Q 42: Laser and Laser Applications

Time: Wednesday 16:30–18:30 Location: P

Q 42.1 Wed 16:30 P

All-glass cell for Rydberg physics in hollow-core photonic crystal fibres — •Daniel Rainer Häupl[1,2], Daniel Weller[3], Robert Löw[3], and Nicolas Yann Joly[2,1] — [1]University of Erlangen-Nürnberg, Staudtstraße 7/B2, 91058 Erlangen, Germany — [2]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [3]5th Physical Institute, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We present a new type of all-glass vapour cell integrating a hollow-core photonic crystal fibre, which then can be filled with alkali metal vapour. The temperature of the cell itself and its reservoir can be independently adjusted. The small size of this cell permits both a high temperature accuracy and rapid adjustment of the temperature and respectively the atomic density. Additionally, the entire fibre is optically accessible from the side since the cell is all-glass made. In this way, analysis of the properties of the optical system does not only rely on transmission through the fibre but local fluorescence spectroscopy along the whole length of the fibre is possible. This allows us for the very first time to study the real-time diffusion of atoms in and out of the fibre by changing the atomic density of Rubidium atoms inside the vapour cell. Such measurements confirm that the fibre can be rapidly filled with Rubidium atoms. The atomic density reaches an equilibrium only after a few days, compared to months. We believe that such a cell makes an attractive tool for atomic spectroscopy, Rydberg physics and non-linear optics, as well as being much smaller than previous setups.

Q 42.2 Wed 16:30 P

Microcavity based photothermal spectroscopy — •Matthias Mader[1,2] and Theodor W. Hänsch[1,2] — [1]Ludwig-Maximilians-Universität München, Fakultät für Physik, Geschwister-Scholl-Platz 1, 80539 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Sensitive optical spectroscopy of tiny amounts of gases allows to study dynamic processes as well as processes where only small gas volumes are involved e.g. in biology or medicine. Furthermore, a small detection volumes enables miniaturization of the measurement devices making it possible to easily perform to experiments also outside the lab, e.g. for climate research.

Here, cavity-sensed photo thermal-spectroscopy is used to perform background free absorption spectroscopy. For macroscopic volumes, this technique has been shown to be extremely sensitive [1]. Combining it with microscopic fiber-based high-finesse Fabry-Pérot cavities [2] allows to miniaturize the detection volume while sustaining high sensitivity.

We present first experiments towards miniaturization of photo thermal absorption spectroscopy using a microscopic cavity as detector with a detection volume of $900\,\mu\mathrm{m}^3$ and we show first measurements on oxygen achieving a sensitivity below 5% for the volume concentration.

[1] Waclawek et al, Opt. Express 29, 7794-7808 (2021)
[2] Hunger et al, New J. Phys. 12 065038 (2010)

Q 42.3 Wed 16:30 P

A compact ultrafast electron source and its application for cell irradiation experiments — •Bastian Löhrl, Leon Brückner, and Peter Hommelhoff — Chair for Laser Physics, Friedrich-Alexander-University Erlangen-Nuremberg (FAU), Staudtstr. 1, 91058 Erlangen

Dielectric Laser Acceleration (DLA) could open new avenues in clinical radiotherapy due to its potential to create a compact accelerator on a chip [1]. DLAs place strong requirements on the emittance and brightness of the electron beam. Motivated by this, we are investigating the performance of a compact electron source [2] containing nano tips. The emitters are placed in ultra-high vacuum and are laser triggered by near-infrared laser pulses. The source can create ultrashort electron pulses with a high bunch charge. We are aiming towards using this source for biological experiments such as cell irradiation. The current state of the experiment will be discussed.

[1] England, R. Joel, et al. "Dielectric laser accelerators." Reviews of Modern Physics 86.4 (2014): 1337.
[2] Hirano, Tomohiko, et al. "A compact electron source for the dielectric laser accelerator." Applied Physics Letters 116.16 (2020): 161106.

Q 42.4 Wed 16:30 P

Paleoclimate Reconstruction with the ArTTA Quantum Technology — •David Wachs[1,2], Julian Robertz[1], Yannis Arck[2], Florian Meienburg[1,2], Florian Freundt[2], Werner Aeschbach[2,3], and Markus Oberthaler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute of Environmental Physics, Heidelberg, Germany — [3]Heidelberg Center for the Environment, Heidelberg, Germany

The ArTTA method for measuring ^{39}Ar concentrations represents an applied quantum technology to perform age dating of environmental samples. The isotope with its half life of 269 years uniquely enables dating in the age range between 150 and 1000 years. However, the very low isotopic abundance of about 10^{-16} sets high demands on the measurement method. Applied to different environmental archives the age itself can provide information about environmental changes and processes. However, combining the dating method with information obtained from other tracers can help to shed light on past conditions in certain environments.

In the past years several sampling and measurement campaigns involving ^{39}Ar and aiming at paleoclimate reconstruction have been realized. Firstly, samples obtained from groundwater were analyzed towards their age distribution and additionally their recharge temperatures. Secondly, alpine glacier ice was sampled and measured with the goal of reconstructing the impact of climate fluctuations at higher altitudes. Altogether such studies provide the opportunity to better understand climate fluctuations of the last millennium.

Q 42.5 Wed 16:30 P

Novel Approches in Distributed Raman Temperature Sensing — •Esther Renner[1,2], Lisa-Sophie Haerteis[1,2], and Bernhard Schmauss[1,2] — [1]Institute of Microwaves and Photonics, Friedrich-Alexander University Erlangen-Nürnberg — [2]Max Planck School of Photonics

Fiber optical sensors for temperature or strain sensing offer unique advantages compared to common electrical sensors, e.g. immunity to electromagnetic fields, (durability in rough environments and) chemical inertness and coverage of both, long sensing distances and multiple sensing points. Well known fiber sensors for temperature sensing are Fiber Bragg Gratings (FBG), used to determine temperatures at distinctive points of interest along the fiber. To obtain a distributed temperature measurement along the whole fiber, FBG interrogation can be combined with the detection of the temperature dependent spontaneous Raman backscattering [1].

Besides interrogation based on optical time domain reflectometry, spatial resolution can be obtained by incoherent optical frequency domain reflectometry (IOFDR). Here, we present two cost-efficient novel approaches for the integration of distributed Raman temperature sensing in a simple IOFDR system for FBG interrogation [2] using first, a broadband light source and second, a L-band pump laser diode.

[1] Koeppel, M. et al., J. Sens. Sens. Syst., 7, 91-100, 2018.
[2] Haerteis, L. et al., in OSA Optical Sensors and Sensing Congress 2021, paper SM5A.7.

Q 42.6 Wed 16:30 P

Thermische Effekte in der Einzephotonendetektion — •Julian Dietz — Helmut-Schmidt-Universität, Universität der Bundeswehr Hamburg, Holstenhofweg 85, 22043 Hamburg

Die ALPS Kollaboration präsentiert: Für das ALPS II Experiment am DESY, Hamburg, wird ein Einzelphotonendetektor benutzt, um die Existenz von in Licht umgewandelte Axion-ähnliche Teilchen zu beweisen. Als Signal wird lediglich ungefähr 1 Photon pro Tag bei einer Wellenlänge von 1064 nm (= 1,165 eV) erwartet, was hohe Anforderungen an die Dunkelrauschrate des Detektors stellt. Die Dunkelrauschrate ist durch Schwarzkörperstrahlung dominiert, und liegt laut Simulationen 3 Größenordnungen über der Signalstärke.

Schmalbandige optische Filter können bei einer Temperatur von 40 K diese Strahlung reduzieren und wurden innerhalb der in diesem Vortrag vorgestellten Versuchsreihe charakterisiert. Ein experimenteller Aufbau wurde entwickelt, der aufzeigt, dass sich die Zentralwellenlänge von Filtern um +0,0125 nm/K +- 6,25 % unter Temperaturerhöhung verschiebt. Die zu erwartende Zentralwellenlänge bei einer Umgebungstemperatur von 40 K wurde abgeschätzt und beträgt 1066,63 nm +- 6,25 %, wobei die Transmissionseffizienz hier 68,93 % +- 0,25 % (relative Messabweichung) beträgt. Parallel wurde ein Effizienzverlust von 25 % einer Filterbank gemessen, während diese um 260 K abgekühlt wurde. Zusammengesetzt ergibt sich bei 40 K eine Effizienz von 51,71 % +- 0,25 % (relative Messabweichung) bei 1064 nm. Im Anschluss werden Verbesserungsvorschläge diskutiert, um die Messunsicherheiten zu reduzieren und die Effizienz zu verbessern.

Q 42.7 Wed 16:30 P

Influence of Temperature and Salinity on the Spectral Characteristics of Brillouin Scattering in Water — •Daniel Koestel and Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, 64289 Darmstadt

In our group we are developing a LIDAR system for remote measurement of temperature and salinity in the ocean upper-mixed layer ($\sim$ 100 m depth). We successfully demonstrated the functionality of this setup with a temperature resolution of up to 0.07 °C and a depth resolution of up to 1 m [1]. Both spectral Brillouin shift and Brillouin linewidth (FWHM) depend on temperature and salinity. The spectral shift dependency of said parameters has already been studied extensively in the past [2,3]. This contribution aims to bring light to the less researched linewidth dependency on temperature and salinity [4]. For this purpose, we generated spontaneous Brillouin scattering at 530 nm in water in a laboratory environment at different temperatures and salinity. The scattering signal is then analyzed by a scanning FPI (Fabry-Pérot interferometer). We will present our latest results and discuss further steps in the development. [1] Th. Walther et al., Opt. Eng. 53(5) (2014). [2] Th. Walther et al., Appl. Phys. B 97(4), (2009). [3] E. S. Fry et al., Appl. Opt. (1997). [4] E. S. Fry et al., J. Modern Opt. (2002).

Q 42.8 Wed 16:30 P

Novel tunable cw and pulsed UV laser systems for laser cooling of bunched relativistic ion beams — •Jens Gumm[1], Benedikt Langfeld[1], Daniel Kiefer[1], Sebastian Klammes[2], and Thomas Walther[1] — [1]TU Darmstadt — [2]GSI Darmstadt

Experiments with highly charged ions at relativistic energies are of great interest for many atomic and nuclear physics experiments at accelerator facilities. To decrease the longitudinal momentum spread and emittance, laser cooling has proven to be a powerful tool.

In this work, we present two UV-laser systems operating at 257.25 nm for ion beam cooling at ESR in Darmstadt. The first laser is a Fourier limited, pulsed master-oscillator-power-amplifier system with individually adjustable pulse duration from 50 ps to 735 ps and repetition rates between 1 MHz to 10 MHz for broadband laser cooling in order to reduce ion beam heating due to intrabeam scattering. The second laser is a cw system that can be scanned mode-hop free, via two SHG stages, over 20 GHz (50 Hz scan rate). It will be used to minimize the final ion beam momentum spread and, therefore, the ion bunch length. For the cw system, we aim to achieve a power of 1 Watt in the UV-regime.

Q 42.9 Wed 16:30 P

Coupling in optical Microcavity Arrays — •Tom Rodemund, Lukas Seemann, and Martina Hentschel — TU Chemnitz, Chemnitz, Germany

Optical microcavities have proven their potential as microlasers. Their circular shape promotes the formation of whispering-gallery modes (WGM), which possess the high Q factor necessary for efficient lasing operation. However, the directionality of the far field of single cavities can still be improved by utilizing an array of several cavities. This gives rise to new phenomena due to the coupling between the constituents of the array. This contribution investigates possible avenues in which the coupling taking place can be characterized.

When two microdisc cavities approach one another, eigenfrequency splitting takes place. Considering discs with radius R and a distance between them D, the splitting is significant for $D/R < 0.3$. At that point, the distance is low enough for the WGMs to meaningfully pass from one resonator to the other by optical tunneling, which indicates strong coupling between the resonators. The influence of this on the modes is apparent in the Husimi functions of the cavities, which are a phase space representation of the system. The coupling is also reflected in the time a signal starting in one resonator needs to get back to its origin. These tools are applied to arrays consisting of verious amounts of oscillators, where the exact array size can have a pronounced influence on the system dynamics.

Q 42.10 Wed 16:30 P

Experimental Analysis of Raman interactions underlying intracavity coupling of femtosecond soliton molecules — •Timo Wirth and Georg Herink — Experimental Physics VIII - Ultrafast Dynamics, University of Bayreuth, Germany

The phononic contribution of the nonlinear refractive index n_2 governs bound states of femtosecond pulses or "soliton molecules" inside Ti:sapphire laser oscillators, as recently resolved via real-time spectroscopy [1]. In this contribution, we present an experimental analysis of the relative contribution of electronic and nuclear nonlinearities based on different extra-cavity detection schemes for time-resolved Raman spectroscopy. In particular, we compare results from impulsive stimulated Raman scattering (ISRS) obtained via optical Kerr effect (OKE), spectrally resolved two-beam coupling (SRTBC) and Kerr-lens spectroscopy. The latter detection scheme is closely related to intra-cavity soliton binding and yields quantitative insights into the fundamental soliton interaction.

[1] A. Völkel, et al., "Intracavity Raman Scattering couples Soliton Molecules via Terahertz Phonons" (in review, 2021)

Q 42.11 Wed 16:30 P

Tracing sub-cycle electron dynamics in two-colour nearfields of nanometric metal tips — •Philip Dienstbier[1], Lennart Seiffert[2], Timo Paschen[3], Thomas Fennel[2], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen — [2]Institut für Physik, Universität Rostock, Rostock — [3]Fraunhofer-Institut für Keramische Technologien und Systeme IKTS, Forchheim

Metal nanostructures exposed to intense laser fields enable the realization of strongly localized and well-controlled sub-cycle electron dynamics. These targets are readily used as high-brightness electron sources and initial building blocks for petahertz electronics. Despite broad initial success in these applications, the mapping of electron emission and propagation with attosecond precision has so far been restricted to gas phase atomic and molecular systems. Here, we show that phase-resolved photoemission in two color-laser fields can disentangle the propagation from ionization dynamics at the surface of nanometer sharp tungsten needle tips. In the experiment, the relative phase dependent plateau and cut off features in the electron spectra yields a characteristic energy dependent modulation depth and optimal phase. Matching the results with the solution of the time-dependent Schrödinger equation and with results from the simple-man's model allow us to identify the electron wavepacket dynamics, determine precise values for the optical nearfield strengths, and enable us to infer a duration of 710±30 attoseconds for the electron emission from a solid.

Q 42.12 Wed 16:30 P

Enhanced high-harmonic generation from silicon metasurfaces — •Pavel Peterka[1], Martin Kozák[1], Zbyňek Šobáň[2], František Trojánek[1], and Petr Malý[1] — [1]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [2]Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10, 162 00 Prague 6, Czech Republic

We report on the enhancement of high harmonic generation (HHG) yield in a metasurface consisting of amorphous silicon disks in periodic array on insulator substrate. The structure was designed by the finite-difference time-domain method, which allows us to optimize the geometry of the metasurface to reach the highest enhancement of HHG due to local field enhancement effect. The HHG was driven by 20 fs pulses at central wavelength 2 μm in reflective geometry. High harmonics are diffracted by the periodic structure and zero order signal is collected. The measured enhancement factors of the fifth and seventh harmonics with photon energies 3.1 eV and 4.3 eV, respectively, are larger than 20x compared to unpatterned amorphous silicon with the same width, even though the area from which the harmonics are generated is 4-times smaller in the case of metasurface. Our theoretical and experimental results demonstrate the possibility of creating engineered structures to study ultrafast strong field phenomena at the nanoscale.