Short Time-scale Physics and Applied Laser Physics Division
Fachverband Kurzzeitphysik (K)

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Overview of Invited Talks and Sessions

(Lecture rooms MB HS; Poster Wassersaal)

Invited Talks

K 1.1	Mon	14:00–14:40	MB HS	**Abklingzeit, Zufall und Information** — •Rudolf Germer
K 2.1	Mon	16:15–16:45	MB HS	**Leistungsfähigkeit und Entwicklungsrichtungen moderner Bildsensoren und Kamerasysteme** — •Gerhard Holst
K 3.1	Tue	14:00–14:30	MB HS	**Glass joining by ultra-short pulsed lasers** — •Kristian Cvecek, Johannes Heberle, Isamu Miyamoto, Michael Schmidt
K 4.1	Wed	14:00–14:30	MB HS	**Experimental Results from the Development of a Triggered Vacuum Switch (TVS) at the Pohang Accelerator Laboratory (PAL)** — •Klaus Frank, Wung Hoa Park, Suk Ho An, Byung Joon Lee

Invited Talks of the Internal Symposium Optic Coatings and Plasma Technology

K 7.1	Thu	10:30–11:00	MB HS	**A global model for radio frequency magnetron sputtering processes** — •Dennis Engel, Laura Kroll, Ralf Peter Brinkmann
K 7.2	Thu	11:00–11:30	MB HS	**The Multipole Resonance Probe as a powerful diagnostic tool for industrial plasma processes** — •Moritz Oberberg, Stefan Ries, Christian Wölfel, Jens Harhausen, Dennis Pohle, Christian Schulz, Oliver Schmidt, Wladislaw Dobrygin, Ilona Rolfes, Ralf Peter Brinkmann, Peter Awakowicz
K 7.3	Thu	11:30–12:00	MB HS	**Prospects for the enhancement of PIAD processes by monitoring of optical thickness and plasma parameters** — •Jens Harhausen, Rüdiger Foest, Margarita Baeva, Detlef Loffhagen, Olaf Stenzel, Steffen Wilbrandt, Christian Franke, Norbert Kaiser, Ralf Peter Brinkmann
K 7.4	Thu	12:00–12:30	MB HS	**Stabilisierung von Rate und Schichtdickenuniformität im IBS-Prozess über adaptiv geregelte Prozessparameter** — •Florian Carstens, Henrik Ehlers, Detlev Ristau
K 7.5	Thu	12:30–13:00	MB HS	**Structural and optical properties of virtual materials** — •Holger Badorreck, Marco Jupé, Detlev Ristau

Invited talks of the joint symposium SYPS

See SYPS for the full program of the symposium.

SYPS 1.1	Mon	14:00–14:30	RW HS	**Floquet engineering of interacting quantum gases in optical lattices** — •André Eckardt
SYPS 1.2	Mon	14:30–15:00	RW HS	**Experiments on driven quantum gas and surprises** — •Cheng Chin
SYPS 1.3	Mon	15:00–15:30	RW HS	**Exploring 4D Quantum Hall Physics with a 2D Topological Pumps** — •Oded Zilberberg, Michael Lohse, Christian Schweizer, Immanuel Bloch, Hannah Price, Yaacov Kraus, Sheng Huang, Mohan Wang, Kevin Chen, Jonathan Guglielmon, Mikael Rechtsman

SYPS 1.4	Mon	15:30–16:00	RW HS	**Floquet Discrete Time Crystals in a Trapped-Ion Quantum Simulator** — •Guido Pagano, Jiehang Zhang, Paul Hess, Antonis Kyprianidis, Patrick Becker, Jacob Smith, Aaron Lee, Norman Yao, Tobias Grass, Alessio Celi, Maciej Lewenstein, Christopher Monroe

Invited Talks of the Joint Symposium SYAD

See SYAD for the full program of the symposium.

SYAD 1.1	Tue	10:30–11:00	RW HS	**Integrated photonic quantum walks in complex lattice structures** — •Markus Graefe
SYAD 1.2	Tue	11:00–11:30	RW HS	**Testing the Quantumness of Atom Trajectories** — •Carsten Robens
SYAD 1.3	Tue	11:30–12:00	RW HS	**Engineering and probing topological bands with ultracold atoms** — •Nick Fläschner
SYAD 1.4	Tue	12:00–12:30	RW HS	**Statistical signatures of many-particle interference** — •Mattia Walschaers

Invited Talks of the Joint Symposium SYPT

See SYPT for the full program of the symposium.

SYPT 1.1	Thu	10:30–11:00	M 00.910	**Pseudospark Research in Southern California** — •Martin Gundersen
SYPT 1.2	Thu	11:00–11:30	M 00.910	**Features of a hollow-cathode discharge in pseudospark switches** — •Yuri Korolev
SYPT 1.3	Thu	11:30–12:00	M 00.910	**Overview of R&D Activities on Vacuum and Gas Discharges and Their Applications in South Korea** — •Sang Hoon Nam
SYPT 1.4	Thu	12:00–12:30	M 00.910	**Plasma Stripper, Plasma Window, Plasma Gun as Applications of Discharge Plasmas** — •Joachim Jacoby
SYPT 2.1	Thu	14:00–14:30	M 00.910	**Plasmaphysical Basics of Vacuum Switching Devices for High Currents and Voltages** — •Norbert Wenzel
SYPT 2.2	Thu	14:30–15:00	M 00.910	**Discharge inception and breakdown in weakly and strongly electronegative gas in HV switchgear applications** — •Martin Seeger
SYPT 2.3	Thu	15:00–15:30	M 00.910	**Plasma Technological Research for Electrical Engineering and Medicine** — •Dirk Uhrlandt
SYPT 2.4	Thu	15:30–16:00	M 00.910	**Progress in Understanding Arc-Electrode Interaction** — •Jürgen Mentel

Sessions

K 1.1–1.6	Mon	14:00–15:55	MB HS	**Optical Methods - EUV and x-ray Sources**
K 2.1–2.5	Mon	16:15–17:45	MB HS	**Optical Methods - Light and Radiation Sources**
K 3.1–3.7	Tue	14:00–16:00	MB HS	**Laser Systems and Applications**
K 4.1–4.6	Wed	14:00–15:45	MB HS	**Pulsed Power - Laser-Beam Matter Interaction**
K 5	Wed	15:45–16:00	MB HS	**Annual General Meeting of the Short Time-scale Physics and Applied Laser Physics Division**
K 6.1–6.9	Wed	16:15–18:15	Orangerie	**Poster**
K 7.1–7.5	Thu	10:30–13:00	MB HS	**Internal Symposium Optic Coatings and Plasma Technology**

Annual General Meeting of the Short Time-scale Physics and Applied Laser Physics Division

Mittwoch 15:45–16:00 Raum M HS

- Bericht des Vorsitzenden
- Tagungsplanung
- Verschiedenes

K 1: Optical Methods - EUV and x-ray Sources

Time: Monday 14:00–15:55 Location: MB HS

Invited Talk K 1.1 Mon 14:00 MB HS
Abklingzeit, Zufall und Information — •Rudolf Germer — ITPeV, Berlin — TU-Berlin

Welche Rolle spielt Informationen als physikalische Größe? Um einer Antwort auf diese Frage näher zu kommen, wollen wir uns im folgenden Beitrag mit der Abklingzeit fluoreszierender Atome beschäftigen. Solche Fluoreszenz ist ohne Zweifel vom Zufall begleitet, wir können nicht vorhersagen, welches Atom von den angeregten zu welcher Zeit seine Energie abgibt, nur das Verhalten von vielen Atomen kann global beschrieben werden. Parallel dazu können wir das Entladen von einem großen oder vielen kleinen Kondensatoren betrachten und im Vergleich feststellen, auf welche Art Energie und Information zusammengehören. Ergänzt mit Würfelexperimenten kann man schließlich sehen, an welcher Stelle Naturgesetze ihre Wirkung zeigen und wie der Zufall eine Brücke zwischen der klassischen und der Quantenbeschreibung liefert.

K 1.2 Mon 14:40 MB HS
Narrow-band hard-x-ray lasing — •Chunhai Lyu, Stefano M. Cavaletto, Zoltán Harman, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We put forward a scheme to obtain a narrow-band x-ray laser by K-shell photoionization of Li-like highly charged ions in a laser-generated plasma. Ions of Ne, Ar, Kr and Xe have been examined. Numerical simulations show that the intensities of such x-ray lasers saturate within a few millimeters with transform-limited profiles. Such temporal coherences provide x-ray laser bandwidths up to three orders of magnitude narrower compared to the future seeded-XFEL sources in the hard x-ray regime.

K 1.3 Mon 14:55 MB HS
Ptychographic Wavefront Measurement of a High Harmonic Seeded Soft X-ray Laser — •Michael Zürch[1,2,3], Frederik Tuitje[1], Tobias Helk[1], Julian Gautier[4], Fabian Tissandier[4], Jean Philippe Goddet[4], Stephane Sebban[4], and Christian Spielmann[1,2] — [1]Institute of Optics and Quantum Electronics, Abbe Center of Photonics, Jena University, Jena, Germany — [2]Helmholtz Institute Jena, Jena, Germany — [3]Department of Chemistry, University of California, Berkeley, CA 94720, USA — [4]LOA, ENSTA, CNRS, Ecole Polytechnique, Universite Paris-Saclay, F-91762 Palaiseau cedex, France

Soft X-ray lasers (SXRL) are intense sources of quasi-monochromatic coherent short wavelength radiation with pulse durations of about 1 ps in a table top scheme. The beam quality of a SXRL can be significantly enhanced by seeding the X-ray amplifier with a laser-driven high harmonic generation (HHG) source. Here, we employ ptychographic coherent diffraction imaging for nanoscale imaging as well as measuring the complex-valued illumination function of a HHG-seeded SXRL operating at 32.8 nm wavelength with high fidelity. Backpropagation of the field allows determining source properties in unprecedented quality. We find that HHG seeding results in excellent spatial coherence properties, while a high degree of temporal coherence is maintained through the narrow-band amplification. The results suggest that HHG-seeded SXRL are combining high photon flux ($>10^{12}$ photons/shot) with excellent spatial and temporal coherence properties rendering it an ideal source for high resolution coherent X-ray imaging.

K 1.4 Mon 15:10 MB HS
Continuously wavelength-tunable high harmonics generation via soliton dynamics — •Francesco Tani[1], Michael H. Frosz[1], John J.C. Travers[1,2], and Philip St.J. Russell[1] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

Soliton dynamics offer a range of powerful tools for nonlinear manipulation of ultrashort light pulses. In gas-filled hollow-core photonic crystal fiber (HC-PCF), the weak anomalous dispersion supports solitons over a broad spectral range in the visible and infrared regions. By exploiting these dynamics, gas-filled HC-PCFs have been successfully used, within a broad range of laser wavelengths, for pulse self-compression down to single cycle durations and for upshifting the pulse central frequency. Here we combine a gas-filled HC-PCF with a gas-jet for high harmonic generation (HHG), driven by laser pulses of a few tens of micro-Joule, which undergo soliton self-compression in the fiber. We show that by exploiting the interaction of the soliton with free electrons created by ionization in the gas, we can continuously upshift the soliton frequency and as a result tune the frequency of the generated harmonics. In this way, we achieved a blue-shift of almost 3 eV, while keeping the ionization in the gas jet at a low level (high levels degrade the coherence of the harmonics). The high efficiency and low pulse energies suggest that this HHG scheme will open a new route to developing a tunable extreme ultraviolet sources that, uniquely, can easily be scaled to MHz repetition rates.

K 1.5 Mon 15:25 MB HS
Nanoscale magnetic imaging using high-harmonic radiation in the extreme-UV — •Ofer Kfir[1,2], Sergey Zayko[1], Christina Nolte[1], Murat Sivis[1], Marcel Möller[1], Birgit Hebler[3], Sri Sai Phani Arekapudi[3], Daniel Steil[1], Sascha Schäfer[1], Manfred Albrecht[3], Oren Cohen[2], Stefan Mathias[1], and Claus Ropers[1] — [1]University of Göttingen, Göttingen, Germany — [2]Technion, Haifa, Israel — [3]University of Augsburg, Augsburg, Germany

Pulsed extreme-UV (EUV) and X-ray beams offer a unique probe for element specific imaging of magnetic textures and their dynamics [1-3]. To date, such experimentas are available exclusively at synchrotrons and free-electron lasers, producing a high flux of coherent short-wavelength radiation with circular polarization.

Here, we demonstrate nanoscale magnetic imaging using high harmonic radiation. By controlling the circular polarization of the EUV beam [4], we harness resonant XMCD contrast of cobalt in a Co/Pd multilayer stack. We enhance the scattering signal by a strong auxiliary wave, comprised of multiple spatial waveguide modes [5]. The reconstructed image shows sub 50-nm spatial resolution. These results open the path towards an element-specific probing of magnetic dynamics at the nanometer- and femtosecond-scales, in a setup as compact as an optical table.

[1] Eisebitt, Nature, 432, 885 (2004) [2] Willems, Struct. Dynam. 4, 014301 (2017) [3] Büttner, Nat. Phys. 11 255 (2015) [4] Kfir, APL 108 211106 (2016) [5] Zayko, Opt. Exp. 23, 19911 (2015)

K 1.6 Mon 15:40 MB HS
Generation of microjoule pulses in the deep ultraviolet at megahertz repetition rates — •Felix Köttig[1], Francesco Tani[1], Christian Martens Biersach[1], John C. Travers[1,2], and Philip St.J. Russell[1] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK

Although ultraviolet (UV) light is important in many areas of science and technology, there are very few if any sources capable of delivering wavelength-tunable ultrashort UV pulses at high repetition rates. Dispersive wave (DW) emission from self-compressed solitons in gas-filled hollow-core photonic crystal fiber (PCF) provides a powerful approach, offering simple wavelength-tunability, low requirements on the pump energy and high conversion efficiency. We report the generation of deep UV pulses at megahertz repetition rates and microjoule energies by means of DW emission in gas-filled single-ring hollow-core PCF. Pulses from an ytterbium fiber laser (~300 fs) are first compressed to <25 fs in a single-ring PCF-based nonlinear compression stage and subsequently used to pump a second single-ring PCF stage for broadband DW generation in the deep UV. The UV wavelength is tunable by selecting the gas species and the pressure. Through rigorous optimization of the system, in particular employing a large-core fiber filled with light noble gases, we achieve 1 μJ pulse energies in the deep UV, which is more than 10 times higher, at average powers more than four orders of magnitude greater (reaching 1 W) than previously demonstrated, with only 20 μJ pulses from the pump laser.

K 2: Optical Methods - Light and Radiation Sources

Time: Monday 16:15–17:45 Location: MB HS

Invited Talk K 2.1 Mon 16:15 MB HS

Leistungsfähigkeit und Entwicklungsrichtungen moderner Bildsensoren und Kamerasysteme — •Gerhard Holst — PCO AG, Donaupark 11, 93309 Kelheim

Seit der Ankündigung der Firma Sony im Januar 2015, dass sie die Produktion von CCD (Charge Coupled Devices) Bildsensoren einstellen will hat sich der Fokus auf CMOS (Complementary Metal Oxide Semiconductors) Bildsensoren noch vergrössert. Seit dem letzten Überblick wurden einige neue Kamerasysteme mit mehr Empfindlichkeit oder besseren Leistungsdaten realisiert und auch im kommerziellen Bereich neue Konzepte vorgestellt, die möglicherweise auch in wissenschaftliche Kamerasysteme Einzug halten werden. Der Vortrag wird anhand von Beispielen einen Überblick hierzu geben und soweit möglich Resultate zeigen.

K 2.2 Mon 16:45 MB HS

Ptychographic reconstruction and characterization of optical vortices — •Frederik Tuitje[1,2], Michael Zürch[1,2], and Christian Spielmann[1,2] — [1]Institute for Optics and Quantum Electronics, Abbe Center of Photonics, Friedrich Schiller University Jena, Germany — [2]Helmholtz Institute Jena, Germany

Electromagnetic fields exhibiting helical phase profiles, so-called optical vortices (OV), are widely used in high-resolution imaging as structured light field, in spectroscopy to measure dipole-forbidden transitions and in particle manipulation. Recent research focusses on generating OV beams in the extreme ultraviolet regime via high harmonic generation [1]. In this spectral region, conventional beam characterization approaches for helical wavefronts are difficult to implement owing to the lack of efficient optical elements. Here, we present a method to fully characterize an optical vortex in amplitude and phase by employing ptychographic reconstructions following detection of a series of coherent diffraction patterns formed by a binary aperture. With this method, we can successfully reconstruct the helical phase of an OV yielding information about the topological charge, shape and size of the illuminating OV in unprecedented quality.

[1] Zürch, M.; Kern, C.; Hansinger, P.; Dreischuh, A.; Spielmann,C.: Strong-field physics with singular light beams. In: Nature Physics 8 (2012)

K 2.3 Mon 17:00 MB HS

Spatio-spectral analysis of ultrashort vortex pulses by radial meta-moments — •Max Liebmann[1], Alexander Treffer[1], Martin Bock[1], Thomas Seiler[2], Thomas Elsaesser[1], and Ruediger Grunwald[1] — [1]Max Born Institut for Nonlinear Optics and Short-Pulse Spectroscopy, Berlin — [2]FernUniversität Hagen, Optische Nachrichtentechnik, Hagen, Germany

The propagation-dependent spectral structure of ultrashort-pulsed wavepackets with orbital angular moment was characterized by high-resolution and high sensitivity spatially resolved spectroscopy and adapted statistical tools. In particular, a rotation of extremal spectral features around the singularity was observed which is explained by a Gouy phase shift (spectral Gouy rotation [1]). A more complex oscillatory behavior is revealed by advanced statistical tools on the basis of spectral meta-moments [2]. The analysis of radially and azimuthally dependent meta-moments enables to adequately describe fast variations in shape and size of spectral maps like symmetry break and spiral distortion. The propagation time interval for a complete switching between minimum and maximum spatial diameter of the spectral peaks was found to be < 34 fs.

References: 1. M. Liebmann et al., Spectral anomalies and Gouy rotation around the singularity of ultrashort vortex pulses, Opt. Express 25, 26076-26088 (2017). 2. M. Liebmann et al., Spectral anomaly of ultrashort vortex pulses with axially oscillating twist, Photonics West, Complex Light and Optical Forces XII, paper 10549-14, San Francisco, USA (to be submitted, 2018).

K 2.4 Mon 17:15 MB HS

PHz-wide spectral interference through coherent plasma-induced fission of higher-order solitons — •Felix Köttig[1], Francesco Tani[1], John C. Travers[1,2], and Philip St.J. Russell[1] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK

Gas-filled hollow-core photonic crystal fibers provide a unique platform for studying strong-field nonlinear fiber optics, in particular the interaction of optical solitons with self-induced plasmas. While this has practical applications, for example in the generation of spectra extending from the ultraviolet to the mid-infrared, soliton-plasma interactions can also lead to as-yet-unexplored soliton dynamics. We report a novel regime of soliton-plasma dynamics in which high-intensity ultrashort pulses of intermediate soliton order undergo coherent plasma-induced fission. Experimental results obtained in gas-filled hollow-core photonic crystal fiber are supported by rigorous numerical simulations. In the anomalous dispersion regime, the cumulative blueshift of higher-order input solitons with ionizing intensities results in pulse splitting before the point of maximum self-compression, leading to the generation of robust ultrashort pulse pairs with PHz bandwidths. The observed dynamics close the gap between plasma-induced adiabatic soliton compression and modulational instability.

K 2.5 Mon 17:30 MB HS

μTRLFS: Spatially- and time-resolved laser fluorescence spectroscopy of Eu(III) sorption on Eibenstock granite — •Konrad Molodtsov[1,2] and Moritz Schmidt[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Institute of Resource Ecology, Germany — [2]Technische Universität Dresden, Germany

Time-resolved laser fluorescence spectroscopy (TRLFS) is a widely used method to obtain information about the surrounding chemical environment of fluorophores with trace concentration sensitivity. This method allows determining the symmetry and grade of complexation of the fluorophore and provides information about the surrounding quenchers, mainly water as well. For highly heterogeneous systems however distinguishing and separating multiple binding species becomes an unsolvable problem. In this study a new method called μTRLFS is introduced, which will add a spatial dimension to TRLFS, giving the possibility to separate a multi-phase system into discrete single-phase systems. Because of its advantageous fluorescence properties we use europium as an analogue for Am(III) and Cm(III) to study the sorption behaviour of granite as a possible host rock for high-level nuclear waste repositories. Spatially resolved sorption experiments with Eu(III) on granite samples from Eibenstock in Erzgebirge, Germany are presented. These samples are excited by a focused and pulsed UV laser beam, and scanned with a resolution of 20 μm. Through this approach it becomes possible to characterize Eu(III) sorption on single grains of the complex material by mapping fluorescence intensity, band ratios, as well as lifetimes.

K 3: Laser Systems and Applications

Time: Tuesday 14:00–16:00 Location: MB HS

Invited Talk K 3.1 Tue 14:00 MB HS

Glass joining by ultra-short pulsed lasers — •Kristian Cvecek[1,2], Johannes Heberle[2,3], Isamu Miyamoto[2,4], and Michael Schmidt[1,2,3] — [1]Bayerisches Laserzentrum GmbH, Erlangen, Germany — [2]SAOT - Erlangen Graduate School in Advanced Optical Technologies, Friedrich-Alexander-University of Erlangen-Nuremberg, Germany — [3]Chair of Photonic Technologies, Friedrich-Alexander-University of Erlangen-Nuremberg, Germany — [4]Osaka University, Japan

Glass welding by ultra-short pulsed lasers is a complex and highly dynamic process that is influenced by many parameters such as pulse repetition rate, feed speed, pulse duration or laser wavelength. Despite the complexity the understanding of the underlying processes has progressed far enough to support first industrial applications. In the present work basic mechanisms of the USP glass welding will be described and novel developments of this topic discussed.

K 3.2 Tue 14:30 MB HS

Laser-induced Micro- and Nanostructures on Ti-alloy Cylinders for Reduced Adhesion of Biological Cells — •Peter Fosodeder[1], Johannes Heitz[1], Agnes Weth[2], and Werner Baumgartner[2] — [1]Institute of Applied Physics, Johannes Kepler University Linz, Altenberger Straße 69, 4040 Linz, Austria — [2]Institute of Biomedical Mechatronics, Johannes Kepler University Linz, Altenberger Straße 69, 4040 Linz, Austria

Irradiation of cylindrical Ti-alloy samples with a Ti:sapphire fs-laser results in the formation of self-organized micro- and nanostructures, i.e., sharp cones or spikes covered by fine sub-wavelength ripples. The motivation of this work is to create a structured ring on a small cylinder with cell-repellent properties, similar as we demonstrated recently for flat substrates [1]. We aim to create such structures on a miniaturized implantable pacemaker to avoid tissue growth around the device.

[1] J. Heitz, C. Plamadeala, M. Muck, O. Armbruster, W. Baumgartner, A. Weth, C. Steinwender, H. Blessberger, J. Kellermair, S. Kirner, J. Krüger, J. Bonse, A.S. Guntner, A.W. Hassel, Appl. Phys. A 123, 734 (2017)

K 3.3 Tue 14:45 MB HS

Ultrakurzpulslaserinduzierte Nanostrukturen zur Steigerung der Umwandlungseffizienz von Laserstrahlung in Röntgenstrahlung — •Jürgen Imgrunt[1], Alexander A. Andreev[1] und Ulrich Teubner[1,2] — [1]Institut für Laser und Optik, Hochschule Emden/Leer, University of Applied Sciences, 26723 Emden, Deutschland — [2]Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26111 Oldenburg, Deutschland

Nanostrukturierte Oberflächen haben vielfältige Anwendungen. Sie können diese überall dort finden, wo die Lichtabsorption oder die Lichteinkopplung in ein Material gesteigert werden soll. Hier werden Ultrakurzpulslaserinduzierte periodischen Oberflächenstrukturen untersucht, die die Umwandlungseffizienz von ultrakurz gepulster Laserstrahlung in Röntgenstrahlung erhöhen sollen. Strukturanalysen und Simulationen zeigten, dass diese Strukturen nahezu optimale Parameter für eine maximale Laserabsorption besitzen. Für relativ niedrige Intensitäten erhöhen Nanostrukturen sowohl die Umwandlungseffizienz als auch die Photonenenergie signifikant. In einem ersten Schritt wurde die Targetoberfläche durch Anlegen von etwa zehn Laserpulsen nanostrukturiert, sodass die Nanostrukturen direkt im Anschluss für den Umwandlungsprozess in Röntgenstrahlung genutzt werden können. Diese In-Situ-Laserstrukturierung erlaubt im Prinzip die Entwicklung eines Targetsystems mit hoher Repetitionsrate.

K 3.4 Tue 15:00 MB HS

High fluence femtosecond laser ablation of molybdenum targets — •Julian Wegner[1], Dongye Zhao[2,3], Niels Gierse[3], Marcin Rasinski[3], Sebastijan Brezinsek[3], Georg Pretzler[1], Honging Ding[2], and Christian Linsmeier[3] — [1]Institut für Laser- und Plasmaphysik, Heinrich Heine Universität Düsseldorf, Germany — [2]Key Laboratory of Materials Modification by Laser, Ion, and Electron Beams, Dalian University of Technology, Dalian, P R China — [3]Institut für Energie- und Klimaforschung - Plasmaphysik, Forschungszentrum Jülich GmbH, Germany

We present experimental data on the ablation of molybdenum targets by femtosecond laser pulses over five orders of magnitude in laser fluence. The experiments were performed with a Ti:Sa laser with sub 7 fs (FWHM) laser pulses and a pulse energy of 0.4 mJ illuminating flat Mo targets. The samples were analyzed post mortem by electron microscopy concerning surface morphology and ablation rate. Furthermore, cross-section images in the craters were taken by focused ion beam technique, yielding information on the structure of the remaining bulk. This analysis gives a detailed overview on ablation with laser fluences along many orders of magnitude. Five distinct regimes are identified by this analysis. Four of them – with lower laser fluence – are compared to models in the literature. The fifth regime with laser fluences up to 6000 J/cm^2 has not been described before. We present a new model to explain this new ablation regime.

K 3.5 Tue 15:15 MB HS

Sub-Cycle Optical Parametric Synthesizer — •Roland E. Mainz[1,2], Giulio Maria Rossi[1,2], Fabian Scheiba[1,2], Shih-Hsuan Chia[1,2], Yudong Yang[1,2], Oliver D. Mücke[1,2], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2] — [1]Center for Free-Electron Laser Science, Notkestrasse 85, 22607 Hamburg, Germany — [2]Physics Department and The Hamburg Centre for Ultrafast Imaging, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Coherent light-field synthesis is a promising route to scale the bandwidth of optical parametric amplifiers beyond one octave. Our vision is to generate custom-tailored sub-cycle optical waveforms opening up unprecedented prospects for precision control of strong-field interactions, for the generation of intense isolated attosecond pulses and for attosecond pump-probe spectroscopy. We present our system based on three OPA spectral channels each featuring a three stage amplification chain. The system delivers a combined bandwidth of more than two octaves (500 nm - 2.2 μm) allowing for sub-cycle electric field transients with pulse durations below 1.9 fs and millijoule-level pulse energies. The sub-cycle pulse duration allows for immediate isolated attosecond pulse generation without gating techniques, and the synthesized non-sinusoidal waveforms are expected to significantly enhance the HHG efficiency for bright isolated attosecond pulses. The challenges of this approach are the CEP-stable ultra-broadband seeds generation, the timing/phase synchronization, the more than two-octave-wide dispersion management and the long term stability of a setup based on more than 28 non-linear conversion stages (WLGs and OPAs).

K 3.6 Tue 15:30 MB HS

Cascaded regime of optical parametric amplification for efficient terahertz generation — •Giovanni Cirmi[1,2], Halil Olgun[1,3], Nicholas Matlis[1], Michael Hemmer[1], Koustuban Ravi[1,4], Ivanka Grguras[1], Yi Hua[1], Anne-Laure Calendron[1], Luis E. Zapata[1], and Franz X. Kärtner[1,2,4] — [1]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]Physics Department and The Hamburg Centre for Ultrafast Imaging, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — [4]Research Laboratory of Electronics, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA 02139, USA

The efficient generation of multi-cycle coherent THz radiation is of primary importance to drive novel table-top FELs. We explore the cascaded OPA, a new regime of OPA. We start from a home-built Yb:YLF amplifier at 1017-1020 nm temporally chirped to 800-ps. We generate intra-band DFG in a PPLN crystal phase matched for 0.5 THz. The interaction of the IR pulses with the THz pulses produces several spectrally cascaded orders, allowing for the generation of THz radiation beyond the Manley-Rowe limit. This technique promises IR-to-THz conversion efficiencies in the order of 1-10%. After studying the system at room temperature, we explored the case of a crystal at 77 K, which provides much lower THz absorption. The experimental results support the theoretical findings, and reveal that improvements in laser bandwidth and dispersion will lead to the calculated efficiencies.

K 3.7 Tue 15:45 MB HS

Optimized pulse characterization from UV to IR by two-dimensional spectral shearing interferometry (2DSI) — •Fabian Scheiba[1,2], Giulio Maria Rossi[1,2], Roland E. Mainz[1,2], Yudong Yang[1,2], Shih-Hsuan Chia[1,2], Oliver D. Mücke[1,2], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2] — [1]Center for Free-Electron Laser Science, Notkestrasse 85, 22607 Hamburg, Germany — [2]Physics Department and The Hamburg Centre for Ultrafast Imaging, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

To manipulate electron dynamics in their inherent time scale, ultrashort laser sources delivering pulse durations below one optical cycle are under development. Pulse characterization methods have to keep pace with the ultrabroad bandwidth of sub-cycle pulses. We present our simplified and compact version of 2DSI, capable of characterizing a variety of broadband light sources. The ancillary pulses can be derived from the pump laser allowing to measure even low energy pulses quickly. Moreover the possibility to up- or downconvert the fundamental spectrum permits to measure in the visible range a large variety of sources spanning from IR to UV. The two-dimensional data trace allows for direct graphical evaluation of group delay and pulse stability. This gives the opportunity to monitor the spectral phase in real-time for >1 kHz rep.-rate systems. 2DSI measurements of a two-color driven hollow core fibre, an OPA synthesizer and an octave-spanning Ti:sapphire oscillator, demonstrate the capability to characterize ultrabroadband pulses with energies from few nJs to mJs level.

K 4: Pulsed Power - Laser-Beam Matter Interaction

Time: Wednesday 14:00–15:45 Location: MB HS

Invited Talk K 4.1 Wed 14:00 MB HS

Experimental Results from the Development of a Triggered Vacuum Switch (TVS) at the Pohang Accelerator Laboratory (PAL) — •Klaus Frank[1], Wung Hoa Park[2], Suk Ho An[2], and Byung Joon Lee[2] — [1]Physics Department University of Erlangen Nuremberg, Erlangen,Germany — [2]Pohang Accelerator Laboratory, Pohang, South Korea

The TVS is an extremely robust devices that can survive over-voltage, overcurrent, and reverse-current faults. At the Pohang Accelerator Laboratory in 2015 started the development of a non-sealed-off TVS prototype. The experimental set-up consists of the 6 * rod prototype TVS switch, a charging circuit with a capacitor bank with C = 16.63 μF, which has at 20 kV charging voltage a total stored charge of 0.3 C or a total energy of 3.3 kJ. The peak current Ip is 88 kA. Introductorily a short review of the history of TVS development is given. For better understanding of triggering and breakdown the basic model of TVS breakdown is briefly described. Usually the trigger unit is at an elevated position with regard to the cathode surface. Therefore it is inevitably exposed to metal vapor deposition from the main discharge plasma. At PAL a second position of the trigger unit was studied. The trigger unit is positioned in a recess of the cathode. Lifetime comparisons of both trigger positions are presented. In parallel, the metallic layer deposition on the ceramic disc of the trigger is investigated by several methods of thickness analysis. Finally an outlook for future experiments is given.

K 4.2 Wed 14:30 MB HS

Semiconductor Lasers Optically Pumped in the Tunnel Excitation Regime — •Richard Hollinger[1,2], Valentina Shumakova[3], Pavel Malevich[3], Skirmantas Ališauskas[3], Lukas Trefflich[4], Robert Röder[4], Audrius Pugžlys[3], Andrius Baltuška[3], Carsten Ronning[4], Christian Spielmann[1,2], and Daniil Kartashov[1] — [1]Institute of Optics and Quantum Electronics, Abbe Center of Photonics, University Jena, 07743 Jena, Germany — [2]Helmholtz-Institut Jena, Helmholtzweg 4, 07743 Jena, Germany — [3]Institute for Photonics, TU Vienna, Gußhausstrasse. 25-29, 1040 Vienna, Austria — [4]Institute for Solid State Physics, University Jena, Max-Wien-Platz 1, 07743 Jena, Germany

Since the famous work of Albert Einstein at the beginning of the last century, we describe light matter interaction in the photon picture, i.e.the absorption of light depends only on the frequency of the photon and not on the intensity of the light wave. With the advent of intense lasers, multiphoton excitation has been realized, i.e. two or more low energy photons have to be absorbed simultaneously to excite an atom. There, excitation depends not only on the photon energy but also on the intensity of the incident light wave. Here, we show that further lowering the pump photon energy brings us into the regime of tunneling excitation. Now the excitation of atoms becomes (nearly) independent of the frequency but solely depends on the incident intensity of the light wave. Experimentally we confirm the wavelength and intensity scaling in the tunneling excitation regime by studying the visible emission of semiconductor nanolasers under mid-infrared pumping.

K 4.3 Wed 14:45 MB HS

Influence of the system lengthscale in the Strong Field Photoelectron Energy Spectra — •Abraham Camacho Garibay[1], Zhou Wang[1], Hyunwook Park[1], Ulf Saalmann[2], Jan-Michael Rost[2], and Louis DiMauro[1] — [1]The Ohio State University, Columbus, OH, USA — [2]MPI-PKS, Dresden

Electrons emitted from atoms in the presence of a strong (IR) lasers are successfully explained by the Three-Step Model, which considers the parent atom to have no volume. This model describes the features of photoelectron spectra in terms of direct electrons driven by the field, or backscattered ones from binary collisions, with cutoff energies of 2 and 10 U_p respectively. In previous experiments with rare gas clusters, the resemblance to the atomic case was not clear and a thermalization process was considered to be dominant. With current laser capabilities with tunnable wavelength, along with variable cluster sizes, we show (experimentally and numerically) that energetic electrons are produced by field driven backscattered electrons. More importantly, we have found that this cutoff energy is universally determined by the dimensionless scaled cluster radius R_{cl}/r_w, naturally extending our understanding of the atomic case.

K 4.4 Wed 15:00 MB HS

Modellierung der Erwärmung von CFK durch cw-Laserstrahlung unter Berücksichtigung der thermischen Strahlung zwischen den einzelnen Faserschichten — •Rüdiger Schmitt — Deutsch-französisches Forschungsinstitut Saint-Louis, Postfach 1260, D-79547 Weil am Rhein

Aufgrund Ihres inhomogenen Aufbaus finden bei der Beaufschlagung von Verbundwerkstoffe mit leistungsstarker Laserstrahlung vielfältige Prozesse statt, die eine Modellierung im Gegensatz zu beispielsweise Metallen erschweren.

In der Präsentation werden Ergebnisse numerischer Berechnungen vorgestellt, die die thermische Entwicklung innerhalb einer laserbeaufschlagten Laminatstruktur aus Kohlenstofffasern und einer Kunststoff-Matrix beschreiben. In der FEM-Rechnung wurde berücksichtigt, dass das Harz einen relativ niedrigen Siedepunkt hat und die Wärmeleitfähigkeit nach dem Verdampfen stark vermindert wird. Wie die Rechnungen zeigten, kann die thermische Strahlung zwischen den einzelnen Faserschichten einen großen Teil zum Wärmetransport beitragen.

Ergänzend zu den FEM-Rechnungen wurden analytische Beziehungen hergeleitet, die basierend auf der Wärmeleitungsgleichung und einem thermischen Ersatzschaltbild die Berechnung eines temperaturabhängigen, anisotropen Wärmeleitkoeffizienten ermöglicht. Gerade bei dickeren Strukturen kann hierdurch die innere Wärmeübertragung durch thermische Strahlung berücksichtigt werden, ohne jede der nur wenige mu dicken Fasern bei der Erstellung der Geometrie berücksichtigen zu müssen.

K 4.5 Wed 15:15 MB HS

Development of a highly reflective double-pulsed plasma mirror with emphasis on plasma scale length control — •Gregor Indorf[1,2], Graeme Scott[3], Malte Ennen[1], Lisa Scaife[3], Alexander Andreev[1,2], Ulrich Teubner[1,2], and David Neely[3] — [1]Institut für Laser und Optik, Hochschule Emden/Leer, D-26723 Emden — [2]Institut für Physik, Universität Oldenburg, D-26129 Oldenburg — [3]STFC Central Laser Facility OX11 0QX, United Kingdom

For the last decade, plasma optics have constantly been used in the field of high power laser related studies and applications, revealing multiple possibilities to manipulate pulses or generate high harmonics in attosecond trains. Plasma mirrors have proven to be powerful tools not only for increasing the temporal contrast of ultrashort intense laser systems by several orders of magnitude, but also for providing an ultrafast optical switch capable of working at high fluences. A record reflectivity of a double-pulse plasma mirror system has been presented by G.G. Scott et al in 2015[1] to be around 96% of an incoming laser pulse of 1 ps. We are now concentrating on achieving similar results for a 40fs pulse, paying special attention to the quality of the reflected wave-front by optimising the prepulse and the interpulse delay between pre- and mainpulse. The driving laser for these studies is a 500mJ, 10Hz Ti:sapphire system at the Rutherford Appleton Laboratory at Harwell, UK. This work has been sponsored by grant EP/K022415/1. [1] G.G. Scott et al., Optimisation of plasma mirror reflectivity and optical quality using double laser pulses. New journal of physics, 2015.

K 4.6 Wed 15:30 MB HS

Mid-infrared supercontinuum generation in germanate and tellurite photonic crystal fibers — •Rafal Sopalla[1], Heinar Hoogland[2,3], Jiapeng Huang[1], Fehim Babic[1], Roland Holzwarth[2], Xin Jiang[1], and Philip St.J. Russell[1] — [1]Max-Planck-Institute for the Science of Light, 91058 Erlangen, Germany — [2]Menlo Systems GmbH, 82152 Martinsried, Germany — [3]Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany

We report recent advances in the development of soft-glass photonic crystal fibers, with tailored dispersion for broadband supercontinuum extending into the mid-infrared. Two types of PCFs, made from germanate and tellurite glasses, are engineered for pumping at 2 μm. The tellurite PCF has a solid core with diameter 6.2 μm, surrounded by five-rows of hollow channels, with a relatively high air-filling-fraction of >80%. This highly nonlinear solid-core PCF has a zero dispersion wavelength of 1.8 μm, shifted from 2.2 μm in bulk material. The germanate PCF has a core ~1.9 μm in diameter held in place by three thin glass membranes and thus surrounded by three large hollow channels. Its zero dispersion wavelength is 1.5 μm. A 2.05 μm fiber laser CPA system (based on MenloSystems Red-Fiber) generating 400-fs pulses at 10 MHz and 1.2-W average power is used as pump., The generated supercontinuum spectrum in a 16 mm length of tellurite PCF starts from 0.54 μm and extends well beyond 3.5 μm. The results are verified by numerical simulations based on the commonly used generalized nonlinear Schrödinger equation for the slowly varying complex envelope of the pulses.

K 5: Annual General Meeting of the Short Time-scale Physics and Applied Laser Physics Division

Time: Wednesday 15:45–16:00 Location: MB HS

Duration 15 minutes

K 6: Poster

Time: Wednesday 16:15–18:15 Location: Orangerie

K 6.1 Wed 16:15 Orangerie

Plasma shock wave simulation for laser shock processing — •Vasily Pozdnyakov and Jens Oberrath — Institute of Product and Process Innovation, Leuphana University Lüneburg, Germany

Improvement of mechanical properties such as fatigue life, corrosion, wear and erosion resistance of material surfaces has become an integral part of industrial operations. Laser shock peening (LSP) is one of the advanced surface modification techniques. When focusing a short (ns range) and intense (>1 GW/cm2) laser pulse onto a metallic target, surface layers instantaneously vaporize into a high temperature (about 10 000 K) and high pressure (> 1 GPa) plasma. This plasma induces a shock wave during expansion from the irradiated surface and a mechanical impulse transfers to the target resulting in plastic deformations and residual stresses appear.

In this work a 1D model, based on a global model of Zhang et al. [1, 2], is implemented in Python. As a result of its numerical solution the influence of laser parameters on the results of processing is investigated. Pressure distribution and plasma parameters are defined and compared both with experimental results and numerical models of other researchers.

[1] W. Zhang and Y.L. Yao, Proceedings of the ICALEO 2001
[2] W. Zhang, Y.L. Yao, I.C. Noyan, J. Manuf. Sci. E. - T. ASME 126, 10 (2004)

K 6.2 Wed 16:15 Orangerie

Laser processing of silicon suboxide for the fabrication of diffractive phase elements — •Lukas Janos Richter, Clemens Beckmann, Jörg Meinertz, and Jürgen Ihlemann — Laser-Laboratorium Göttingen e.V., Hans-Adolf-Krebs-Weg 1, 37077 Göttingen

Matierals processing by UV excimer laser ablation offers fast and flexible ways for microfabrication. A prerequisite for precise patterning is strong absorption in the UV regime. In contrast to UV-transparent fused silica (SiO_2), silicon suboxide (SiO_x, x<2) is absorbing in the UV and can be machined with high precision. By thermal treatment the silicon suboxide can subsequently be oxidised to fused silica. This two step process allows for the fabrication of microstructured components made entierly of fused silica. E. g., diffractive optical elements with two phase-quantized levels (binary DOEs) can be produced via rear-side ablation of a thin film of silicon suboxide on a fused silica substrate [1]. In a next step a multilevel structure is produced by repeating the steps of ablation and oxidation after recoating the surface with silicon suboxide.

[1] Fricke-Begemann et al., Applied Physics A 117:13-18 (2014)

K 6.3 Wed 16:15 Orangerie

Time resolved coherent lensless imaging of plasma dynamics — •Elisa Appi[1], Ahmed Maghraoui[2], Willem Boutu[2], Hamed Merdji[2], and Milutin Kovacev[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]LIDYL Laboratory CEA-Saclay, 91191 Gif-sur-Yvette, France

Coherent lensless imaging is a powerful technique that offers spatial resolution at the order of the wavelength, thanks to the fact that no optical elements are required. The capability of imaging objects with nanometric spatial resolution and on femtosecond time scales in a single shot mode has been demonstrated [1]. Here we present a pump-probe setup to perform coherent diffractive imaging with time resolution from the few-femtosecond scale up to nanoseconds to measure the laser driven plasma dynamics in for example Titanium spheres. After the interaction with an ultrashort pump pulse which enables the dynamics, the samples are illuminated by an intense XUV coherent beam with high photon flux. Using the technique of holography with extended references (HERALDO) it is possible reconstruct the final image from the recorded diffraction patter in a more efficient way [2] than standard Fourier transform holography. The temporal resolution should allow to observe the very early stage of the plasma heating, phase transitions and plasma expansion which conventional light microscopy techniques cannot resolve.

[1] A. Ravasio *et al.*, Phys. Rev. Lett. **103**, 028104 (2009).
[2] D. Gauthier *et al.*, Phys. Rev. Lett. **105**, 093901 (2010).

K 6.4 Wed 16:15 Orangerie

Femtosecond mode-locked Ti:Sapphire laser pumped by the 461 nm laser diode — •Denis A. Kopylov[1], Tatiana V. Murzina[1], Aleksandr V. Konyashchenko[2], and Anton I. Maydykovskiy[1] — [1]Physics Department, Moscow State University, 119991 GSP-1, Leninskie Gory, Moscow, Russia — [2]P.N. Lebedev Physics Institute, Russian Academy of Sciences, Leninskiy prosp 53, 119991 Moscow, Russia

One of the most widely used femtosecond solid-state lasers is based on a titanium-doped aluminum oxide crystal (Ti:Sapphire), possessing a wide fluorescence spectra ranging from 690 nm up to 1050 nm, which allows to create continuous wave and the Kerr-lens mode-locked lasers with the pulse duration from 5 fs up to 150 fs as well. The absorption spectrum of the Ti:Sapphire crystals corresponds to the spectral range 450-530 nm. Thus pumping of a Ti:Sapphire laser can be realized by using blue laser diodes. The laser diode beam profile is elliptical with a strong astigmatism. Therefore the beam correction schemes have to be developed for effective pumping of the Ti:Sapphire oscillator.

We demonstrate the mode-locked Ti:Sapphire oscillator pumped by a single diode laser (461 nm, 4 W) with the M^2 equal to 2.6 and 11.8 for the fast and slow axes, respectively. We successfully demonstrate the CW and Kerr-lens mode-locked regimes of operation of laser diode pumped Ti:Sapphire with 3 mm, 5 mm and 10 mm length crystals. The pulses as short as 15 fs and a power of 170 mW are presented. The factors that have an effect on efficiency of Ti:Sapphire laser pumped by the laser diode are analyzed.

K 6.5 Wed 16:15 Orangerie

The Small Quantum Systems - SQS Instrument at the European XFEL — •Patrik Grychtol, Alexander Achner, Thomas Baumann, Rebecca Boll, Alberto De Fanis, Sascha Deinert, Markus Ilchen, Tommaso Mazza, Jacobo Montano, Yevheniy Ovcharenko, Nils Rennhack, Rene Wagner, Pawel Ziolkowski, and Michael Meyer — Small Quantum System Group, European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld

This contribution presents the Small Quantum System (SQS) scientific instrument, which is one of six experimental end stations at the European XFEL. This experimental platform is designed for investigations of atomic and molecular systems, as well as clusters, nano-particles and small bio-molecules. It is located behind the SASE 3 soft x-ray undulator, which will provide horizontally polarized FEL radiation in a photon energy range between 260 eV and 3000 eV (4.8 nm to 0.4 nm) with 0.1 to 2 × 10^{14} photons per pulse and up to 27000 pulses per second. Two high-quality elliptical mirrors in Kirkpatrick-Baez configuration will focus the FEL beam to a FWHM spot size of approximately 1 μm diameter. This is going to result in an intensity of more than $10^{18}\,W/cm^2$ within the interaction region, which will allow for studying non-linear multi-photon processes. Furthermore, the short FEL pulse duration between 2 fs and 100 fs in combination with a synchronized optical femtosecond laser will enable time-resolved studies of dynamic processes, thus capturing the motion of electrons and nuclei with unprecedented resolution in space on ultrafast time scales.

K 6.6 Wed 16:15 Orangerie

Investigating Resonant Two-Color Photoionization Processes in Atoms and Molecules — •Rene Wagner, Alexander Achner, Thomas Baumann, Rebecca Boll, Alberto De Fanis, Sascha Deinert, Patrik Grychtol, Markus Ilchen, Tommaso Mazza, Jacobo Montano, Yevheniy Ovcharenko, Nils Rennhack, Pawel Ziolkowski, and Michael Meyer — Small Quantum System Group, European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld

We present an experimental tabletop set-up dedicated to investigations of ultrafast processes in atoms and molecules combining near infrared (NIR) and extreme ultraviolet (EUV) radiation pulses. Our experiments will focus on the study of electron correlations in highly excited auto-ionizing resonances by different pump-probe techniques aiming to obtain novel insights into atomic and molecular dynamics. For this purpose, a femtosecond laser driven EUV source based on high harmonic generation (HHG) is employed in combination with a pulsed molecular jet, a delay-line based velocity map imaging (VMI) detector and a time-of-flight (TOF) spectrometer. We are going to show first results quantifying the performance of our experimental apparatus having captured and analysed the angular electron distributions of the auto- and cross-correlations with our ultrafast NIR and EUV pulses in atomic argon, respectively.

K 6.7 Wed 16:15 Orangerie

Synchronous VUV light source for FLASH II — •Elisa Appi[1], Eike Lübking[1], Tino Lang[2], Christoph Heyl[2], Ingmar Hartl[2], Robert Moshammer[3], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]DESY, Notkestrasse 85, D-22607 Hamburg — [3]Max Planck Institute of Nuclear Physics, D-69117 Heidelberg

The design of a VUV radiation source, based on high harmonic generation (HHG), is presented. Driven by 700-900nm femtosecond laser pulses and their harmonics, it will generate femtosecond pulses with photon energies between 10 and 40 eV. The source will be installed as a permanent device for the free electron laser FLASH II at DESY and the VUV pulses will be optically synchronized with the FLASH burst. The challenge of the project is the high pulse repetition rate in the burst of the FLASH, which limits the pulse energy of the IR driver. Due to the low available pump energy a highly efficient HHG process is required and different HHG schemes are been evaluated to obtain the highest photon fluxes in the spectral range of interest. First experiments on single-molecule spectroscopy will be performed on the installed reaction microscope (REMI) using the new VUV-FLASH pump-probe capabilities.

K 6.8 Wed 16:15 Orangerie

Soliton-effect self-compressed single-cycle 9.6 W mid-IR pulses from a OPCPA at 3.25 μm and 160 kHz — •Alexey Ermolov[2], Ugaitz Elu[1], Matthias Baudisch[1], Hugo Pires[1], Francesco Tani[2], Michael H. Frosz[2], Felix Köttig[2], Philip St.J. Russell[2], and Jens Biegert[1,3] — [1]ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — [2]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [3]ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Spain

Gas-filled hollow-core photonic crystal fiber (HC-PCF) has been successfully used, over a broad range of laser wavelengths, for compressing laser pulses in the micro-Joule energy range down to single cycle durations. Here we report compression, in a gas-filled HC-PCF, of pulses from a mid-IR optical parametric chirped pulse amplifier. The results out-perform previous systems by more than an order of magnitude, achieving peak powers of 3.9 GW at a 160 kHz repetition rate with intrinsically carrier envelope phase-stable pulses near the single-cycle limit. The 97 fs pulses at the laser output were compressed down to 14.5 fs (corresponding to 1.35 cycles) using soliton dynamics in a HC-PCF filled with argon. The compression scheme was remarkably efficient, introducing only 20% loss, thereby yielding 60 μJ output energy pulses at 3.3 μm with 9.6 W average power. This system presents a significant step forward in the generation of coherent hard x-rays and subsequent access to the zeptosecond regime of light-matter interactions.

K 6.9 Wed 16:15 Orangerie

Zeitaufgelöste interferometrische Diagnostik an einem Plasmastripper — •Philipp Christ, Konstantin Cistakov, Marcus Iberler und Joachim Jacoby — Goethe-Universität Frankfurt, Institut für Angewandte Physik, Plasmaphysik

Die interferometrische Plasmadiagnostik zeichnet sich als Messtechnik mit aktiver elektromagnetischer Strahlung durch eine hohe Genauigkeit, hohe Zeitauflösung und durch vielseitige Anpassbarkeit an die Experimentbedingungen aus. Darüber hinaus bietet sie die Möglichkeit eine zeitaufgelöste Magnetfeldmessung simultan zur Messung der Elektronendichte durchzuführen. Durch diese Vorteile hebt sie sich von Messtechniken mit passiver elektromagnetischer Strahlung, wie die Spektroskopie, ab.

Dieser Beitrag soll von der Problemstellung ausgehend das Konzept aufzeigen, wie eine interferometrische Diagnostik in der Praxis umgesetzt werden könnte. Dabei soll das Interferometer das heterodyne Messverfahren nutzen, wobei die notwendige Frequenzverschiebung akusto-optisch erzeugt wird. Des Weiteren soll eine kollineare Zwei-Farben-Vibrationskompensation zum Einsatz kommen, bei welcher die Problematik der akusto-optischen Dispersion durch einen AOTF (Acousto-Optical Tunable Filter) umgangen werden soll.

K 7: Internal Symposium Optic Coatings and Plasma Technology

Time: Thursday 10:30–13:00 Location: MB HS

Invited Talk K 7.1 Thu 10:30 MB HS

A global model for radio frequency magnetron sputtering processes — •Dennis Engel, Laura Kroll, and Ralf Peter Brinkmann — Institute of Theoretical Electrical Engineering, Ruhr University Bochum, Germany

Magnetron sputtering is an established technology to deposit thin films on large substrates. Employing RF power (instead of the conventional DC power) allows to sputter not only electrically conductive materials but also dielectrics like optical coatings. This contribution presents a global model for such an RF driven magnetron which is an extension of a previously published lumped circuit description of unmagnetized RF discharges [1]. As its predecessor, the model represents the discharge by separate bulk and sheath zones which communicate via Kirchhoff relations. The extension accounts for the presence of a magnetized region with reduced electric conductivity [2,3]. The model evaluates quickly and may be used for the purpose of model based control.

Invited Talk K 7.2 Thu 11:00 MB HS

The Multipole Resonance Probe as a powerful diagnostic tool for industrial plasma processes — •Moritz Oberberg[1], Stefan Ries[1], Christian Wölfel[2], Jens Harhausen[3], Dennis Pohle[4], Christian Schulz[4], Oliver Schmidt[5], Wladislaw Dobrygin[5], Ilona Rolfes[4], Ralf Peter Brinkmann[6], and Peter Awakowicz[1] — [1]Lehrstuhl für Allgemeine Elektrotechnik und Plasmatechnik, Ruhr-Universität Bochum — [2]Lehrstuhl für Automatisierungstechnik und Prozessinformatik, Ruhr-Universität Bochum — [3]Leibniz Institut für Plasmaforschung und Technologie, INP Greifswald — [4]Lehrstuhl für Hochfrequenzsysteme, Ruhr-Universität Bochum — [5]Robert Bosch GmbH — [6]Lehrstuhl für Theoretische Elektrotechnik, Ruhr-Universität Bochum

Based on the concept of active plasma resonance spectroscopy (APRS) the Multipole Resonance Probe (MRP) has been introduced as a diagnostic tool for electron density measurements. In recent years efforts in modeling, simulation, and experiments lead to advances in understanding and design of the MRP. In this contribution, its application in industrial processes such as sputtering and plasma ion assisted deposition (PIAD) is presented. The probe is insensitive against dielectric coatings and can be adapted as a highly functional and fast diagnostic system for such deposition processes, where other diagnostics, e. g. Langmuir probes, fail. It can be used for real-time process monitoring and has been tested in control loops to stabilize deposition processes. Further challenges for both academia and industry are addressed such as the temperature stability. Funded by BMBF (13N13212)

Invited Talk K 7.3 Thu 11:30 MB HS

Prospects for the enhancement of PIAD processes by monitoring of optical thickness and plasma parameters — •Jens Harhausen[1], Rüdiger Foest[1], Margarita Baeva[1], Detlef Loffhagen[1], Olaf Stenzel[2], Steffen Wilbrandt[2], Christian Franke[2], Norbert Kaiser[2], and Ralf Peter Brinkmann[3] — [1]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — [2]Fraunhofer Institute of Applied Optics and Precision Engineering, Jena, Germany — [3]Ruhr University, Institute of Theoretical Electrical Engineering, Bochum, Germany

Plasma ion assisted deposition (PIAD) is a common technique employed for the production of optical interference coatings. Present control schemes concerning the plasma state focus on parameters of the supply units, such as gas fluxes, or electrical quantities. In-situ data on the growing films are obtained by quartz crystal microbalance (QCM) and optical monitoring (OM). In order to access plasma parameters during the deposition process, we employ optical emission spectroscopy (OES) and active plasma resonance spectroscopy (APRS). Data on radiance by OES and electron density from APRS are used to develop novel schemes for plasma-based control. The impact of the control procedure on the reproducibility of layer properties is discussed based on results obtained for a quarterwave stack serving as test case. In particular, it is attempted to disentangle variations in the refractive index from OM data of constant optical thickness. Results presented in this contribution are based on funding by the German Federal Ministry of Education and Research under grant 13N13213.

Invited Talk K 7.4 Thu 12:00 MB HS

Stabilisierung von Rate und Schichtdickenuniformität im IBS-Prozess über adaptiv geregelte Prozessparameter — •Florian Carstens, Henrik Ehlers und Detlev Ristau — Laser Zentrum Hannover e.V., Hannover, Deutschland

Sputter-Depositionsprozesse, insbesondere das Ionenstrahl-Zerstäuben (Ion Beam Sputtering, IBS), stellen die derzeit etablierten Verfahren dar, wenn es um die Beschichtung von optischen Komponenten zur Herstellung besonders anspruchsvoller Interferenzfilter geht. Hierbei kommt es vor allem auf eine hohe Schichtdickenpräzision und reproduzierbare Dispersionseigenschaften des Schichtmaterials an. Anders als beispielsweise beim Magnetron-Sputtern werden nach dem gegenwärtigen Stand der Technik in IBS-Prozessen materialspezifische, feste Parametersätze ohne eine In-situ-Regelung der Prozessgrößen verwendet. Eine derartige adaptive Regelung birgt jedoch ein erhebliches Potential, um eine vor allem für industrielle Anwendungen notwendige weitere Steigerung der Qualität, Reproduzierbarkeit und Ausbeute der hergestellten Beschichtungen zu realisieren. Im Rahmen des BMBF-Forschungsverbunds PluTO$^+$ wurden am Laser Zentrum Hannover verschiedene adaptive Regelungsansätze zur Stabilisierung des IBS-Beschichtungsprozesses erforscht. Mit Hilfe dieser Verfahren konnte unter anderem die Stabilität der Beschichtungsrate des Prozesses sowie die Schichtdickenuniformität auf den zu beschichtenden Optiken deutlich erhöht werden. Der Vortrag gibt einen Überblick über die verfolgten Regelungsansätze und demonstriert die jeweils erreichte Prozessstabilitätsverbesserung.

Invited Talk K 7.5 Thu 12:30 MB HS

Structural and optical properties of virtual materials — •Holger Badorreck, Marco Jupé, and Detlev Ristau — Laser Zentrum Hannover e.V., Hannover, Deutschland

Physical deposition processes for thin film optical coatings are modeled in the Virtual Coater framework. This concept combines different simulation techniques in a multi scale model, which covers the material transport in the coating plant, the atomistic growth of the thin films and electronic and optical properties of these films. The material transport is simulated by Direct Simulation Monte Carlo and the atomistic growth is performed by classical molecular dynamics. For the calculation of optical properties usually the density functional theory can be employed, but only for a limited structural size in the order of about 100 atoms. The structural properties, that cannot be described by this limited number of atoms, like voids and pores, therefore needs to be described by effective medium approximations, for example. This approach allows to describe the impact of structural inhomogeneities on the optical properties. Pores amount and orientation can be modeled to obtain direction dependent effective index ellipsoids. However, for applying the effective medium theory, the optical properties of the different dense materials need to be known, which can be obtained by the density functional theory. The possibilities and limitations of the approach are discussed.