Q 24: Poster: Quantum Optics and Photonics I

Time: Tuesday 16:30–18:30 Location: S Fobau Physik

Q 24.1 Tue 16:30 S Fobau Physik

Fabrication of nanophotonic resonators for interfacing individual Erbium ions — •Andreas Gritsch, Lorenz Weiss, and Andreas Reiserer — Max Planck Institut of Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching

Localized defect modes in photonic crystals form cavities which can combine Q-factors in the order of one million and sub-wavelength mode volumes resulting in unprecedented Purcell enhancement factors. We numerically design such photonic crystal cavities and fabricate them in one-dimensional silicon waveguides using electron beam lithography and reactive ion etching. Efficient off-chip coupling is achieved by evanescent couplers formed by wet-etched tapered optical fibers and tapered waveguide ends. Our devices can be transfered to the surface of suited Erbium-doped crystals to reduce the long lifetime (14ms) of the ions dramatically and guide the emitted photons efficiently. We present simulation data and fabrication results of our devices.

Q 24.2 Tue 16:30 S Fobau Physik

Optimized microstripline antenna for spin manipulation of color centers in diamond — •Oliver Opaluch, Richard Nelz, Michel Challier, and Elke Neu — Universität des Saarlandes, Fakultät NT - Fachrichtung Physik,Campus E2.6, 66123 Saarbrücken

Nitrogen Vacancy (NV) color centers in diamond are highly-suitable nanoscale quantum sensors for e.g. electrical and magnetic fields. NV-based sensing often relies on utilizing microwave antennas to manipulate the NV center's coherent and optically addressable electron spin states [1]. Commonly, free standing wires or antennas directly structured on the diamond sample are used. Using such antennas, major challenges arise due to the radiation field's inhomogeneity along the sample and the antenna characteristics uniformity as well as the reproducibility with respect to positioning. To overcome these obstacles we present an optimized Ω-shaped microstripline antenna design. We show that our antennas create a homogenous microwave field over a macroscopic area of approximately 600 μm in diameter, discuss their microfabrication, design optimization, implementation into experimental setups and their applicability to advanced measurement schemes.

[1] L. Rondin et al., Rep. Prog. Phys. 77 056503 (2014)

Q 24.3 Tue 16:30 S Fobau Physik

Optimized fabrication of single crystal diamond nanostructures for sensing applications — •Lara Render, Richard Nelz, Michel Challier, Abdallah Slablab, Mariusz Radtke, and Elke Neu — Universität des Saarlandes, Fakultät NT - Fachrichtung Physik, Campus E2.6, 66123 Saarbrücken

Nitrogen vacancy (NV) color centers in diamond are bright, photostable dipole emitters [1] and exceptionally useful as quantum sensors for e.g. electrical and magnetic fields. To achieve nanoscale resolution, shallowly-implanted NVs in nanostructured diamonds are scanned close to the sample under investigation. To this end, plasma-etched nanopillars on top of a cantilever-like structure are incorporated into a combination of a confocal and atomic force microscope [2]. However, fabricating structures is highly challenging: Whereas the employed etching-plasma determines the shape of the nanopillars it can also influence the charge state stability of NV centers and the surface quality of the diamond. We here show nanostructures manufactured using different plasma recipes and their influence on shallowly-implanted NV centers. Using confocal laser fluorescence microscopy, we investigate the collection efficiency improvement of NV centers embedded in the nanopillars.

[1] Bernardi et al., Crystals **7** 124 (2017).
[2] Appel et al., Rev. Sci. Instrum. **87** 063703 (2016).

Q 24.4 Tue 16:30 S Fobau Physik

Simulation of NV centers coupled to Si_3N_4 photonic crystal nanobeam cavities — •Jan Olthaus[1], Philip Schrinner[2], Carsten Schuck[2], and Doris E. Reiter[1] — [1]Institut für Festkörpertheorie, Universität Münster, 48149 Münster, Germany — [2]Physikalisches Institut, Universität Münster, 48149 Münster, Germany

The efficient integration of single-quantum emitters with photonic circuits is a major challenge for the development of quantum technologies. A scalable implementation of single-photon emitters (SPEs) on a chip requires a low-loss interface and strong light-matter interaction.
To provide such a platform we create a photonic crystal nanobeam cavity (PhC), which supports a localised mode at the wavelength of the single-photon emitter. If placed inside a resonant cavity, the spontaneous emission rate of SPEs in the weak coupling regime can be enhanced significantly (Purcell effect). The critical parameters for this enhancement are the Q-factor, mode volume and relative electric field strength at the SPEs position. A wavelength-scale mode volume can be easily achieved by an appropriate design and there are many approaches to minimise scattering losses of the defect mode.
We present results based on 3D-FDTD simulations of a PhC embedded with a Si_3N_4 waveguide on SiO_2 substrate coupled to a NV-center in nanodiamond. Besides geometry optimisations, we analyse effects of a substrate and the positioning of an emitter with finite volume.
Our results pave the way for an efficient integration of single-photon sources into photonic circuits.

Q 24.5 Tue 16:30 S Fobau Physik

Towards efficient light extraction and directional light emission from SiV color centers in planar Yagi-Uda antennas — •Hossam Galal[1], Assegid Flatae[1], Stefano Lagomarsino[1], Christoph Wild[2], and Mario Agio[1] — [1]Laboratory of Nano-Optics and Cu, University of Siegen, 57072 Siegen, Germany — [2]Diamond Materials GmbH, 79108 Freiburg, Germany

Color centers in diamond represent a promising hardware for developing quantum optical technologies. However, light cannot be easily collected from such systems due to radiation at wide angles and total internal reflection at the diamond interface. Typically, advanced optical nanostructures and/or sophisticated external optics are required to overcome these issues. Recently, we have proposed a planar configuration of an optical Yagi-Uda antenna, which leads to large extraction efficiencies and strong directional emission from solid-state quantum emitters [1]. Here, we apply our scheme to SiV color centers in diamond, which we create in a controlled manner [2]. Polycrystalline diamond membranes with thicknesses on the order of 50 nm - 170 nm have been implanted with silicon ions to create SiV color centres. Next, we have deposited dielectric and metal films to build our planar antenna. We investigate the emission characteristics of such hybrid system and explore its potential for single-photon emission.

References:
[1] H. Galal and M. Agio, Opt. Mater. Express 7, 1634 (2017). [2] S. Lagomarsino, et al., Diam. Relat. Mater. 84, 196 (2018).

Q 24.6 Tue 16:30 S Fobau Physik

Towards efficient light extraction and directional light emission from SiV color centers in planar Yagi-Uda antennas — •Hossam Galal[1], Assegid Flatae[1], Stefano Lagomarsino[1,3], Christoph Wild[2], and Mario Agio[1] — [1]Laboratory of Nano-Optics and Cu, University of Siegen, 57072 Siegen, Germany — [2]Diamond Materials GmbH, 79108 Freiburg, Germany — [3]Istituto Nazionale di Fisica Nucleare, Sezione di Firenze, 50019 Sesto Fiorentino

Color centers in diamond represent a promising hardware for developing quantum optical technologies. However, light cannot be easily collected from such systems due to radiation at wide angles and total internal reflection at the diamond interface. Typically, advanced optical nanostructures and/or sophisticated external optics are required to overcome these issues. Recently, we have proposed a planar configuration of an optical Yagi-Uda antenna, which leads to large extraction efficiencies and strong directional emission from solid-state quantum emitters [1]. Here, we apply our scheme to SiV color centers in diamond, which we create in a controlled manner [2]. Polycrystalline diamond membranes with thicknesses on the order of 50 nm - 170 nm have been implanted with silicon ions to create SiV color centres. Next, we have deposited dielectric and metal films to build our planar antenna. We investigate the emission characteristics of such hybrid system and explore its potential for single-photon emission.

References:
[1] H. Galal and M. Agio, Opt. Mater. Express 7, 1634 (2017). [2] S. Lagomarsino, et al., Diam. Relat. Mater. 84, 196 (2018).

Q 24.7 Tue 16:30 S Fobau Physik

High stability micro-cavity setup for quantum optics at low temperatures — •Thomas Hümmer[1,2], Jonathan Noé[3], Alexander Högele[3], Theodor W. Hänsch[1,2], and David Hunger[4] — [1]Ludwig-Maximilians-Universität München, Deutschland — [2]Max-Planck Institut für Quantenoptik, Garching, Deutschland — [3]Fakultät für Physik and Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München, München, Deutschland — [4]Karlsruher Institut für Technologie, Karlsruhe, Deutschland

High-finesse, open-access, mechanical tunable, optical micro-cavities [1] offer a compelling system to enhance light matter interaction in numerous systems, e.g. for single-photon sources, quantum computation and spectroscopy of nanoscale solid-state systems. However, the advantages of the mechanical degrees of freedom, like coupling to different points of the sample with one and the same cavity, or fast and flexible tuning of the cavity resonance, bear also downsides. Especially in highly vibrating environments, like inside close-cycle cryostats, fluctuations of the cavity length on the picometer scale are often enough to detune the cavity resonance from a narrow transition in quantum emitters of interest. We present our approaches to a fully 3D-scannable, yet highly stable cavity setup which features at ambient conditions a passive stability on the femtometer scale. Furthermore, we present the progress of operating it at low temperatures inside a closed cycle cryostat. [1] Hunger et al., NJP 12, 065038 (2010)

Q 24.8 Tue 16:30 S Fobau Physik

An optical nanofiber-based interface for solid-state quantum emitters — •Sarah M. Skoff[1], Hardy Schauffert[1], Johanna Hütner[1], Thomas Hoinkes[1], and Arno Rauschenbeutel[1,2] — [1]Atominstitut, TU Wien, Stadionallee 2, A-1020 Vienna, Austria — [2]Department of Physics, Humboldt-Universität zu Berlin, 10099 Berlin, Germany

In recent years, solid-state quantum emitters have gained increased interest as building blocks for quantum networks, quantum metrology and nanosensors. For all these applications, strong light-matter interactions are essential.

A versatile tool to achieve such interactions is an optical nanofiber, which is the tapered part of a commercial optical fiber that has a subwavelength diameter waist. This allows an appreciable amount of light to propagate outside the fiber in the form of an evanescent wave. We use such optical nanofibers to optically address individual molecules in solids and we will present this fully fiber-integrated system in more detail.

Due to the transverse confinement of the light field provided by the optical nanofiber, the interaction with quantum emitters is already significant. However, this nanofiber-based approach can be combined with a fiber-based cavity to enhance the light-matter interaction even further. As many solid-state quantum emitters require cryogenic temperatures, we will show the implementation of an optical resonator for these temperatures and demonstrate that it is sufficient to reach the strong coupling regime.

Q 24.9 Tue 16:30 S Fobau Physik

Scanning Cavity Microscopy of semiconducting SWCNTs — •Thea Moosmayer[1], Thomas Hümmer[2], Frank Hennrich[1], Ralph Krupke[1,3], and David Hunger[1] — [1]Karlsruher Institut für Technologie — [2]Ludwig-Maximilians-Universität München — [3]Technische Universität Darmstadt

Semiconducting single-walled carbon nanotubes (SWCNTs) are promising candidates for efficient, electrically triggered, single-photon sources at room temperature in the telecom wavelengths, which would be essential for quantum cryptography. A scanning cavity microscope consiting of a tunable high-finesse Fabry-Pérot microcavity is developed. It allows for real time absorption imaging of single SWCNTs. Beeing able to individually adress SWCNTs, the cavity will be used for Purcell enhancement of the fluorescence of localized excitons. The SWCNTs can furthermore be electrically contacted to drive photon emission.

Q 24.10 Tue 16:30 S Fobau Physik

Wavelength-scale errors in optical localization due to spin-orbit coupling of light — •Stefan Walser[1], Gabriel Araneda[2], Yves Colombe[2], Daniel B. Higginbottom[2,3], Jürgen Volz[1], Rainer Blatt[2,4], and Arno Rauschenbeutel[1,5] — [1]Atominstitut TU-Wien — [2]Universität Innsbruck — [3]Research School of Physics and Engineering, The Australian National University — [4]Institut für Quantenoptik und Quanteninformation, Innsbruck — [5]Department of Physics, Humboldt-Universität zu Berlin

The precise determination of the position of sub-wavelength scale emitters using far-field optical imaging techniques is of utmost importance for a wide range of applications in medicine, biology, astronomy and physics. We theoretically and experimentally show that, for a standard optical imaging system like an optical microscope, the image of an elliptically polarized point-like emitter does in general not coincide with the emitter's real position. Instead, even for perfect, aberration-free imaging with high numerical aperture, the image can in general be shifted. Imaging a single gold nanoparticle in a standard immersion microscopy setup, we experimentally demonstrate this effect and observe shifts up to one optical wavelength. Such shifts can lead to a systematic error in the optical localization of emitters which exceeds the typical precision of super-localization microscopes by far. Moreover, for the case of small numerical aperture, the shift can in principle reach arbitrarily large values. Beyond its relevance for optical imaging, the demonstrated phenomenon may also occur for sources of other types of waves as for instance in radar and sonar imaging.

Q 24.11 Tue 16:30 S Fobau Physik

Superresolution via 3D structured illumination intensity correlation microscopy — •Anton Classen[1,2], Joachim von Zanthier[1,2], and Girish S. Agarwal[3] — [1]Institut für Optik, Information und Photonik und — [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT), Universität Erlangen-Nürnberg, 91052 Erlangen — [3]Texas A&M University, College Station, TX 77843, USA

Intensity correlation microscopy (ICM), which is prominently known through antibunching microscopy or super-resolution optical fluctuation imaging (SOFI) [1,2], provides superresolution through a correlation analysis of antibunching of independent quantum emitters [1] or temporal fluctuations of blinking fluorophores [2]. For correlation order m the PSF is effectively taken to the mth power, and directly shrunk by the factor $\sqrt{m}$. Combined with deconvolution a close to linear resolution improvement of factor m can be obtained. Yet, analysis of high correlation orders is challenging, what limits the achievable resolutions. Here we propose to use three dimensional structured illumination [3] along with ICM to obtain an enhanced scaling of up to $m + m = 2m$ [4]. Hence, resolutions far below the diffraction limit in full 3D imaging can potentially be achieved already with low correlation orders. Since ICM operates in the linear regime our approach may be particularly promising for enhancing the resolution in biological imaging at low illumination levels. [1] O. Schwartz et al., PRA 85, 033812 (2012); [2] T. Dertinger et al., PNAS 106, 22287 (2009); [3] M. G. L. Gustafsson et al., J. Micr. 198, 82 (2000), Biophys. J. 94, 4957 (2008); [4] A. Classen et al., Optica 4, 580 (2017), Opt. Exress 26, 27492 (2018)

Q 24.12 Tue 16:30 S Fobau Physik

Transverse-mode coupling artefacts in scanning cavity microscopy — •Julia Benedikter[1,2], Matthias Mader[1,3], Theodor W. Hänsch[1,3], and David Hunger[2] — [1]Ludwig-Maximilians-Universität München — [2]Karlsruher Institut für Technologie — [3]Max-Planck-Institut für Quantenoptik, Garching

Scanning fibre cavities combine an enhanced light matter interaction with high resolution imaging in an open access environment. Due to the deviations of the fibre mirror profile from a sphere, transverse mode coupling can occur when the resonance condition is simultaneously met for several transverse modes, leading to additional losses. When laterally scanning the plane mirror through the cavity mode, one observes distinct ring shaped mode coupling artefacts as well as background patterns with features smaller than the diffraction limit. We show in detailed scanning cavity transmission measurements that the structures are isocontours of a varying penetration depth into the mirror coating and therefore a sensitive probe of the mirror properties. We examine the typical checker-board background pattern and find that it is also a mode coupling effect and can be attributed to the mirror roughness.

Q 24.13 Tue 16:30 S Fobau Physik

Slow light-enhanced optical imaging of microfiber radius variations with sub-Angström resolution — •Jürgen Volz[1], Khaled Kassem[1], Michael Scheucher[1], Philipp Schneeweiss[1], and Arno Rauschenbeutel[1,2] — [1]Atominstitut der TU Wien, Austria — [2]Humboldt Universität zu Berlin, Germany

Optical fibers play a key role in many different fields of science and technology. For many of these applications it is of outmost importance to precisely know and control their local radius. Here, we demonstrate a novel technique to determine the variation of the radius of a micrometer-sized silica fiber with sub-Angström precision over several hundred micrometer in a single shot. For this purpose, we image the axial mode structure of whispering gallery modes (WGMs) that form along the fiber. Due to these WGMs, the speed of the light along the fiber axis is strongly reduced. This speed reduction results in a magnification of the axial wavelength in axial direction which enables us to optically measure the fiber radius variations with significantly enhanced resolution. By exciting several different axial modes at different probing fiber positions, we verify the precision and reproducibility of our method and demonstrate that we can achieve a precision better than 0.3 Angström. The demonstrated method can be generalized to many experimental situations where slow light occurs and, thus, has a large range of potential applications in the realms of precision metrology and optical sensing.

Q 24.14 Tue 16:30 S Fobau Physik

Few-cycle laser pulse illumination of a nanoscale junction in an ambient-conditioned STM — •Jonas Heimerl, Takuya Higuchi, Maximilian Ammon, Alexander Schneider, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Metal needle tips render a perfect model system to investigate nonlinear light-matter interaction using few-cycle laser pulse illumination since they show large optical field enhancement at the tip apex. This enhancement enables peak electric fields above 1 V/Å while keeping the pulse energy sufficiently low, in order to prevent material damage. Such large electric fields lead to strong-field effects at the apex of the tips, such as rescattering of electrons. Moreover, nanometer sharp tips play an important role in scanning tunneling microscopes (STM), where a tip and a flat sample form a nanoscale junction. When this junction is illuminated with few-cycle laser pulses, the local electric fields are expected to be even more enhanced due to the coupling of optical near-fields between tip and metallic sample. This effect can also be observed in tip-enhanced Raman spectroscopy. We discuss the operation of a home-built ambient-conditioned STM under illumination of few-cycle laser pulses. The nanometer-precision control of the junction in STM operation allows us to precisely investigate the optical near-fields arising in the junction.

Q 24.15 Tue 16:30 S Fobau Physik

Enhanced light-matter interaction with nanoantennas coupled to a tunable microcavity — •Moritz Kappeler[1], Aina Quintilla[1], Silvia Diewald[1], David Hunger[1], Michael Förg[2], Alexander Högele[2], Michael Kaniber[3], Marko Petric[3], and Jonathan Finley[3] — [1]Karlsruher Institut für Technologie, Karlsruhe, Deutschland — [2]Ludwig-Maximilians-Universität, München, Deutschland — [3]Technische Universität, München, Deutschland

The controlled coupling between quantum emitters and photonic devices is essential for future applications like single photon sources, quantum non-linear optics and nanolasers. The coupling strength is typically amplified by cavities or nanoplasmonic antennas which are opposite with respect to quality factor and volume. In our work we use a hybrid approach consisting of a fiber-based microcavity and a lithographically produced bowtie nanoantenna. This allows both to increase the emission enhancement and to tune the bandwidth. We are working towards the combination with a monolayer of a transition metal dichalcogenide material exfoliated on an array of nanoantennas with different resonance frequencies. We report on the current status of the experiment.

Q 24.16 Tue 16:30 S Fobau Physik

Spatio-spectral analysis of ultrashort-pulsed vortex beams by means of high order statistical moments — •Max Liebmann, Treffer Alexander, Martin Bock, Ruediger Grunwald, and Thomas Elsaesser — Max Born Institut for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin, Germany

An orbital angular momentum essentially influences the spatio-spectral structure of ultrashort-pulsed wave packets by inducing anomalies in the vicinity of the phase singularity. The spatial redistribution of spectral components was previously addressed and further investigated by applying adapted statistical tools. 2D-spectral scans with high resolution and high sensitivity reveal so-called "spectral eyes" in 2D maps of spectral centers of gravity. Most recent results show that higher order statistical moments not only confirm the first order characteristics but, additionally, are strongly correlated to angular orientation and shape of anomalies. Therefore, combinations of higher order moments enable enhanced spectral contrast and diversify the quantification of even weak spectral features.

Q 24.17 Tue 16:30 S Fobau Physik

First diode pumped cw ruby laser — Walter Luhs[1] and •Bernd Wellegehausen[2] — [1]Photonic Engineering Office, Freiburger Str. 33 79427 Eschbach, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany

Almost 60 years after Maiman's famous first laser, cw laser oscillation of ruby at 694 nm in linear and ring resonators is reported, pumped with a 1 W diode laser at 405 nm. The ruby laser operates at room temperature with a threshold of 200 mW. So far output powers up to 36 mW have been achieved. With the ring resonator highly coherent single frequency operation will be possible.

Q 24.18 Tue 16:30 S Fobau Physik

Frequenzverdopplung in BBO mittels elliptischer Fokussierung in einem externen Resonator für "*amplification without inversion*" — •Rudolf Homm, Daniel Preissler, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, LQO, Schlossgartenstr. 7, 64289 Darmstadt

Die Entwicklung von kontinuierlich strahlenden UV-Lasern ist durch die für Besetzungsinversion notwendige Pumpleistung stark limitiert, da diese mit der vierten Potenz der Laserfrequenz ansteigt. Mit "*lasing without inversion*"(LWI) wird dieses Problem umgangen, indem Quanteninterferenzeffekte genutzt werden, um die Absorption kohärenter Strahlung auf dem Laserübergang zu unterdrücken [1]. An einem LWI-System in Quecksilber soll zu Beginn "*amplification without inversion*" realisiert werden. Dafür wurde ein Lasersystem bei der LWI-Zielwellenlänge 253,7 nm aufgebaut, welches unter anderem zur Charakterisierung des Systems genutzt wird. Die zweite Frequenzverdopplungsstufe des Lasersystems wurde durch einen Resonator mit elliptischem Fokus ersetzt, um Degradierung im verwendeten BBO-Kristall [1] zu verhindern. Dadurch wird eine niedrigere Spitzenintensität im Kristall erreicht, ohne die Konversionseffizienz zu senken [2], wodurch höhere Leistungen im UV möglich sind [3]. Im Beitrag werden die bisher mit dem Resonator erreichten experimentellen Ergebnisse präsentiert.

[1] B.Rein, Dissertation, TU Darmstadt (2016).
[2] A. Steinbach et al., Opt Commun. 123, 207-214 (1996).
[3] D. Preißler, Masterthesis, TU Darmstadt (2018).

Q 24.19 Tue 16:30 S Fobau Physik

Design eines UV SHG Resonators mit elliptischem Fokus zur Vermeidung von Degradierungseffekten in BBO — •Daniel Preissler, Daniel Kiefer, Thorsten Führer und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schlossgartenstr. 7, 64289 Darmstadt

Eine gängige Praxis zum Erreichen von Dauerstrichstrahlung im UV-Bereich beinhaltet die Frequenzverdopplung in Überhöhungsresonatoren mittels BBO. Deren Langzeitstabilität ist oft durch Degradierungseffekte in den verwendeten Kristallen limitiert. Durch Senken der Spitzenintensität kann das Risiko solcher Beschädigungen verringert werden. Dies kann durch elliptisch fokussierte Gaußstrahlen, deren Einfluss auf die erreichbare harmonische Leistung bereits analyisiert wurde [1], erreicht werden. In diesem Beitrag untersuchen wir den Zusammenhang von fundamentaler Spitzenintensität und harmonischer Leistung unter Anwendung elliptischer Fokussierung. Nach Auswahl einer Gaußmode, die eine signifikant geringere Intensität ohne Leistungseinbußen der Harmonischen ermöglicht, wurde mit Hilfe von evolutionären Algorithmen eine stabile Resonatorgeometrie unter Verwendung zylindrischer Spiegel gefunden. Mit diesem Resonator konnte eine UV-Leistung von 600 mW bei 257 nm über einen Zeitraum von über acht Stunden demonstriert werden.

[1] A. Steinbach et al., Opt. Commun. 123, 207-214 (1996).

Q 24.20 Tue 16:30 S Fobau Physik

Collisional redistribution laser cooling and spectroscopy of high pressure alkali-buffer gas mixtures — •Till Ockenfels[1], Stavros Christopoulos[1,2], Peter Moroshkin[1,3], Frank Vewinger[1], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Universität Bonn, Germany — [2]Present address: Department of Science, American University of the Middle East, Kuwait — [3]Present address: Okinawa Institute of Science and Technology, Japan

Collisional redistribution laser cooling is a technique applicable to alkali-noble gas mixtures at a typical pressure of a few hundred bars, where the pressure broadening of spectral lines approaches the thermal energy in the gas [1,2]. Frequent atom-noble buffer gas collisions here shift atomic absorption lines into resonance with a far red detuned laser beam, while spontaneous decay occurs close to the unperturbed transition frequency, such that thermal energy is extracted from the sample. In recent work, aiming at a spectroscopic, non-contact temperature measurement of the cooled sample, we have carried out both absorption and emission spectroscopic measurements of the dense rubidium-argon gas mixture. The ratio of absorption and emission spectral profiles was found to follow a Boltzmann-like (Kennard-Stepanov) frequency scaling in the dense gaseous system. We have also determined both pressure broadening and shift of the high-pressure buffer gas D-lines system [3].

[1] P. R. Berman and S. Stenholm, Opt. Commun. 24, 155 (1978).
[2] U. Vogl and M. Weitz, Nature 461, 70 (2009).
[3] S. Christopoulos et al., Phys. Scr. 93, 12 (2018).

Q 24.21 Tue 16:30 S Fobau Physik

A self-made 1064 nm fiber amplifier for producing an optical lattice for ultracold RbYb molecules — •Torsten Kemmerling, Tobias Franzen, Bastian Pollklesener, and Axel Görlitz — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

We present a low-cost, self-made and easy-to-build 1064 nm Yb fiber amplifier pumped at 975 nm to amplify a 100 mW signal from a commercial Nd:YAG laser to 6 W.

The amplifier is build entirely with fiber components, which results in a compact design and good beam quality.

It will be employed in our apparatus for the production of ultracold RbYb molecules. The beam will be used to create the optical lattice necessary for the molecule production.

Q 24.22 Tue 16:30 S Fobau Physik

The Heidelberg ArTTA: Application of Quantum Technology for radiometric dating of environmental samples – Latest News — •Julian Robertz[1], Lisa Ringena[1], Maximilian Schmidt[1,2], Zhongyi Feng[1], Arne Kersting[2], Werner Aeschbach[2,3], and Markus K. Oberthaler[1] — [1]Kirchhoff Institute for Physics, Heidelberg, Germany — [2]Institute for Environmental Physics, Heidelberg, Germany — [3]Heidelberg Center for the Environment, Heidelberg, Germany

The Heidelberg Argon Trap Trace Analysis (ArTTA) apparatus applies quantum optical methods to establish an ultra-sensitive detection method for the radioisotope ^{39}Ar, which, with a half-life of 269 years, serves as a unique tracer for dating of environmental samples. The ratio of ^{39}Ar to Ar in fresh air is 10^{-16}. To distinguish the isotope of interest from the huge background of abundant isotopes the isotopic shift in optical resonance frequency is utilized. The high selectivity is achieved by a multitude of scattering processes, which are realized in a magneto-optical trap (MOT), where single atoms are captured and detected.

A second apparatus is built up to increase the measurement throughput. Several optimizations have been made compared to the existing measurent setup. We will present latest developments and new design ideas.

Q 24.23 Tue 16:30 S Fobau Physik

Compression of supercontinuum pulses using different chirped mirror technologies — Han-gyeol Lee, •Sudheendran Vasudevan, Alexander Kastner, Hendrike Braun, Arne Senftleben, and Thomas Baumert — Universität Kassel, Institut für Physik und CINSaT, D-34132 Kassel, Germany

White light continua spanning a broad spectral region generated in a noble gas filled hollow-core fiber are a prerequisite for the generation of few-cycle light pulses. The white light pulses are interesting due to their broad bandwidth paving the way to excite more intermediate resonances in atomic or molecular systems, while in the few cycle limit, ionization out of a nearly frozen nuclear configuration can be achieved.
In this contribution, we demonstrate our recent approaches to compress a white light continuum spanning the 450-1000 nm spectral region down to the few-cycle limit using different chirped mirror technologies. One is based on double angle technology [1], while the other one is based on a variable angle of incidence [2].
The light pulses are characterized in the temporal domain by using a home-built transient grating frequency resolved optical gating (TG-FROG) [3]. The $\chi^{(3)}$ process-based TG-FROG makes use of intrinsic phase-matching to characterize the white light continuum.

[1] V. Pervak et al. Opt. Express 17, 7943, (2009)
[2] Laser Quantum homepage
[3] R. Trebino et al., Rev. Sci. Instrum. 68 (9), (1997)

Q 24.24 Tue 16:30 S Fobau Physik

Characterization of laser-triggered high-brightness electron sources — •Leon Brückner, Norbert Schönenberger, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Ultrashort electron pulses have become invaluable in research, for applications such as dielectric laser acceleration [1] or ultrafast electron microscopy [2]. These applications require high peak brightness and are therefore limited by the electron source. We investigate the performance and beam parameters of different high brightness needle tip electron sources [3,4]. The emitters are mounted in ultra-high vacuum in a commercial electron gun from a SEM and are operated either in DC mode or laser-triggered by UV laser pulses. The beam emittance is estimated by measuring the spot size on an MCP as a function of the focal strength of the electrostatic condenser lens of the electron gun and comparing the results with simulations.

[1] J. McNeur et al., Optica 5, 687-690 (2018)
[2] L. Piazza et al., Nature Communications 6, 6407 (2015)
[3] H. Zhang et al., Nature Nanotechnology 11, 273-279 (2016)
[4] S. Meier et al., Appl. Phys. Lett. 113, 143101 (2018)

Q 24.25 Tue 16:30 S Fobau Physik

Optical pulse shaping for dielectric laser acceleration — •Anna Mittelbach, Norbert Schönenberger, Johannes Illmer, Ang Li, Alexander Tafel, Peyman Yousefi, Roy Shiloh, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Dielectric laser accelerators (DLAs) - novel accelerators based on the interaction of laser pulses with electrons at dielectric nanostructures [1 - 3] - were able to show the highest acceleration gradients among damage limited accelerators, currently in the range of 1 GeV/m [4]. Compared to conventional radiofrequency accelerators, DLAs enable a high electron energy gain within a small interaction region using the high peak fields of ultrashort laser pulses. In the past, not only acceleration but also transverse and longitudinal electron control as well as energy modulation have been proposed by changing the design of the used nanostructures [5]. Here we present envelope shaped and frequency modulated laser pulses as a different approach for tuning laser-electron-interaction in DLA structures.

[1] E. A. Peralta, Nature 2013, 503, 91-94.
[2] J. Breuer, P. Hommelhoff, Phys. Rev. Lett. 2013, 111, 134803.
[3] R. J. England et al., Rev. Mod. Phys. 2014, 86, 1337-1389.
[4] D. Cesar et al., Nat. Commun. 2018, 1, 46.
[5] U. Niedermayer et al., Phys. Rev. Lett. 2018, 121, 214801.

Q 24.26 Tue 16:30 S Fobau Physik

Optical phase-controlled photocurrent generation in graphene — •Timo Eckstein, Christian Heide, Heiko B. Weber, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Recently, it has been demonstrated that ultrashort few-cycle laser pulses generate a carrier-envelope phase dependent photocurrent in graphene [1,2]. In the weak-field limit, the light-graphene interaction can be treated perturbatively and the photon picture is helpful to understand the dynamics. Odd-order interference such as ω-2ω or 2ω-3ω excitation can result in a phase dependent photocurrent that increases monotonically with a power law scaling.

Here, we show that the temporal delay between two laser pulses, the fundamental near-infrared laser pulses (ω) and their second harmonic (2ω) generates a phase sensitive photocurrent in graphene as well. This phase-controlled photocurrent represents an ultrafast current switch at optical frequencies. Latest experimental results and a simple theoretical model based on a tight-binding approach will be presented.

[1] Heide et. al., PRL 121, 207401 (2018)
[2] Higuchi et. al., Nature 23900 (2017)