Q 49: Ultrashort Laser Pulses: Generation and Applications

Time: Thursday 14:30–16:45 Location: P 5

Q 49.1 Thu 14:30 P 5

Frequency conversion from the near-infrared to the deep UV with an MgO crystal — •Dennis Mayer, Mario Niebuhr, Christian Matthaei, Axel Heuer, and Markus Gühr — Institut für Physik und Astronomie, Universität Potsdam

Femtosecond pulses in the deep and vacuum ultraviolet region are ideal probes for ultrafast molecular and solid state photoelectron spectroscopy. Due to the recent progress in amplified high repetition rate sources, the nonlinear conversion schemes established at kHz repetition rates need to be scaled to a regime of higher average flux and lower per pulse energy. Newly established solid state harmonic generation provides advantages over conventional gas phase harmonic generation in terms of the conversion efficiency [1]. However, this comes at the cost of higher absorption and shorter effective harmonic generation length.

We concentrate on the generation of harmonics in wide bandgap insulators and on the harmonics emitted below the bandgap. We utilize a 100 kHz amplified Yb:KGW system and present a systematic study of femtosecond nonlinear conversion in MgO.

[1] Y.S. You et al., Nature Physics (2016)

Q 49.2 Thu 14:45 P 5

Development and characterization of a pulse preserving XUV multilayer monochromator — •Tanja Neumann[1], Yudong Yang[2], Roland Mainz[2], Franz Kärtner[2], and Thorsten Uphues[1] — [1]CFEL, Attosecond Research and Science Group, Hamburg University, Luruper Chaussee 149, 22761 Hamburg — [2]Center for Free-Electron Laser Science, DESY and Department of Physics, University of Hamburg, Hamburg, Germany

HHG based time-resolved experiments in the XUV are a key technologie to study atomic, surface and chemical processes in realtime. Some of these experiments require high energy resolution to distinguish between spin compenents or resolve chemical shifts in the corresponding energy spectra. In the frame work of a master thesis a narrow bandwidth multilayer mirror monochromator (MMM) was developed for separation and energy tunability of a well defined spectral bandwidth from a high order harmonic spectrum generated by 25 femtosecond laser pulses at 800 nm central wavelength. The MMM is tailored to the experimental requirements of a surface experiment and is able to select a defined bandwidth of less than 1 eV from the harmonic spectrum in the photon energy range between 90 and 98 eV. For time resolved experiments it designedto be used at the same time to recombine the laser pulse and the XUV pulse and focus them down to the experiment maintaining temoral and spectral overlap in the given energy range. A major advantage of the MMM is the preservation of the time structure of the XUV and laser pulse, thus addition dispersion correction is not needed.

Q 49.3 Thu 15:00 P 5

Design and testing of a setup for sub two-cycle optical pulse compression from Ti:sapphire oscillators — •Philip Dienstbier[1], Takuya Higuchi[1], Francesco Tani[2], Michael Frosz[2], John Travers[3], Philip St. J. Russell[2], and Peter Hommelhoff[1] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstraße 1, 91058 Erlangen, Germany — [2]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [3]Heriot-Watt University, Edinburgh, EH14 4AS, United Kingdom

Ultrashort pulsed lasers with a duration of a single oscillation of the electric field are an ideal tool to investigate the sub-cycle dynamics of electrons under an intense field [1] as the temporal contrast is increased. Recent observation of rescattering physics at nanotips with the aid of optical field enhancement suggests that the strong-field regime can be reached with pulse energies even below 1 nJ [2]. Commercial laser systems in the nJ-regime such as Ti:sapphire oscillators however are limited to pulse durations around two optical cycles. Here we present a setup to spectrally broaden the output of a Ti:sapphire oscillator by a customized solid-core photonic crystal fiber and a prism based 4f-pulse compressor with expected compression down to 3 fs corresponding to a single optical cycle. A MIIPS pulse characterization scheme for various overlapping spectral ranges was realized and used to test the pulse compressor.

[1] M. T. Hassan et al., Rev. Sci. Instrum. **83**, 111301 (2012).

[2] M. Krüger, M. Schenk and P. Hommelhoff, Nature **475**, 78 (2011).

Q 49.4 Thu 15:15 P 5

Design and simulation of a NOPA for the pulse diagnostics XUV PUMA at FLASH, DESY — •Niklas Borchers[1,2], Martin Büscher[1,2], Mark Prandolini[3], Sven Toleikis[3], Bert Struve[1], and Ulrich Teubner[1,2] — [1]Institut für Laser und Optik, Hochschule Emden/Leer, D-26723 Emden — [2]Institut für Physik, Universität Oldenburg, D-26129 Oldenburg — [3]Deutsches Elektronen-Synchrotron DESY, D-22607 Hamburg

To allow precise measurement of the jitter and pulse duration of free electron lasers such as FLASH on a shot to shot basis novel techniques are necessary. Of course, this is a difficult task in the extreme ultra violet spectral region (4.2 to 45nm; XUV), in particular in combination with the ultrashort time scales (<50fs). A corresponding diagnostic which is based on a plasma gate is XUV PUMA (Pulsdauermeßapparatur), which is currently under development. As the resolution is mainly limited by the probe pulse, ultrashort tunable sub- 30fs pulses in a range from 580nm to 680nm wavelength with a pulse energy $>1\mu$J are required for the cross correlator as one key element of the diagnostics. The pulses will be generated with a NOPCPA (non-collinear optical parametric chirped pulse amplifier). Prior to set-up, the NOPCPA has been simulated in all major aspects (SHG, dispersion, efficiency, etc.) using a tailored MATLAB program. With the aid of the simulation, a compact system, as required by the FLASH beamline end station, has been designed to optimally match the parameters required by the XUV PUMA. This work is sponsored by BMBF 05K16ME1.

Q 49.5 Thu 15:30 P 5

Non-Collinear Circular Polarized High Harmonic Generation — •Patrik Grychtol[1], Jennifer Ellis[1], Kevin Dorney[1], Carlos Hernández-García[2], Franklin Dollar[1], Christopher Mancuso[1], Tinting Fan[1], Dmitriy Zusin[1], Christian Gentry[1], Charles Durfee[3], Daniel Hickstein[1], Henry Kapteyn[1], and Margaret Murnane[1] — [1]JILA-NIST and Department of Physics, University of Colorado, Boulder, CO 80309, USA — [2]Grupo de Investigación en Aplicaciones del Láser y Fotónica, Departamento de Física Aplicada, University of Salamanca, Spain — [3]Department of Physics, Colorado School of Mines, Golden, CO 80401, USA

The process of high harmonic generation (HHG) allows for producing attosecond bursts of extreme ultraviolet and soft x-ray light on the tabletop. HHG sources are ideal tools for a variety of scientific and technologically important applications, such as imaging of nanoscale material properties, ultrafast spectroscopy of photoelectrons or element-specific characterization of spin dynamics. While the emission of bright HHG radiation had been limited to linear polarization for quiet a long time, recent exciting breakthroughs have demonstrated the production of high harmonic beams with controllable polarization using two counter-rotating circularly polarized driving laser beams in a collinear or non-collinear geometry. This contribution will focus on the non-collinear case, which offers several key benefits, such as the polarization selective angular separation of the harmonics without a spectrometer. Furthermore, it will be demonstrated how full phase-matching in a non-collinear geometry can be achieved.

Q 49.6 Thu 15:45 P 5

Synchronous interaction of free electrons with optical evanescent wave excited by femtosecond laser pulses — •Martin Kozak, Paul Beck, Joshua McNeur, Norbert Schönenberger, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

In recent years, the coherent interaction between optical near-fields and free-electrons became the basis for several experimental techniques focused on electron acceleration (dielectric laser accelerators, DLAs [1]) or energy-resolved electron imaging (photon-induced near-field electron microscopy, PINEM [2]). In classical DLA schemes, the synchronous near-field mode is excited by femtosecond laser pulse on top of a periodic dielectric element with period smaller than the laser wavelength [1]. Preparation of such a nanoscale phase-mask elements requires advanced nanofabrication. In this contribution we show the first demonstration of the synchronous interaction between free propagat-

ing electrons and an evanescent optical wave excited by total internal reflection on the flat surface of high-refractive index dielectrics. The maximum observed energy modulation is comparable to the grating-based DLA and is limited by the electron group velocity dephasing with respect to the phase velocity of the evanescent wave. Light coupling to the synchronous evanescent wave can be in future improved using the evanescent field of a transverse magnetic mode guided in an optical waveguide. [1] J. Breuer, and P. Hommelhoff, Phys. Rev. Lett. 111, 134803 (2013). [2] B. Barwick, D. J. Flannigan, and A. H. Zewail, Nature 462, 902-906 (2009).

Q 49.7 Thu 16:00 P 5

Ultrashort pulsed compact 2050 nm fiber laser accelerating electrons at a dielectric structure — Heinar Hoogland[1,2], Joshua McNeur[2], Martin Kozák[2], •Peter Hommelhoff[2], and Ronald Holzwarth[1] — [1]Menlo Systems GmbH, Am Klopferspitz 19a, 82152 Martinsried, Germany — [2]Lehrstuhl für Laserphysik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 1, 91058 Erlangen, Germany

A robust all-polarization maintaining fiber laser system at 2050 nm emitting femtosecond pulses at 1-MW peak power level is studied for subsequent dielectric laser acceleration of non-relativistic electrons. The laser setup consists of a Thulium/Holmium codoped gain fiber based oscillator in figure-9 design and a pulse picked chirped pulse two-stage amplifier arrangement. Both temporal stretching as well as recompression of the 2050 nm pulses are achieved by exploiting a single chirped volume Bragg grating, circumventing a bulky diffraction grating based temporal pulse management solution that is highly prone to mechanical perturbations. The laser emits strictly linear polarized pulses at 370-fs pulse duration and 570 nJ pulse energy. By applying this compact fiber laser architecture to a table-top sized "teeny-tiny" accelerator device based on a single Silicon nanograting, 25-keV electrons are accelerated by gradients up to 53 MeV/m. The overall compactness of the entire experimental stage allows for drastically reduced electron accelerator dimensions over traditional large-scale radio-frequency linear accelerator arrangements.

Q 49.8 Thu 16:15 P 5

Temporal characterization of femtosecond electron bunches in a laser-triggered scanning electron microscope — •Norbert Schönenberger, Martin Kozák, Joshua McNeur, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

To study the dynamics in atomic and condensed matter systems, including phonon excitations and electron dynamics in atoms and molecules, sub-femtosecond timescales need to be resolved. The temporal resolution of these ultrafast experiments with electron beams is limited by both the electron dispersion in vacuum and the Coulomb repulsion between electrons. Here we present the temporal characterization of electron bunches emitted from a Schottky-type tip source inside a standard scanning electron microscope (SEM). Photoemission from the tip is induced by 100 fs ultraviolet pulses. The temporal profile of the bunch is obtained by energy- and time-resolved cross-correlation measurements between the electron bunch and the electromagnetic near-field mode of an infrared laser pulse traversing a periodic dielectric nanostructure. We study the influence of the bunch charge and the settings of the electron column on the longitudinal behaviour of the electron packets emitted from the tip to gain further insight into the behaviour of new electron sources, sub-femtosecond-resolved dielectric laser accelerator (DLA) diagnostics and electron diffraction and microscopy experiments [1].

[1] Martin Kozák, et al. Optical gating and streaking of free-electrons with attosecond precision, arXiv:1512.04394 (2015)

Q 49.9 Thu 16:30 P 5

Ultrafast laser fabrication of biomimetic micro and nano structured surfaces — •Evangelos Skoulas — N.Plastira 100, Heraclion, Greece

We report on the fabrication of artificial biomimetic surfaces fabricated via femtosecond laser processing. Metallic, semiconductor and dielectric surfaces were irradiated and Laser Induced Surface Structures (LIPSS) were observed in each type of material surface. In particular femtosecond laser pulses with linear, circular, radial and azimuthal polarization states were utilized for structuring steel (metallic), silicon (semiconductor) and fused silica (dielectrics) surfaces. Experimental results showed that the direction of LIPSS in each case proved to be polarization dependent. A complete study was carried out for the investigation and understanding of LIPSS dependence on fluence value and the number of pulses per spot at two different wavelengths of irradiation enabling the creation of new and more complex surface structures. Furthermore, different LIPSS morphologies and geometries were observed. Additionally large area surfaces were fabricated, tailored with various micro and nano structures bearing great structural resemblance with surfaces found in nature such as lotus leaf, shark skin and butterfly Greta Oto wing. Those bioinspired surfaces were found to exhibit remarkable optical and wetting properties which were attributed to the specific laser induced surface morphology. Thus femtosecond laser processing can be a novel and one single-step method for the fabrication of functional surfaces on almost all classes of solid materials.