Short Time-scale Physics and Applied Laser Physics Division
Fachverband Kurzzeit- und angewandte Laserphysik (K)

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Overview of Invited Talks and Sessions

(Lecture hall HS XI ITW; Poster Tent)

Invited Talks

K 1.1	Mon	11:00–11:30	HS XI ITW	**Hochleistungs-UKP-Laser für die Fertigung** — •Arnold Gillner
K 3.1	Mon	17:00–17:30	HS XI ITW	**Quantenphysik, klassische Physik und Realität** — •Alfred Eichhorn
K 5.1	Tue	11:00–11:30	HS XI ITW	**Fundamental investigations on the ablation of thin metallic films upon irradiation with ultrafast laser radiation** — •Alexander Horn, Theo Pflug, Andy Engel, Markus Olbrich

Invited Talks of the joint Symposium SAMOP Dissertation Prize 2025 (SYAD)

See SYAD for the full program of the symposium.

SYAD 1.1	Mon	14:30–15:00	HS 1+2	**A simple method to separate single- from multi-particle dynamics in time-resolved spectroscopy** — •Julian Lüttig
SYAD 1.2	Mon	15:00–15:30	HS 1+2	**Time-resolving quantum dynamics in atoms and molecules with intense x-ray lasers and neural networks** — •Alexander Magunia
SYAD 1.3	Mon	15:30–16:00	HS 1+2	**How rotation shapes the decay of diatomic carbon anions** — •Viviane C. Schmidt
SYAD 1.4	Mon	16:00–16:30	HS 1+2	**Interstellar stardust from stellar explosions recorded in a deep-ocean ferromanganese crust within the last 10 million years** — •Dominik Koll

Invited Talks of the joint Symposium Quantum Science and more in Ghana and Germany (SYGG)

See SYGG for the full program of the symposium.

SYGG 1.1	Tue	11:00–11:05	WP-HS	**Welcome Adress** — •Birgit Münch
SYGG 1.2	Tue	11:05–11:20	WP-HS	**Quantum Education in Ghana** — •Dorcas Attuabea Addo
SYGG 1.3	Tue	11:20–11:45	WP-HS	**Mathematical and Computational Physics Research In Ghana: To Cultivate a Knowledge-Based and Sustainable Development Economy** — •Henry Martin, Henry Elorm Quarshie, Mark Paal, Francis Kofi Ampong, Eric Kwabena Kyeh Abavare, Matteo Colangeli, Alessandra Continenza, Jaime Marian
SYGG 1.4	Tue	11:45–12:10	WP-HS	**Forecasting the Economic Health of Ghana Using Quantum-Enhanced Long Short-Term Memory Model** — •Peter Nimbe, Henry Martin, Dorcas Attuabea Addo, Nicodemus Songose Awarayi
SYGG 1.5	Tue	12:10–12:40	WP-HS	**Quantum Technology with Spins** — •Joerg Wrachtrup
SYGG 1.6	Tue	12:40–13:00	WP-HS	**Renewable Energy Technologies for Rural Ghana: The Role of Appropriate Technology for Tailored solutions** — •Michael Kweku Edem Donkor

Prize and Invited Talks of the joint Awards Symposium (SYAS)

See SYAS for the full program of the symposium.

SYAS 1.1	Thu	14:30–15:10	HS 1+2	**A journey in mathematical quantum physics** — •Reinhard F. Werner
SYAS 1.2	Thu	15:10–15:50	HS 1+2	**Precision Tests of the Standard Model at Low Energies Using Stored Exotic Ions in Penning Traps** — •Klaus Blaum
SYAS 1.3	Thu	15:50–16:30	HS 1+2	**Controlling light by atoms and atoms by light: from dark-state polaritons to many-body spin physics** — •Michael Fleischhauer
SYAS 1.4	Thu	16:30–16:35	HS 1+2	**Quantum history at your fingertips: Launch of the DPG's Quantum History Wall** — •Arne Schirrmacher

Sessions

K 1.1–1.6	Mon	11:00–12:45	HS XI ITW	**Laser Systems – Optical Methods (joint session K/Q)**
K 2.1–2.6	Mon	11:00–12:30	HS V	**Laser Technology and Applications (joint session Q/K)**
K 3.1–3.5	Mon	17:00–18:30	HS XI ITW	**Light and Radiation Sources I**
K 4.1–4.8	Mon	17:00–19:00	HS V	**Photonics (3D Print) (joint session Q/K)**
K 5.1–5.4	Tue	11:00–12:15	HS XI ITW	**Laser-Beam Matter Interaction – Light and Radiation Sources II**
K 6.1–6.11	Tue	14:00–16:00	Tent	**Poster**

Members' Assembly of the Short Time-scale Physics and Applied Laser Physics Division

Monday 18:30–19:00 HS XI ITW

- Bericht
- Wahl
- Verschiedenes

K 1: Laser Systems – Optical Methods (joint session K/Q)

Time: Monday 11:00–12:45 Location: HS XI ITW

Invited Talk K 1.1 Mon 11:00 HS XI ITW

Hochleistungs-UKP-Laser für die Fertigung — •Arnold Gillner — Lehrstuhl für Lasertechnik RWTH Aachen Steinbachstrasse 15, 52074 Aachen

Ultrakurzpulslaser mit Pulsdauern von einigen 100 fs bis ps ermöglichen in der industriellen Fertigung neue Bearbeitungsansätze mit bisher unerreichter Genauigkeit. Durch die weitgehende Trennung von Energieabsorption und Materialablation ist der Energieeintrag in den Werkstoff minimal, sofern einige wichtige Randbedingungen berücksichtigt werden. Insbesondere kann es bei hohen Pulswiederholraten zu thermischer Akkumulation kommen und bei hohen Pulsenergien zu Plasmaabschirmung und Beeinflussung des eingehenden Laserstrahls. Als Lösung bieten sich Hochgeschwindigkeits-Scansysteme mit Geschwindigkeiten über 1000 m/s oder Multistrahl-Bearbeitungssysteme mit mehreren 100 Teilstrahlen an, um die eingestrahlte Laserenergie im optimalen Arbeitspunkt zu nutzen. Dieser Arbeitspunkt wird im Wesentlichen von der optischen Eindringtiefe bestimmt, höhere Energiedichten führen mit ballistischen Elektronen zu tieferen Orten der Energiedeposition. Detaillierte Analysen der Wechselwirkung über Pump-and-Probe sowie über hochenergetische Röntgenstrahlung am DESY zeigen dynamische Wechselwirkungsverhältnisse, die es gilt, durch schnelle Strahlformung zu beherrschen. Im Ergebnis steht mit Ultrakurzpuls-Lasern im kW-Bereich ein neues Werkzeug für die Präzisionsfertigung zur Verfügung.

K 1.2 Mon 11:30 HS XI ITW

Electronically tunable fiber-feedback optical parametric oscillator with intracavity Echelle grating stretcher — •Florent Kadriu, Michael Harteker, Tobias Steinle, and Harald Giessen — University of Stuttgart 4th Physics Institute

Tunable light sources in the near-IR are often limited by tuning speed, stability, and reproducibility due to the physical movement of optics. Fiber-feedback optical parametric oscillators (FF-OPOs) offer broad tuning in the IR with high stability. Thus, ideally static optics are required for ultrafast and reproducible tuning. We present a gain-switched diode-based FF-OPO using an intracavity echelle grating stretcher for temporal-dispersion wavelength tuning. This approach enables four distinct tuning ranges corresponding to four grating orders, achieving a theoretical tuning rate of 500 kHz, a narrow linewidth below 1 nm, and 2 pm wavelength reproducibility. This concept can be transferred to other grating types and spectral ranges and is ideal for applications in infrared narrowband AM/FM spectroscopy.

K 1.3 Mon 11:45 HS XI ITW

Advancements in large ring laser gyroscopes for geodesy and seismology — •Jannik Zenner[1], Andreas Brotzer[2], Heiner Igel[2], Karl Ulrich Schreiber[3,4], and Simon Stellmer[1] — [1]Physikalisches Institut, Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany — [2]Department of Earth and Environmental Sciences, Ludwig-Maximilians-Universität, Munich, Germany — [3]Research Unit Satellite Geodesy, Technical University of Munich, Munich, Germany — [4]School of Physical Sciences, University of Canterbury, Christchurch, New Zealand

This winter marks the 100 year anniversary of the Michelson-Gale-Pearson experiment, the first interferometric measurement of Earth's rotation. Ring laser gyroscopes have matured considerably and are now able to continuously monitor Earth's rotation rate at a 10^{-8} level. This opens the possibility to detect subtle earth rotation variations driven by diverse geophysical processes across a wide spectrum of frequencies, which have traditionally only been detected by astronomical techniques. We will highlight the technological advancements in ring laser technology and future perspectives.

K 1.4 Mon 12:00 HS XI ITW

Sub-two-cycle pulses at 1600 nm and in the mid IR from an ultralow-noise fiber-feedback optical parametric oscillator system at 76 MHz — •Johann Thannheimer, Abdullah Alabbadi, Tobias Steinle, and Harald Giessen — University of Stuttgart

We achieve fiber-based self-compression down to sub-two optical cycles (9.5 fs) at 1600 nm with an average power of 620 mW (8.2 nJ) and a 76 MHz repetition rate. A commercial Yb-based pump laser is used to drive a fiber-feedback optical parametric oscillator. The frequency converted pulses are amplified to the Watt scale with an optical parametric amplifier and coupled into a 42-mm-long common single mode fiber. The fiber realizes ultracompact grating-free single stage compression to sub-two optical cycles. An added intra-pulse difference frequency generation stage converts the shot-noise limited few-cycle pulses to tunable ultra-broadband mid-infrared radiation. Beside ultrafast metrology via electro optic sampling, this system is particularly suited for mid-infrared spectroscopy.

K 1.5 Mon 12:15 HS XI ITW

Laser Ranging for Satellite Gravimetry: GRACE-FO and beyond — •Malte Misfeldt[1,2], Vitali Müller[1,2], Gerhard Heinzel[1,2], Kai Voss[3], and Kolja Nicklaus[3] — [1]MPI für Gravitationsphysik, Hannover — [2]IGP, Leibniz Universität Hannover — [3]SpaceTech Immenstaad GmbH

The Laser Ranging Interferometer (LRI) aboard the GRACE Follow-On (GRACE-FO) mission represents a groundbreaking advancement in satellite geodesy. Designed as an experimental addition to the established microwave ranging system, the LRI employs laser interferometry to measure inter-satellite distance variations with nanometer-scale precision. The enhanced sensitivity enables improved tracking of Earth's gravity field variations, offering refined insights into critical climate change processes such as polar ice mass loss. The LRI's successful deployment and operation have set a new benchmark for the accuracy and resolution of space-based gravity measurements.

This presentation will discuss the key technologies of the LRI. As evolved LRI instruments will be the primary payload in future satellite gravimetry missions, we will highlight lessons learned from several years of successful operation in orbit and their relevance to the design. Finally, we will address the new challenges in transitioning the LRI from a technology demonstrator to a primary payload. These include meeting stricter performance requirements, enhancing robustness for long-term operation, and adding a new sub-unit to measure the laser's wavelength in-orbit to better than 25ppb.

K 1.6 Mon 12:30 HS XI ITW

The LISA space mission — •Lennart Wissel — Max Planck Institute for Gravitational Physics — Leibniz University Hannover

The LISA observatory is a large ESA-lead mission that will unlock the yet unaccessible millihertz regime of gravitational waves. It will be launched in the mid-2030s and consists of three spacecraft on a heliocentric orbit, each shielding free-falling test masses acting as geodesic reference points. The triangular formation utilises heterodyne interferometers to measure the variations in light travel times between the test masses across 2.5 million km distances to picometer precision.

This talk gives an overview of the mission concept, highlights its technological challenges, its current status, and finishes with an outlook for the exciting timeline ahead.

K 2: Laser Technology and Applications (joint session Q/K)

Time: Monday 11:00–12:30 Location: HS V

K 2.1 Mon 11:00 HS V

Simulation of Optically Induced Electrical Picosecond Pulses on Coplanar Waveguides Using PySpice — •Sophie-Luise Hachmeister and Heiko Füser — Physikalisch Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

The generation and characterization of optically induced electrical picosecond pulses is vital for the calibration of high-frequency electrical devices. Coplanar waveguides (CPWs) are commonly employed as platform for the generation, propagation and utilization of these pulses. While experimental techniques have been extensively explored, a notable gap persists in accurately simulating the pulse propagation characteristics. This work aims to address this shortcoming by developing a simulation framework utilizing PySpice, an open-source circuit simulation library in Python. The proposed model simulates the generation and propagation of picosecond pulses on CPWs, incorporating optical input parameters, the electrical properties of the CPW, and the characteristics of connected devices. To validate the framework, the simulation results are benchmarked against experimental measurements. Initial findings demonstrate a strong correlation between simulated and observed pulse dynamics, underscoring the model*s capacity to replicate the physical behavior effectively. By bridging the gap between experimental observations and computational simulations, this work offers a powerful tool detailing on high-frequency signal generation and enhances the understanding of optically induced electrical pulses. Future research will expand on these findings by exploring novel experimental setups and adapting the simulation model accordingly.

K 2.2 Mon 11:15 HS V

Generation of high power cw UV radiation using elliptical focusing enhancement cavities — •Jens Gumm, Denise Schwarz, and Thomas Walther — TU Darmstadt

Long term cw laser operation with high output power in the UV spectral range is of great interest in many scientific and commercial applications.

Generation of cw-UV light is often realized by resonant second harmonic generation employing β-Barium Borate (BBO) as the nonlinear optical medium. A known parasitic effect in BBO is the degradation of the crystal due to two-photon absorption.

We theoretically showed that elliptical focusing can lead to higher conversion compared to the spherical optimum and significantly decreases the peak intensity in the nonlinear crystal. Experimentally, we demonstrated UV powers in excess of 2.4W with a fundamental power of 14W.

K 2.3 Mon 11:30 HS V

Transportable Pulsed UV Laser System for Bunched Beam Laser Cooling — •Benedikt Langfeld[1,2], Tamina Grunwitz[1], and Thomas Walther[1,2] — [1]TU Darmstadt, Institut für Angewandte Physik — [2]HFHF Campus Darmstadt

Laser cooling of bunched relativistic ion beams has been shown (e.g. at GSI Helmholtzzentrum) to be a powerful technique to generate ion beams with small emittances and narrow longitudinal velocity distributions. For highly relativistic (large γ-factors) and intense heavy-ion beams, laser cooling will be very efficient and cooling times of the order of seconds are expected. For these reasons, laser cooling will be the only available cooling method at the planned heavy-ion synchrotron SIS100 at FAIR.

In this talk, we discuss the principle of bunched beam laser cooling using multiple laser beams. We will give an overview of one of the laser systems that will be used at the SIS100, namely the tunable high repetition rate (1-10 MHz) pulsed UV laser system - with a continuously adjustable pulse duration between 50 and 735 ps and a high average UV power of up to 4 W. Employing a walk-off compensation design with two BBO crystals, the laser frequency can be tuned over a range of 3.4 THz in the UV.

K 2.4 Mon 11:45 HS V

Integrated Quantum Dot Comb Laser for Three-dimentional Imaging — •Marjan Shojaei, Stephan Amann, and Nathalie Picque — Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin, Germany

Holography is a powerful technique for lensless three-dimensional imaging. It is an interferometric imaging technique that allows to measure phase and amplitude simultaneously. In digital holography, the image acquisition is done with a digital camera sensor, and a computer performs the process of image reconstruction. By using a frequency comb, we do not get a single image as would be the case with a continuous-wave laser, but there are multiple images corresponding to the individual comb lines. This allows to reconstruct the phase over a large unambiguous distance with high accuracy. Here, we assess the potential of quantum dot comb lasers for applications in miniaturized three-dimensional imaging systems. Our quantum-dot comb laser spans over 5nm around the central wavelength of 1310nm with a flat-top spectral distribution and a line spacing of 80 GHz. Due to its large line spacing and turn-key operation, quantum dot lasers are promising comb sources for an application in miniaturized three-dimensional imaging systems and could allow to measure the phase profile of macroscopic objects with interferometric precision.

K 2.5 Mon 12:00 HS V

THz frequency combs for traceable 6G channel characterization — •Adam Kuchnia, David Humphreys, Nora Meyne, and Heiko Füser — Physikalisch Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Traceable characterization of communication systems operating in the 6G frequency range is currently limited by the availability of measurement equipment traced back to primary SI standards. A solution is provided via photoconductive antennas (PCAs) in combination with THz frequency combs, utilized to directly down-convert free-space THz RF signals to baseband. Traceability is ensured by referencing the THz frequency comb to an atomic clock. Within this work, the PCA antenna performance within the 6G frequency range is investigated. CST-Microwave-Studio-based simulations are performed to analyze existing designs and to suggest optimized structures. Channel characterization is realized by measurement of free-space THz RF signals and analyzing amplitude and phase dependency over a wide frequency range. A comparison to the expected antenna behavior is provided. This approach opens new possibilities for THz measurement, including traceable detection of CW and RF-modulated waveforms and channel sounding.

K 2.6 Mon 12:15 HS V

How to generate XUV frequency combs with only 10 W? — •Muhammad Thariq[1,2], Johannes Weitenberg[1,3], Francesco Canella[4,5], Gianluca Galzerano[5], Theodor W. Hänsch[1,2], Thomas Udem[1,2], and Akira Ozawa[1] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, 80799 Munich, Germany — [3]Fraunhofer-Institut für Lasertechnik ILT, 52074 Aachen, Germany — [4]Dipartimento di Fisica, Politecnico di Milano, 20133 Milan, Italy — [5]Istituto di Fotonica e Nanotecnologie - Consiglio Nazionale delle Richerce, 20133 Milan, Italy

The extreme ultraviolet (XUV) frequency comb (FC) is a vital tool for extending optical frequency metrology into the unexplored wavelength range below 200 nm. However, generating XUV FCs via high harmonic generation (HHG) often demands very high peak intensities. This typically requires an enhancement resonator, where a circulating average power of 10 kW leads to heating and damage issues.

In this work, we propose using a low repetition rate FC to drive single-pass HHG. By reducing the repetition rate by three orders of magnitude with an AOM-based pulse picker while maintaining a high peak power and a frequency comb structure, the average power is decreased proportionally. We have generated high harmonics from a 40 kHz-repetition rate FC with a peak power of 140 MW and pulse width of 35 fs. The results demonstrate the feasibility of generating XUV FCs with average powers below 10 W, making them more accessible to researchers across disciplines.

K 3: Light and Radiation Sources I

Time: Monday 17:00–18:30 Location: HS XI ITW

Invited Talk K 3.1 Mon 17:00 HS XI ITW

Quantenphysik, klassische Physik und Realität — •Alfred Eichhorn — Weil am Rhein

Die klassische Physik hat sich als ein sehr mächtiges und erfolgreiches Instrument zur Beschreibung der Natur erwiesen. Sie entspricht weitgehend unserem menschlichen Vorstellungsvermögen. Es hat sich aber gezeigt, dass die klassische Physik nicht ausreicht, um die Natur vollständig zu beschreiben. Es handelt sich um ein im Gödelschen Sinne abgeschlossenes und somit unvollständiges System. Die Quantentheorie gestattet die Beschreibung von Phänomenen, die sich im Rahmen der klassischen Physik nicht mehr beschreiben lassen. Sie stellt ein übergeordnetes System dar, das aber nicht mehr unserem Vorstellungsvermögen entspricht. Intuitiv gehen wir jedoch weiterhin davon aus, die Realität mit Hilfe der klassischen Größen beschreiben zu können. Wenn wir eine solche Größe messen, setzen wir voraus, dass diese Größe eine Eigenschaft des Systems ist, an dem wir die Messung durchführen. Im Grunde erzeugen wir dabei eine Projektion der Realität auf die Ebene der klassischen Physik, d.h. auf die Ebene unseres Vorstellungsvermögens. Ebenso erzeugen wir, wenn wir aus einer Wellenfunktion den Erwartungswert für eine klassische Größe bestimmen, eine Projektion der Wellenfunktion auf die Ebene der klassischen Physik, wobei die Observable, die die klassische Größe repräsentiert, die Art der Projektion bestimmt. Durch eine solche Projektion werden bestimmte Aspekte hervorgehoben, andere vernachlässigt, was zu einer unvollständigen Beschreibung des Gesamtsystems - einer Unschärfe - führt. In diesem Beitrag soll diese Überlegung näher ausgeführt werden.

K 3.2 Mon 17:30 HS XI ITW

Investigating Photoionization Delays with an Attosecond Source Synchronized with an Infrared OPA — •Muhammad Jahanzeb[1], Marvin Schmoll[1], Narendra Shah Ronak[1], Cristian Manzoni[2], and Giuseppe Sansone[1] — [1]Institute of Physics, University of Freiburg, Freiburg, Germany — [2]Institute for Photonics and Nanotechnology - CNR Piazza Leonardo da Vinci 32, 20133 Milano, Italy

The precise measurement of photoionization delays on attosecond timescales is critical to understanding ultrafast electron dynamics in atoms and molecules. The Reconstruction of Attosecond Beating by Interference of Two-Photon Transitions (RABBIT) technique provides a powerful tool to probe these delays [1-2].

We present an experimental setup in development design to investigate continuum-continuum delays in photoionization using synchronized attosecond extreme ultraviolet (XUV) and infrared (IR) pulses. High-order harmonics are generated by an 800 nm driving laser to produce attosecond XUV pulses, which are then combined with a precisely synchronized 1200 nm pulse from a non-collinear optical parametric amplifier (OPA). This setup enables the generation of two sidebands between photoelectron peaks caused by the absorption of single XUV photons. By analyzing the phase oscillations of adjacent sidebands, we aim to disentangle the contribution of continuum-continuum phases in the photoionization process. [1] Paul et al, Science, 292 (2001) [2] Dahlström et al, Journal of Physics, 45 (2012)

K 3.3 Mon 17:45 HS XI ITW

Coherent control of electron emission direction in helium with ω-2ω SASE FEL pulses — •Muwaffaq Ali Mourtada[1], Harijyoti Mandal[1], Hannes Lindenblatt[1], Florian Trost[1], Gergana D. Borisova[1], Alexander Magunia[1], Weiyu Zhang[1], Yu He[1], Lina Hedewig[1], Cristian Medina[1], Arikta Saha[1], Marc Rebholz[1], Ulrike Frühling[2], Carlo Kleine[1], Steffen Palutke[2], Evgeny Schneidmiller[2], Mikhail Yurkov[2], Stefan Düsterer[2], Rolf Treusch[2], Chris H. Greene[3], Yimeng Wang[3], Robert Moshammer[1], Christian Ott[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Deutsches Elektronen Synchrotron DESY, 22607 Hamburg, Germany — [3]Purdue University, West Lafayette, IN 47907, USA

We demonstrate the stability of the phase between ω-2ω in an unseeded SASE FEL at FLASH (DESY). Using a two-photon process driven by the fundamental and a one-photon process driven by the 2nd harmonic, we show that the observed asymmetry in photoelectron emission direction confirms this phase stability. Building on [1], we extend a phenomenon previously observed only in seeded FELs [2, 3]. Phase control is achieved by introducing a refractive medium into the beam path. A photon energy scan near the helium 1s2p resonance reveals a sign flip in asymmetry, consistent with prior studies [3-5]. Stronger asymmetries are observed for pulses with higher spectral correlation. [1] Straub et.al.PRL.129. [2] Prince et.al. Nature Photonics,2016 [3] DiFraia et.al. PRL.123 [4] Wang et.al. Phys. Rev.103:053118, 2021 [5] Ishikawa et.al. Appl. Sci. 2013, 3, 189-213

K 3.4 Mon 18:00 HS XI ITW

Towards a High Repetition-Rate, High Power, High Harmonic Generation Setup for Time-resolved Molecular Spectroscopy — •Lorenzo Pratolli[1,3], Katinka Horn[1,2], Vincent Wanie[1], Terry Mullins[1], Luca Poletto[4], Fabio Frassetto[4], and Francesca Calegari[1] — [1]Center for Free-Electron Laser Science, Hamburg, Germany — [2]ETH Zürich, Zürich, Switzerland — [3]HELIOS, Hamburg, Germany — [4]Universita di Padova, Padova, Italy

High-Harmonic Generation (HHG) is a process that allows to generate extreme ultraviolet (XUV) light pulses with attosecond duration through intense optical fields and has been widely employed for ultrafast time-resolved molecular spectroscopy. Scaling the collection statistics is a challenge to which Yb fibre lasers provide a convenient solution thanks to their high repetition-rate operation. Multi-Pass Cells (MPCs) have emerged as an appealing solution to address the primary issue of these systems, their relatively long pulse duration. These cells can compress pulses from several hundred femtoseconds to durations below 20 femtoseconds, while maintaining over 90% efficiency, a compact setup, and excellent beam quality. Here we present the development of a setup for HHG at high repetition-rates driven by compressed pulses from an MPC, which can also be used for ultrafast UV generation. The setup will carry out pump-probe measurements of biomolecules in water clusters, using XUV-near infrared (NIR) interaction. The setup features also a time-compensating monochromator, with possibility to switch between monochromatic and broadband operation dynamically.

K 3.5 Mon 18:15 HS XI ITW

Resonantly Enhanced Frequency Conversion at High Intensities towards the Vacuum Ultraviolet — •Marietta Coelle, Oskar Ernst, and Thomas Halfmann — Technische Universität Darmstadt

Vacuum Ultraviolet (VUV) light is of big interest for a variety of applications like lithography, attosecond physics or spectroscopy. One approach to generate coherent VUV is the nonlinear frequency upconversion of visible light provided by pulsed laser sources in noble gases. Due to low particle densities and higher order nonlinearity, the conversion efficiencies are generally small. This can be counteracted by increasing the laser intensity as well as by increasing the nonlinear susceptibility when using multi-photon resonances. However, high-power laser systems mostly have a fixed wavelength why it is difficult to find suitable resonances. At intensities above TW/cm^2, additionally, AC stark shifts alter the atomic level structure significantly. We present a way to make use of these shifts. Coupling an additional control transition gives rise to large, intensity-dependent Autler-Townes splittings and by adjusting the control laser intensity, the resonance of the atom can then be shifted towards the frequency of an initially off-resonant multi-photon transition. Specifically, we present a coupling scheme in xenon which only uses one single, fixed-frequency laser, paving the way to efficiently generate VUV light of 100 to 130 nm with compact, fixed-frequency, high-power laser systems.

K 4: Photonics (3D Print) (joint session Q/K)

Time: Monday 17:00–19:00 Location: HS V

K 4.1 Mon 17:00 HS V

Lateral Shear Interferometry for Wavefront Measurements of 3D-Printed Micro-Optics — •Yanqiu Zhao, Lunwei Wang, Jan-Niklas Bauer, Leander Siegle, Julian Schwab, Florian Mangold, and Harald Giessen — 4th Physics Institute and Stuttgart Research Center of Photonic Engineering, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

3D-printed micro-optics offer distinct advantages in terms of precision and compact size, enabling them to navigate narrow human tissues, including arteries, to capture clear images of their surroundings. This capability necessitates a meticulous quality control process, not only of the lens shapes, but also of the propagating wavefronts.

Thus, we carry out such measurements on 3D-printed micro-optics to assess their quality comprehensively. Wavefront measurements provide a more holistic evaluation of the micro-optics performance when compared to conventional shape measurements. The micro-optics used in our study are fabricated using a Nanoscribe Quantum X and are printed directly on substrates or on optical fibers, also comparing simple 2-photon printing with 2-photon gray scale lithography.

We demonstrate consistent and precise wavefront measurements using a simple shear plate interferometer setup. Unlike direct wavefront measurements, shear interferograms reveal the spatial wavefront derivative. By analyzing the interferogram fringes, we extract wavefront information that can be fed back into the design process within an iterative loop. This process supports quality improvement for 3D-printed micro-optics.

K 4.2 Mon 17:15 HS V

Complex light fields produced by 3D-printed computer-generated hologram on fiber — •Zihao Zhang[1], Leander Siegle[1], Pavel Ruchka[1], Daniel Flamm[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany — [2]TRUMPF Laser- und Systemtechnik GmbH, Ditzingen, Germany

Non-Gaussian beams are pivotal in numerous scientific and industrial applications, including multi-atom trapping and laser-based material processing. Holographic optical elements can be employed to generate beams with specific intensity distributions. For instance, multiple Gaussian foci can be precisely positioned within three-dimensional space for optical trapping, and the intensity distribution of a Gaussian beam can be modified into various forms for material processing. Despite their utility, many beam-shaping optics are often complex and bulky. Certain applications necessitate solutions that are not only compact and straightforward but also adaptable and capable of rapid adjustments. In this study, we leverage the state-of-the-art technology of two-photon grayscale polymerization (2GL) to create customizable and precise optical elements on a microscale. Here, we present a 3D-printed on-fiber beam shaper, whose design enables the efficient generation of a three-dimensional distribution of 30 foci along a trefoil optical knot using a highly flexible fiber device.

K 4.3 Mon 17:30 HS V

Millimeter-sized 3D Printed Optics by Two-Photon Grayscale Lithography — •Leander Siegle and Harald Giessen — 4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We demonstrate millimeter-sized optics for focusing and imaging applications fabricated by two-photon grayscale lithography (2GL). Typical sizes of 2GL 3D printed lenses have previously been limited to the sub-millimeter range. Using low-magnification objectives in combination with high photo-initiator density resists, we fabricate aspherical lenses with diameters of 1 to 5 mm. Compared to the typical two-photon polymerization fabrication process, 2GL offers better shape accuracy, while simultaneously increasing throughput. To showcase 2GL fabricated millimeter-sized lenses, we design, 3D print, and optimize high-numerical aperture singlet lenses for focusing and imaging in the visible and near-infrared. We determine the shape accuracy and analyze the optical performance. Furthermore, we investigate a singlet lens for imaging and examine the high-resolution performance with a USAF 1951 resolution test chart. 2GL 3D printed lenses offer toolless rapid prototyping for custom optical solutions in the micron to millimeter range.

K 4.4 Mon 17:45 HS V

Near-infrared Laser damage in 3D printed microoptics — •Sebastian Klein, Pavel Ruchka, Tobias Steinle, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

In recent years, two-photon-polymerization (2PP) 3D printing has seen a significant rise in importance in the field of microoptics, delivering high precision free-form optics with a low manufacturing cost compared to conventional fused silica microoptics. Applications range from biomedical imaging systems such as endoscopes, to employment in compact high-power fiber-based laser systems and material processing using diffractive optical elements for customized beam shaping. For the latter, high reliability and performance even under high power densities are essential.

In this work, we quantify femtosecond laser-induced damage in the 2PP photoresists IP-S and OrmoComp by microscope imaging cube samples irradiated with different wavelengths and fluences. By incorporating the more sensitive differential interference contrast (DIC) imaging technique, we determine damage thresholds of these photopolymers in the NIR spectral range. Furthermore, we introduce a novel approach for damage detection surpassing the sensitivity of DIC microscopy. With this approach, the damaging effects of telecom C-band radiation after multiple hour exposures are studied, giving a first look at the long-time high-power stability of the polymers.

K 4.5 Mon 18:00 HS V

3D printed high NA micro-optics for quantum applications — •Pavel Ruchka[1], Sara Jakovljevic[1], Nam Tran[2], Carlos Jimenez[3], Simone Luca Portalupi[2], Michael Jetter[2], Alois Herkommer[3], Stephan Reitzenstein[4], Sven Höfling[5], Caspar Hopfmann[6], Peter Michler[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart — [2]Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, University of Stuttgart — [3]Institute for Applied Optics and Research Center SCoPE, University of Stuttgart — [4]Institute of Solid State Physics, Technische Universität Berlin — [5]Technische Physik, University of Würzburg — [6]Deutsche Telekom Chair of Communication Networks, TU Dresden

3D-printed micro-optics made with two-photon polymerization have revolutionized fields like imaging, sensing, and illumination. This method allows the creation of complex miniature freeform shapes for mechanical and optical uses with high precision, opening up new possibilities for advanced technology. In this work, we present a novel approach to 3D-printed high numerical aperture (NA) micro-optics on optical fibers, targeting applications such as quantum communication and trapped-atom quantum computing. We fabricate shape-optimized refractive and diffractive lenses with NA values as high as 0.8 and characterize their performance through beam profiling. Additionally, we demonstrate the successful coupling of quantum dots at wavelengths of 780 nm and 1550 nm to corresponding single-mode fibers, enabled by these high-NA 3D-printed micro-optics.

K 4.6 Mon 18:15 HS V

3D printed micro-sized dark-field condenser by two photon polymerization — •Robert Horvat[1], Leander Siegle[1], Pavel Ruchka[1], Michael Schmid[2], Lukas Weseman[3,4], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Printoptix GmbH, Nobelstraße 15, 70569 Stuttgart, Germany — [3]School of Physics, The University of Melbourne, Victoria 3010, — [4]ARC Centre of Excellence for Transformative Meta-Optical Systems, School of Physics, The University of Melbourne, Victoria 3010, Australia

We demonstrate a miniaturized fully 3D printed dark field condenser for microscopy applications. Dark field microscopy is a simple but effective technique for contrast enhancement that allows imaging of transparent samples, useful in bio-medicine. Usually, microscope setups are bulky and costly. Our approach miniaturizes the system to the micro- and millimeter size, while allowing rapid prototyping and quick adaptation for individual system integration. We realise this by using two photon polymerization to 3D print two photoresists on both sides of a microscope glass slide. We first fabricate an annular ring aperture from a highly absorptive photoresist on one side of the glass slide with diameters between 300 and 2000 micrometers. Next we print a high numerical aperture lens within the same diameter range on the other side of the glass slide. We use the 3D printed dark field condenser to illuminate different samples, such as a USAF 1951 resolution test chart, and compare its performance to the typical bright field illumination.

K 4.7 Mon 18:30 HS V

Broadband Mode Division Multiplexing of OAM-Modes by a Micro Printed Waveguide Structure — •Julian Schulz[1] and Georg von Freymann[1,2] — [1]Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Fraunhofer Institute for Industrial Mathematics ITWM, 67663 Kaiserslautern, Germany

To utilize the orthogonal mode space of OAM-modes to increase the amount of information throughput for optical fibers, an efficient and compact device to create, superimpose and to decompose OAM-Modes is needed We present as a proof of principle a waveguide structure, which transformations the eigenmodes from spatially separated single mode waveguides adiabatically into modes of a ring waveguide carrying $|\mathrm{OAM}| \leq 2$. In an adiabatic evolution, the population of the eigenmodes remains constant while the eigenmodes change according to the system. Two mechanisms are utilized to maintain the propagation constants of each individual mode consistently spaced during the propagation thou the structure: Individual waveguides are detuned by changing their radius and an artificial magnetic field is introduced by twisting the structure. The inherent tolerance of an adiabatic evolution allows our device to operate effectively across a wide spectrum of wavelength. Besides that, it can also be used as a demultiplexing structure, if the adiabatic evolution is run backwards. We demonstrate the capabilities of the structure with BPM-simulations and experiments with a polymer waveguide structure fabricated via direct laser writing. [*Advanced Optical Materials* **12**, 2302597, (2024)]

K 4.8 Mon 18:45 HS V

Fiber-based femtosecond 3D printing — •Anton Hellstern[1], Claudia Imiolczyk[1], Pavel Ruchka[1], Marco Wende[2], Theresa Kühn[3], Moritz Flöss[1], Michael Heymann[3], Andrea Toulouse[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Germany — [2]Institute of Applied Optics, University of Stuttgart, Germany — [3]Institute of Biomaterials and Biomolecular Systems, University of Stuttgart, Germany

Ultrashort laser pulses are often used in medical applications, for instance for soft-tissue surgeries. However, the progress on using such laser pulses for additive manufacturing of tissue is rather marginal so far. Therefore, we aim to realize an endoscopic fiber-based femtosecond 3D printer to minimally invasively surgically repair organ damage on a micrometer scale. For this, high peakpower femtosecond laser pulses are required, in order to 3D print the desired geometries using two-photon-lithography. By combining a grating compressor, a single-mode fiber, and suitable 3D printed microobjetives directly on the fiber tip, we achieve subpicosecond pulse durations which are able to polymerize both commercial photopolymers as well as bioinks. We report on dose tests, the optimization of printing speed, laser power, pulse compression ratio and pulse duration, as well as slicing and hatching variation. We demonstrate solid cubes as well as connected lines, leading to 3D woodpile structures that represent scaffolds which ultimatively could be colonized by living cells. This direct printing of cell scaffolds by endoscopic 3D printing should allow in the future for example printing of bone tissue inside the body.

K 5: Laser-Beam Matter Interaction – Light and Radiation Sources II

Time: Tuesday 11:00–12:15 Location: HS XI ITW

Invited Talk K 5.1 Tue 11:00 HS XI ITW

Fundamental investigations on the ablation of thin metallic films upon irradiation with ultrafast laser radiation — •Alexander Horn, Theo Pflug, Andy Engel, and Markus Olbrich — Laserinstitut Hochschule Mittweida

Understanding the fundamental processes of ablation induced by the irradiation with ultrafast laser radiation represents the key parameter in explaining the results of laser-material processing. By combining our complementary ultrafast metrology such as pump-probe imaging reflectometry, interferometry, and spectroscopy the dynamic of ablation can be determined by measuring the change of the optical properties from the femtosecond up to the microsecond range. Additionally, a modeling of the interaction of the laser radiation with the material must be performed to assign the changes of the optical properties to physical processes such as excitation of the electron system, generation of shockwaves, spallation, and phase explosion or the expansion of the induced ablation plume. The modeling includes the two-temperature model in combination with the hydrodynamics (TTM-HD) as well as the beam propagation of the probe radiation.

K 5.2 Tue 11:30 HS XI ITW

Investigations on the ablation and the irreversible material changes of single-crystalline silicon irradiated with ultrashort pulsed laser radiation — •Andy Engel, Markus Olbrich, Theo Pflug, and Alexander Horn — Laserinstitut Hochschule Mittweida, Hochschule Mittweida, Technikumplatz 17, 09648 Mittweida, Germany

In this study the irradiation of single-crystalline, <111> -oriented silicon is investigated by varying the fluence of the applied ultrashort pulsed laser radiation (pulse duration 40 fs, wavelength 800 nm) and the number of single pulses per spot. The resulting irreversible material changes due to the laser radiation-matter interaction are presented and discussed. These material changes were observed by measuring the spatial- and spectral-resolved refractive index using ex-situ ellipsometry and SEM analyses. Comparative analyses of the topography of the irradiated surfaces were performed using confocal laser scanning microscopy and atomic force microscopy. Additional information about the depth of the thermally induced material phase changes have been obtained by downstream wet chemical etching. The ex-situ analyses were supported by ultrafast metrology, pump-probe imaging reflectometry and interferometry as well as optical modeling and simulations of the laser-matter interaction. This complementary approach enables a more accurate description of the physical processes induced by ultrashort pulsed laser irradiation, starting from changes in crystallinity up to ablation.

K 5.3 Tue 11:45 HS XI ITW

GASFIR: How to retrieve the dynamics of strong-field ionization from ionization probabilities — •Manoram Agarwal[1] and Vladislav Yakovlev[2] — [1]Max Planck Institute of Quantum Optics — [2]Ludwig-Maximilians-Universität München

We introduce the General Approximator for Strong-Field Ionization Rates (GASFIR), a model that reconstructs nonadiabatic, sub-optical-cycle ionization dynamics for an arbitrary optical pulse impinging on an atom or solid. This reconstruction uses only a few ionization probabilities for precisely known electric fields as input. These probabilities can be obtained from numerical calculations or experimental measurements, highlighting the non-trivial fact that ionization probabilities contain sufficient information to reconstruct the underlying dynamics. Due to its nonadiabatic nature, GASFIR is applicable to multiphoton and tunneling ionization, as well as the intermediate regime.

K 5.4 Tue 12:00 HS XI ITW

Ultra-Narrowband Coherent THz Source for Quantum Control and Advanced Spectroscopy Applications — Peng Han[1], Steven. L. Johnson[1,2], and •Biaolong Liu[1] — [1]Pump laser group, laboratory of nonlinear optics, center of photon science, Paul Scherrer Institute — [2]Institute of quantum electronics, Department of physics, ETH Zürich

The development of compact terahertz (THz) sources capable of generating high field strengths (>100 kV/cm) with narrow bandwidth (<10%) has become crucial for manipulating functional properties in quantum materials by selectively activating specific low-energy excitations. In fact, many collective modes have linewidths below 100 GHz. Moreover, the spacing between first neighboring modes can be in the same order of the linewidths. Thus, there is a high demand on THz pulses with even narrower bandwidth (<3%). However, this remains challenging, especially within the 3-15 THz range, commonly referred to as the "THz gap". Here, we present a tabletop, ultra-narrowband (<3% bandwidth) THz source, capable of delivering sub-microjoule, carrier-envelope-phase stable, transform-limited transients tunable between 3 and 4 THz, utilizing a chirped-pulse DFG approach. This source will be ideal to create entangling gates in nanostructured semiconductors by optically manipulating the quantum states of Rydberg atoms for quantum information processing. This novel, coherent THz source holds promise not only for quantum device integration but also as a valuable resource for large-scale solid-state research and, potentially, time-resolved studies in chemistry and biology.

K 6: Poster

Time: Tuesday 14:00–16:00 Location: Tent

K 6.1 Tue 14:00 Tent

Ultrafast Spectroscopy Reveals Spin-Crossover Behavior in Nanometric Thin Films — •Raluca Denisa Coltuneac[1], Maciej Lorenc[2], Nicolas Godin[2], Cristian Enachescu[1], and Laurentiu Stoleriu[1] — [1]Faculty of Physics Alexandru Ioan Cuza University of Iasi, Iasi, Romania — [2]Institute of Physics (IPR), Rennes, France

This study examines thermal and spin-crossover (SCO) dynamics in nanometric thin films under laser irradiation. Using$[Fe(HB(tz)_3)_2](tz = 1,2,4 - triazol - 1 - yl)$ complexes we combine analytical and experimental approaches to explore heat diffusion and SCO transitions.

A Fourier-based heat conduction model incorporates thermal conductivity and laser-induced heating across 2D and 3D geometries, revealing how system shape affects heat dissipation. SCO dynamics were analyzed with femtosecond transient absorption spectroscopy (fs-TAS), tracking spin-state transitions in thermally evaporated thin films on silica. The bistable spin behavior, studied under UV-visible excitation, showed strong links between thermal and light-induced transitions, with spectral control achieved through pump-probe delay adjustments.

These findings advance understanding of nanoscale SCO behavior, offering insights for thermal and optical applications in advanced materials.

K 6.2 Tue 14:00 Tent

Time-, space- and spectral-resolved characterization of the ablation plume generated with ultrafast laser radiation — •Phillip Börner, Markus Olbrich, Andy Engel, and Alexander Horn — Laserinstitut Hochschule Mittweida, 09648 Mittweida, Germany

The knowledge of the size and density of the ablation plume generated by ultrafast laser radiation represents a key parameter to understand the interaction of multi-pulsed ultrafast laser radiation with matter particularly in the case of applying bursts of ultrafast laser radiation with pulse separation times of several 100 ps up to a few ns within the burst. A complementary experimental setup combining pump-probe imaging reflectometry, interferometry, and spectroscopy is presented. This setup enables the measurement of space- and spectral-resolved changes in intensity over time, allowing the calculation of changes in the optical properties and geometrical shape of the material surface as well as of the induced ablation plume. Based on these changes, the excitation of the electron system and the generation of the ablation plume is determined by reflectometry and interferometry within the first nanoseconds after the irradiation. The emission of the ablation plume is measured by the combination of an imaging spectrograph coupled with an em-ICCD camera for later timescales. Therefore, this setup enables a detailed understanding of laser-matter-interaction, especially in describing the ablation plume.

K 6.3 Tue 14:00 Tent

Ping-Pong with microparticles — •Krishna Kant Singh[1,2], Ajitesh Singh[2], Deepak Kumar[2], and Debabrata Goswami[2,3] — [1]Department of Physics, University of Kassel, Germany — [2]Department of Chemistry, Indian Institute of Technology Kanpur, India — [3]Centre for Lasers and Photonics, Indian Institute of Technology Kanpur, India

Optical tweezers [1] have become a versatile and potent instrument in the realms of experimental physics, biology, and nanotechnology, allowing for the manipulation of particles ranging from micrometres to nanometres. While the use of high-repetition-rate ultrafast lasers has garnered significant attention, particularly in nanoparticle manipulation, low-repetition-rate lasers have not received comparable recognition due to challenges in achieving stable trapping. Seeking further insights, we employed an amplified kHz laser source in an optical tweezers setup for the first time, yielding intriguing findings. Our results demonstrated distinct particle behaviours compared to conventional optical tweezers, showcasing a ping-pong motion within an optically confined zone. Moreover, we achieved the successful dragging and trapping of particles from considerable distances by synergizing an amplified kHz beam with a MHz beam, a phenomenon not observed in traditional optical tweezers setups.

References [1]A. Ashkin, J. M. Dziedzic, J. E. Bjorkholm, and S. Chu, "Observation of a single-beam gradient force optical trap for dielectric particles," Opt. lett., vol. 11, no. 5, pp. 288-290, 1986.

K 6.4 Tue 14:00 Tent

A passive laser gyroscope for Earth rotation monitoring — •Tessa Koch, Jannik Zenner, and Simon Stellmer — Physikalisches Institut, Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany

Active ring lasers have been the leading variant in detecting subtle earth rotation variations influenced by diverse geophysical processes across a wide spectrum of frequencies. On the other hand, passive laser gyroscopes are still a far less advanced concept. By placing the gain medium outside of the optical resonator, the passive variant removes many of the systematic limitations of active gyroscopes, and holds the potential to increase sensitivity. We will report on the current status of a unique setup that can be operated both actively and passively, with the goal of characterizing both operation concepts.

K 6.5 Tue 14:00 Tent

Ultrafast Detection of Quantum Emitters at High Repetition Rates — •Amr Farrag[1], Assegid Mengistu Flatae[1], Amir Ashjari[2], Doris Möncke[2], and Mario Agio[1,3] — [1]Laboratory of Nano-Optics and Cμ, University of Siegen, 57072 Siegen, Germany — [2]Inamori School of Engineering at the New York State College of Ceramics, Alfred University, Alfred, New York 14802, USA — [3]National Institute of Optics (INO), National Research Council (CNR), 50125 Florence, Italy

Single-photon sources have become essential for quantum science and for quantum-based technologies. Detection of ultrafast quantum emitters is currently limited by the temporal resolution of time-correlated single-photon counting (TCSPC) down to a few ps. Nonlinear sampling techniques such as optical Kerr gate (OKG) can offer sub-ps temporal resolution. Here, we present OKG experiment with Bismuth Borate Silicon Dioxide (BBS) glass and Graphene as a Kerr media, using a gate laser beam at 1 GHz repetition rate, thereby allowing addressing ultrafast single-photon emitters.

K 6.6 Tue 14:00 Tent

Interferometric Visualization of High-Power Standing Ultrasound Fields — •Regina Schuster[1], Murat-Jakub Ilhan[1], Marius Foith[1], Jan Helge Dörsam[2], Christoph Haugwitz[2], Class Hartmann[2], Sören Soennecken[2], Yannick Schrödel[3,4], Christoph M. Heyl[3,4], Mario Kupnik[2], and Anne Harth[1] — [1]ZOT, AASAP, Aalen University, Aalen, Germany — [2]TU Darmstadt, Darmstadt, Germany — [3]DESY, Hamburg, Germany — [4]Helmholtz Institute, Jena, Germany

The contactless and diffraction-based deflection of laser beams in air [1] requires the use of high-power standing ultrasound fields [2]. Consequently, a non-invasive and detailed characterisation of these intense sound fields is imperative.

In this work, we present a two-dimensional imaging technique for the interferometric visualisation of standing ultrasound fields. The modulation of air pressure induced by sound waves changes the refractive index of air, which can be quantitatively measured using an interferometer. This method enables the two-dimensional acquisition of complex sound field distributions generated by high-power ultrasound transducers in a single measurement.

[1] Y. Schrödel, *et. al., Nature Photonics,* vol. 18, no. 1, pp. 54-59, 2024

[2] A. Jäger, *et. al., 2017 IEEE International Ultrasonics Symposium,* pp. 1-4, 2017

K 6.7 Tue 14:00 Tent

Terahertz-Induced Nonlinear Response in ZnTe — •Felix Selz[1,2,3], Johanna Kölbel[2], Felix Paries[1], Georg von Freymann[1,3], Daniel Molter[1], and Daniel M. Mittleman[2] — [1]Fraunhofer Institute for Industrial Mathematics ITWM, Department Materials Characterization and Testing, 67663 Kaiserslautern, Germany — [2]School of Engineering, Brown University, Providence, Rhode Island 02912, USA — [3]Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Ger-

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Measuring terahertz waveforms in terahertz spectroscopy often relies on electro optic sampling employing a ZnTe crystal. Although the nonlinearities in such zincblende semiconductors induced by intense terahertz pulses have been studied at optical frequencies, the manifestation of nonlinearity in the terahertz regime has not been reported. In this work, we investigate the nonlinear response of ZnTe in the terahertz frequency region utilizing time-resolved terahertz-pump terahertz-probe spectroscopy. We find that the interaction of two copropagating terahertz pulses in ZnTe leads to a nonlinear polarization change which modifies the electro-optic response of the medium. We present a model for this polarization that showcases the second-order nonlinear behavior. We also determine the magnitude of the third-order susceptibility in ZnTe at terahertz frequencies, $\chi^{(3)}(\omega_{\mathrm{THz}})$. These results clarify the interactions in ZnTe at terahertz frequencies, with implications for measurements of intense terahertz fields using electro-optic sampling.

K 6.8 Tue 14:00 Tent

Exploring Intensity Correlations in Strong-Field Frequency Conversion — •Carlo Kleine, Mohamed Attia, Hannah Schlenker, Christian Ott, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

The interaction of light with matter using short, intense laser pulses is a key focus in many areas of research. These pulses enable the investigation of electronic and nuclear dynamics in atoms and molecules, as well as the active control of small quantum systems. Typically, these interactions have been successfully described using a classical electromagnetic field. However, recent experimental findings highlight the necessity of a quantum mechanical description of the field, particularly in extreme nonlinear processes such as high-order harmonic generation (Tsatrafyllis et al, Nat. Commun. 8(1) 2017). This has been demonstrated by investigating the anticorrelation between the transmitted intensity of the driving near-infrared (IR) and the generated extreme ultraviolet (XUV) light. These studies emphasize the importance of exploring intensity correlations in strong-field frequency conversion processes. In this poster, the intensity correlation between perturbative harmonics in the visible and near IR is investigated and analyzed, focusing on both correlation and anticorrelation.

K 6.9 Tue 14:00 Tent

A Dual-driven Hard X-ray Source as Benchmark for High Brilliance Lab-based X-ray Generation — •Lion Günster, Luka Petersen, Jose Mapa, Greta Paruschke, Philip Mosel, Sven Fröhlich, Andrea Trabattoni, Uwe Morgner, and Milutin Kovacev — Leibniz Universität Hannover - Institut für Quantenoptik, Hannover, Deutschland

Conventional X-ray sources have been stagnating in terms of brightness. Melting of target or anode material caused by the electron beam limits conventional sources to a brilliance of $< 10^{10}$ Photon/s mrad^2 mm^2. However, it has been proposed that secondary sources could be the key to advance lab based hard x-ray sources and with the rapid improvements of high energy short pulsed lasers promising results have been achieved.

In my poster I will demonstrate the construction of an apparatus that employs a Galinstan liquid metal jet as target material and allows the switching between an electron beam and a laser produced plasma (LPP) to drive the generation of x-rays without modifying any other experimental parameters. In that way, the apparatus allows a direct comparison between conventional and secondary x-ray sources, which has not been conducted yet.

K 6.10 Tue 14:00 Tent

Laser-Driven X-ray Sources — •Luka Petersen, Lion Günster, Jose Mapa, Greta Paruschke, Philip Mosel, Sven Fröhlich, David Schmitt, Uwe Morgner, Andrea Trabattoni, and Milutin Kovacev — Leibniz University Hannover, Institute of Quantum Optics, Germany

The field of X-ray imaging has gained increasing attention in recent years due to its applications in the medical and industrial sectors. Advancements in this field have enabled to resolve increasingly smaller structures within shorter time frames. However, high-intensity and especially pulsed X-ray sources are usually only available in large-scale facilities.[1]

Here we present our current development of a table-top laser-based high-repetitive X-ray source. The setup is based on the concept of laser-produced plasma (LPP) driven by a high-power laser system that is focused on a liquid metal jet target. The produced plasma consequently emits a strong X-ray burst. The aim is to enhance brilliance and coherence compared to conventional X-ray sources, such as X-ray tubes. This is possible as lasers can achieve much smaller focal spots than electron beams. In first benchmark experiments we will compare different target geometries in terms of photon numbers, X-ray source sizes, debris and handling.

[1] Robert Schoenlein et al., Recent advances in ultrafast X-ray sources 2019, http://doi.org/10.1098/rsta.2018.0384

K 6.11 Tue 14:00 Tent

Debris Detection and Mitigation for Laser-Produced Plasma X-ray Sources — •Greta Paruschke, Lion Günster, Luka Petersen, Jose Mapa, Philip Mosel, Sven Fröhlich, Andrea Trabattoni, Uwe Morgner, and Milutin Kovacev — Leibniz Universität Hannover, Hannover, Germany

Laser produced plasmas (LPP) can produce large amounts of X-rays. X-ray sources from metal based LPPs have several advantages e.g. a high flux and small source point. However, in Laser-based X-ray sources debris production leads to limitations of the performance by degrading components in the proximity of the interaction area. This is unavoidable making efficient debris shielding necessary.

Debris particles come in the form of vapor, ions, dust, and high-speed particles as unwanted byproducts of the plasma that degrade the surface of optics, resulting in lower reflectivity and potential damages on the optic. Mitigation techniques differ depending on the debris composition and source geometry, making each source unique. To fully use the benefits of LPP sources, choosing the appropriate shielding is essential to minimize the degradation of the focusing optics and maintain a high photon flux.

Here we investigate methods to evaluate the composition of debris from our LPP source regarding its particle size and speed distribution. Furthermore, approaches for debris mitigation are presented and evaluated.