QI 44: Quantum Technologies (Detectors and Photon Sources) (joint session Q/QI)

Time: Friday 14:30–16:15 Location: AP-HS

QI 44.1 Fri 14:30 AP-HS

Niobium-based plasmonic superconducting photodetectors for IR — •Sandra Mennle[1], Philipp Karl[1], Monika Ubl[1], Pavel Ruchka[1], Heidemarie Schmidt[2], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Germany — [2]Leibniz Institute of Photonic Technology, Albert-Einstein-Str. 9, 07745 Jena, Germany

In the last decade photon-based quantum technologies have become a fast-growing field of research, which requires fast and reliable detectors. Moreover, applications in the mid-IR like spectroscopy or astronomic photography are in need for highly efficient photodetection. For these applications superconducting nanowire photon detectors feature a great potential due to their high efficiency and sensitivity.

To enhance the absorption at larger wavelengths in the IR spectral range, we are using a plasmonic perfect absorber geometry to match the optical impedance of the detector to the incident light and to suppress any reflection. By design plasmonic resonances feature a large bandwidth, polarization sensitivity and can easily be spectrally tuned.

We present detectors which reach an absorption of over 95% for wavelengths up to 4 μm and demonstrate nanostructures with 90% absorption in 8-12 μm spectral range. This concept than can be extended to use not only one, but multiple detectors which then form a detector array i.e. a highly sensitive camera with plasmonically enhanced efficiency.

QI 44.2 Fri 14:45 AP-HS

Deep ultraviolet laser light for cluster interferometry — •Hannah Foltas, Richard Ferstl, Severin Sindelar, Bruno Ramírez-Galindo, Stefan Gerlich, Sebastian Pedalino, and Markus Arndt — University of Vienna, Faculty of Physics, Boltzmanngasse 5, Vienna, Austria

Matter-wave interferometry with massive nanoparticles may contribute to the understanding of the quantum-classical interface, and it can open new avenues for materials science or lithography at the nanoscale. Here we discuss the need for and recent progress in realizing a light source that can fulfill the requirements for photodepletion gratings for cluster matter-waves: A standing deep ultraviolet (DUV) light wave shall ionize metallic or dielectric nanoparticles in its antinodes by absorption of a single photon and thus form a measurement-induced diffraction grating. Ionization can be achieved if the photon energy exceeds the cluster ionization energy, which depends on the material, size and charge state of the particle. We target a wavelength below 230 nm and a photon energy of 5.4-5.5 eV, which will be sufficient to ionize clusters of vastly different density, such as sodium or gold and even insulating nanoparticles such as silicon. Starting from a TiSa laser beam at 900 - 920 nm (ca. 6 W) we first generate blue light with a power of $>$ 2.5 W behind an external cavity using an LBO crystal and a circular laser beam profile. This light is further doubled to $<$ 230 nm light in a second cavity with elliptical mode profile and using a BBO crystal. We demonstrate the usefulness of this light source in absorption tests on cluster beams.

QI 44.3 Fri 15:00 AP-HS

Ultra-small Nb-based plasmonic superconducting photodetectors arrays — •Philipp Karl[1], Sandra Mennle[1], Monika Ubl[1], Ksenia Weber[1], Pavel Ruchka[1], Mario Hentschel[1], Philipp Flad[1], Detlef Born[2], Heidemarie Schmidt[2], and Harald Giessen[1] — [1]4th Physics Institute, Research Center SCoPE, and IQST, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Leibniz Institute of Photonic Technology, Albert-Einstein-Str. 9, 07745 Jena, Germany

Applications based on quantum technologies, such as quantum computing and quantum cryptography, require precise and highly efficient photodetection. We present a superconducting plasmonic perfect absorber detector.

The absorption of our plasmonic structures can be increased by utilizing the plasmonic perfect absorber principle, to achieve up to almost 100% absorption over a wide spectral range.

In addition, our concept is compatible with meander patterns to create scalable pixelated detector arrays. We demonstrate up to 64x64 pixel designs whose spectral range can be tuned from 1 μm up to 11 μm.

QI 44.4 Fri 15:15 AP-HS

Micro-Integrated ECDL-MOPA Laser Modules for Quantum Technology Applications — •Janpeter Hirsch, Martin Gärtner, Stephanie Gerken, Nora Goossen-Schmidt, Simon Kubitza, Norbert Müller, Max Schiemangk, Dian Zou, and Andreas Wicht — Ferdinand-Braun-Institut (FBH), Berlin, Germany

We present our next generation of micro-integrated ECDL-MOPA laser modules, each operating at a specific wavelength of 689, 767, 780, 794, and 922 nm, with adaptability to other wavelengths. The 767 nm module exemplifies their performance, delivering over 350 mW of fiber-coupled output power, a FWHM linewidth below 200 kHz at 1 ms timescales, and an extended mode-hop-free tuning range exceeding 100 GHz [1].

These modules are further designed with enhanced robustness to facilitate operation on mobile platforms and in space environments [2]. We will present results of preliminary mechanical stress testing, including shock tests at accelerations beyond 1000 g, to demonstrate their resilience and reliability under extreme conditions.

We acknowledge funding from Federal Ministry of Education and Research within the funding program "Quantum technologies - from basic research to market" under grant number 13N15724 and from DLR Space Administration / Federal Ministry for Economic Affairs and Climate Action under grant numbers 50WM2152, 50WM2176, 50WM2164, 50WM21694.

[1] J. Hirsch et al., in Proc. of SPIE Vol. 12912, 129120B (2024)
[2] D. Zou et al., in CLEO 2023, JTh2A.70 (2023)

QI 44.5 Fri 15:30 AP-HS

Superconducting nanowire detection of neutral atoms & molecules via their internal and kinetic energy in the eV range, Adv. Phys. Res. DOI: 10.1002/apxr.202400133 — Marcel Strauss[1], Ronan Gourges[3], Martin F. X. Mauser[1], •Linus Kulman[1], Mario Castaneda[3], Andreas Fognini[3], Armin Shayeghi[2], Philipp Geyer[1], and Markus Arndt[1] — [1]University of Vienna, Faculty of Physics & VDSP & VCQ, Boltzmanngasse 5, A-1090 Vienna — [2]University of Vienna, Faculty of Physics & VCQ, Boltzmanngasse 5, A-1090 Vienna and Institute for Quantum Optics and Quantum Information (IQOQI) Vienna, Austrian Academy of Sciences, Boltzmanngasse 3, A-1090 — [3]Single Quantum, Rotterdamseweg 394, 2629 HH, Delft, The Netherlands

Superconducting nanowires have found many applications in photonics as single photon detectors. Here we explore their potential as quantum sensors for neutral matter at low energy. We find that they exhibit outstanding sensitivity both with regard to the detection of internal atomic excitations as well as to the impact of neutral molecules, here demonstrated for metastable atoms as well as supersonic beams of perfluorodecalin. For metastable atoms, the quantum yield of SNWDs compares well with that of secondary electron multipliers and they outperform secondary electron multipliers by orders of magnitude in the detection of neutral molecules at impact energies as low as 2 eV.

QI 44.6 Fri 15:45 AP-HS

A narrowband, decorrelated photon pair source based on a Ti:$LiNbO_3$ waveguide cavity — •Jasmin Sommer, Michelle Kirsch, Kai Hong Luo, Christof Eigner, Harald Herrmann, and Christine Silberhorn — Paderborn University, Integrated Quantum Optics, Institute for Photonic Quantum Systems (PhoQS), Warburger Str. 100, 33098 Paderborn, Germany

Many applications in quantum information processing require narrowband and spectrally pure photon pairs at telecom wavelength. We developed a source for such photon pairs exploiting cavity-enhanced parametric down conversion (PDC) in a periodically poled $LiNbO_3$ waveguide. With coated end-faces of the waveguide, a cavity is formed. The clustering due to different free spectral ranges for TE- and TM-modes leads to spectrally narrowband photon pair generation of the type II phase-matched PDC-process. To obtain decorrelated pairs, it is furthermore necessary to pump the PDC source with tailored pulses of around 775 nm wavelength with an adaptable pulse width in the nanosecond range. We designed a suitable pump source using an electro-optic modulator for pulse carving, fiber amplifiers to boost the signal and a second harmonic stage for conversion to the pump wavelength. Details on the design of the pump source as well as initial results obtained with the photon pair source will be presented.

QI 44.7 Fri 16:00 AP-HS

Investigation of AM-PM conversion noise in nonlinear extensions of a frequency comb — •Angelina Jaros[1], Mattias Misera[1], Thomas Puppe[2], Uwe Sterr[1], and Erik Benkler[1] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [2]TOPTICA Photonics AG, Lochhamer Schlag 19, 82166 Gräfelfing

An application of optical frequency combs is the transfer of frequency stability from an ultra-stable laser to the interrogation laser of an optical atomic clock. The stability transfer is limited by noise added onto the frequency comb. Its source could be the conversion of amplitude modulation (AM) of the seed comb light to phase modulation (PM) noise during the nonlinear processes employed for spectral broadening of the comb spectrum to cover the desired target wavelengths.
We investigate this AM-PM conversion in an Er:fiber fs-laser with two identical nonlinear extension branches. Single-frequency cw lasers at the fundamental and target wavelengths are employed for the generation of RF beats containing the PM. A modulator is employed to introduce AM in one branch before its nonlinear conversion stage, and the differential PM between the two wavelengths is measured after the nonlinear conversion to suppress phase noise due to path-length variations. By comparing to the second, unmodulated branch seeded by the same fundamental comb, phase noise in the seed comb and frequency noise of the cw lasers are suppressed.
The results may lead to further reduction of phase noise added by the nonlinear conversion steps in optical frequency combs.