in mid- to long-range quantum communication networks. However, many known single photon sources operate at wavelengths in the visible or near-infrared, where transmission in telecommunication fibers is far from optimal. A promising technology to bridge this wavelength gap is quantum frequency conversion. In this talk, a novel device is presented that was designed to convert light from 637nm to telecommunication wavelengths using difference frequency generation (DFG). The heart of the device is a periodically poled LiNbO3 waveguide with two poling sections, allowing two consecutive DFG steps in a single waveguide using just one pump laser. While comparable one-step conversions have been performed in the past (e.g. Dréau et al., Phys. Rev. Applied 9, 064031 (2018)), this two-step approach promises a far better signal-to-noise ratio while keeping coupling losses minimal.

Q 39.6 Wed 15:45 F342

Quantum light source based on two-photon interferences — •Martin Cordier, Max Schemmer, Philipp Schneeweiss, Jürgen Volz, and Arno Rauschenbeutel — Department of Physics, Humboldt-Universität zu Berlin, 10099 Berlin, Germany

The transmission of coherent light through an optically dense ensemble has wide applications ranging from biology to chemical spectroscopy. Since the 18th century it has been commonly described by Beer-Lambert's law. Recently, it has been shown that, the light transmitted through an ensemble of two-level emitters is violated due to incoherent scattering at the single emitter level [1]. Here, building on the work of [2,3], we realize an interferometer that allows us to tune the quantum phase between the transmitted coherent and incoherent light fields. By tuning this phase we show interference fringes in the photon coincidence rate. Beyond clarifying the fundamental nature of what is commonly termed incoherently scattered light, our study lends itself to developing applications in quantum technologies, such as novel quantum light sources.

[1] Veyron et al., Phys. Rev. Research 4, 033033 (2022).
[2] Mahmoodian, et al., Physical Review Letters 121, 143601 (2018).
[3] Prasad et al., Nature Photonics 1 (2020).

Q 39.7 Wed 16:00 F342

Optimized integration of quantum emitters on the Silicon platform — •Lida Shamsafar[1], Thomas Weiss[1,2], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Institute of Physics, University of Graz, and NAWI Graz, Graz, Austria

Stability and environmental control during operation is one of the necessary requirements desired for quantum-technological applications. The most promising way for such control of the surrounding is the direct integration of all required components on one chip. The most advanced and versatile platform for the implementation of highly complex and scalable photonic logic is the silicon platform. In this work, we utilize and optimize designs of photonic cavities in order to obtain high coupling efficiencies of quantum emitters to silicon waveguides. We will discuss how quantum emitter positioning will modify the light-matter interaction and how we can achieve best performance. Furthermore, radiation diagrams of TE and TM modes for the guided modes and free space modes are investigated in order to reduce radiative losses and maximize the coupling to the waveguides.

Q 39.8 Wed 16:15 F342

Single Mode Coupled Emission of Resonant Excited GaAs Quantum Dots — •Martin Kernbach[1,2], Julian Siller[1], Sophia Fuchs[1], and Andreas W. Schell[1,2] — [1]Leibniz Universität Hannover, Deutschland — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland

Quantum technologies like computing, QKD, or sensing demand for deterministic bright sources of single indistinguishable photons. In order to provide quantum light of isolated systems properly usable for quantum information science, an efficient excitation and extensive collection in a single mode is required. Single molecules and cavity confined quantum dots are convenient sources. The coupling to the excited state is maximized on resonance, but challenges the usability of the emitter due to the costs for the separation of the optical excitation mode from the mode of emission. A temporal, spacial, spectral, or combined method for separation is typically used. Here we present a realization of a single emitter under resonant excitation in a confocal setup coupled into a single mode fiber with the emission mode filtered by polarization. So far, a free beam is directed on the objective mounted with the scanning stages on a 1 m long stick in a liquid helium reservoir. For resonant cw excitation of GaAs semiconductor quantum dots a SNR of polarization suppression up to 100 and count rates of 280 kcps are archived by using a collecting lens with NA 0.68 only. Under this scheme further investigations regarding the blinking behavior are possible as well as probing alternative emitters like single molecules.