Q 13: Ultrashort Laser Pulses: Generation II

Time: Monday 16:30–19:00 Location: F 342

Q 13.1 Mo 16:30 F 342

Optimierung des LIBS-Signals an Metallen durch Femtosekunden Doppelpulse — •Jutta Mildner[1], Lars Englert[1], Waldemar Wessel[2], Alexander Horn[1], Angelika Brueckner-Foit[2], Matthias Wollenhaupt[1] und Thomas Baumert[1] — [1]Universität Kassel, Institut für Physik und CINSaT, Heinrich-Plett-Str. 40, D-34132 Kassel, Germany — [2]Universität Kassel, Institut für Werkstofftechnik - Qualität und Zuverlässigkeit, Mönchebergstr. 3, D-34125 Kassel, Germany

Die verschiedenen Anregungsprozesse im Festkörper skalieren auf einer Femtosekunden bzw. Pikosekunden Zeitskala und sind zeitlich voneinander getrennt [1]. Ablationsprozesse bewegen sich hingegen auf einer längeren Zeitskala [2] und finden erst nach der fs-Anregung statt. Daher kann die Dynamik dieser Prozesse durch die Anwendung zeitlich geformter fs-Laserstrahlung gezielt angesprochen werden. In unseren Untersuchungen wurden Femtosekunden Doppelpuls-Experimente an Metallen mittels Laserinduzierter Breakdown-Spektroskopie (LIBS) durchgeführt. Der Einfluss der Verzögerungszeit und der Intensitätsverhältnisse zwischen den beiden Laserpulsen auf das LIBS-Signal und auf die Ablationsstrukturen werden diskutiert. Auf diese Weise soll die spektrochemische Sensitivität von fs-LIBS erhöht werden, während die hohe räumliche Auflösung [3] erhalten bleibt.

[1] B. Rethfeld *et al.*, Appl. Phys. A **79**, 767–769 (2004)
[2] Y. P. Raizer, Soviet Physics Uspekhi **8**, 650–673 (1966)
[3] A. Assion *et al.*, Appl. Phys. B **77**, 391–397 (2003)

Q 13.2 Mo 16:45 F 342

Energy-resolved measurements of laser-triggered electron pulses from ultrasharp metal tips — •Markus Schenk, Michael Krüger, and Peter Hommelhoff — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München, Germany

For quantum optics experiments with free electrons a spatially and temporally well-controlled electron source is of high interest. Focusing few-cycle pulses of a Titanium:Sapphire-oscillator onto a sharp metal tip triggers electron emission on short timescales. Here we show that different processes occur and can be favored by properly choosing parameters such as laser intensity and static electric field[1]. We perform energy resolved measurements. At low static fields we observe pure over-the-barrier multi-photon photoemission. For higher static fields (narrower tunneling barrier) electrons from below the barrier can tunnel out of the tip after absorption of one or two photons (photo-field emission). At higher laser intensities electrons with energies corresponding to the absorption of up to 7 photons are observed (above-threshold-photoemission). This talk will give an overview about these observed processes.

[1] see also contributions by Michael Krüger et al. and Hanno Kaupp et al.

Q 13.3 Mo 17:00 F 342

Propagation of ultrashort UV pulses in a nonlinear dispersive self-defocusing gas: A route to an effective compression scheme? — •Christian Koehler[1], Luc Berge[2], and Stefan Skupin[1,3] — [1]Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]CEA-DAM, DIF, F-91297 Arpajon, France — [3]Friedrich-Schiller-University, Institute of Condensed Matter Theory and Solid State Optics, 07743 Jena, Germany

Compression of UV femtosecond laser pulses in xenon gas is studied numerically. Due to temporal modulational instability (MI), occurring in the normal dispersion regime with large negative Kerr index, ∼100 fs pulses are compressed by a factor up to eight to singly peaked wave-forms with unchanged shape over meters of propagation range. A detailed discussion of the compression mechanism is given for the (1+1)-dimensional waveguided case and a combination of MI theory and variational techniques is used to identify suitable parameters for compression in bulk (3+1)-dimensional configuration. Furthermore, a comparison between models with and without dispersive nonlinearity exhibits qualitative agreement, leading to the conclusion that even in the case of strong nonlinear dispersion the classical NLS equation captures the basic physical ingredients for this self-compression mechanism. Since in bulk configuration these ultrashort structures naturally evolve without any guiding devices, our findings give rise to a very simple and effective compressor for ultrashort pulses in the UV range.

Q 13.4 Mo 17:15 F 342

High Order Harmonic Enhancement Mediated by the Carrier-Envelope Phase — •J. Biegert[1,6], D. Faccio[1,2], C. Serrat[1,3], J.M. Cela[4], A. Farres[4], and P. Di Trapani[2,5] — [1]ICFO-Institut de Ciènces Fotòniques, Mediterranean Technology Park, 08860 Castelldefels, Barcelona, Spain — [2]CNISM and Dept. of Physics and Mathematics, Università dell'Insubria, IT-22100 Como, Italy — [3]DTDI Universitat de Vic, 08500 Vic, Barcelona, Spain — [4]CASE Barcelona Supercomputing Center, 08034 Barcelona, Spain — [5]Virtual Institute for Nonlinear Optics, Centro di Cultura Scientifica Alessandro Volta, 22100 Como, Italy — [6]ICREA Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain

A two decade enhancement in the conversion efficiency of high harmonic generation is observed and interpreted as the consequence of nonlinearly induced modulation in the phase mismatch between the generating dipole and the propagated harmonics.

We propose a novel technique to improve the efficiency of HHG with few-cycle pulses by controlling their Carrier-Envelope-Phase (CEP) so as to achieve a periodic modulation of the pump peak intensity along with propagation. We have performed numerical simulations based on a three dimensional propagation model in cylindrical coordinates using the nonadiabatic Strong Field Approximation (SFA) to calculate the atomic response. The harmonic grows linearly and after some propagation reaches a value roughly two orders of magnitude higher than the non-modulated, phase-mismatched case.

Q 13.5 Mo 17:30 F 342

Tm:KLu(WO_4)$_2$ laser mode-locked by a single-walled carbon nanotube saturable absorber — •Andreas Schmidt[1], Günter Steinmeyer[1], Valentin Petrov[1], Uwe Griebner[1], Won Bae Cho[2], Sun Young Choi[2], Jong Hyuk Yim[2], Soonil Lee[2], and Fabian Rotermund[2] — [1]Max Born Institute, Berlin, Germany — [2]Ajou University, Suwon, South Korea

Mode-locked solid-state lasers in the 2-μm spectral range are of great interest for various applications. Numerous Tm^{3+}-doped materials showed high efficiency and output powers in the CW and Q-switched regimes. So far only active mode-locking has been demonstrated with bulk Tm-lasers, and passive mode-locking using a SESAM has been shown solely in a Tm:Ho - codoped KY(WO_4)$_2$ laser operating around 2.05 μm [1]. Here, we demonstrate a passively mode-locked Tm:KLu(WO_4)$_2$ laser using a transmittive single-walled carbon nanotube saturable absorber (SWCNT-SA). The nonlinear dynamics of the SWCNT-SA were investigated by the pump-probe technique at 1.92 μm. The recovery time of the SWCNT-SA was estimated to be ≈ 1.2 ps. The laser yields picosecond pulses with maximum average output powers of 240 mW generated near 1.94 μm. The RF spectrum at the fundamental beat note of 126 MHz showed no spurious modulations and a noise floor that was approximately 60 dB below the signal. This high signal-to-noise ratio confirms stable single-pulse mode-locking without Q-switching instabilities.

[1] A. A. Lagatsky et. al., Opt. Lett. **34**, (2009) 2587.

Q 13.6 Mo 17:45 F 342

High peak and average power few-cycle OPCPA system — •Stefan Demmler[1], Jan Rothhardt[1], Steffen Hädrich[1], Enrico Seise[1], Franz Tavella[2], Arik Willner[2], Stefan Düsterer[2], Holger Schlarb[2], Josef Feldhaus[2], Jens Limpert[1,3], Jörg Rossbach[2], and Andreas Tünnermann[1,3] — [1]Friedrich Schiller University, Institute of Applied Physics, Jena, Germany — [2]Deutsches Elektronensynchrotron DESY, Hamburg, Germany — [3]Helmholtz Institute, Jena, Germany

Processes initiated by coherent XUV radiation have found interesting applications. Such photons are typically yielded via high harmonic generation, which suffers from low conversion efficiency. To increase the photon count, high repitition rate driver systems are required. The combination of parametric and chirped pulse amplification seems to be to date the only technique to amplify sub 10fs pulses to highest average powers. To further increase the average power of OPCPA systems, the pump power needs to be increased. This can easily be done by fiber CPA systems. We report on an OPCPA system, which uses two stage OPA and reaches 5.7GW peak power with sub 10fs pulses at a repitition rate of 96kHz (6.7W average power). The peak power of this system could be further enhanced by compressing the pulses to their transform limit, which is not trivial. A technique to obtain FT limited pulses is the multiphoton intrapulse interference phase scan method, which has been used to compress 12fs pulses from a Ti:Sa oscillator to 1% of their FT limit. We show the flexibility for implementation in a few-cycle OPCPA system with peak powers >10GW.

Q 13.7 Mo 18:00 F 342

Modelocked Integrated External-Cavity Surface Emitting Laser (MIXSEL) with output power up to 660 mW and repetition rate up to 10 GHz — •Thomas Südmeyer, Benjamin Rudin, Valentin J. Wittwer, Deran J. H. C. Maas, Yohan Barbarin, Matthias Golling, and Ursula Keller — Department of Physics, ETH Zurich, Switzerland.

Modelocked semiconductor disk lasers (also called VECSELs) achieve higher average output power and shorter pulses than any other ultrafast semiconductor laser technology. However, a modelocked VECSEL contains two separate semiconductor elements in a folded cavity, which is a challenge for cost-efficient high volume fabrication, as well as for reaching high repetition rates. Modelocked integrated external-cavity surface emitting lasers (MIXSELs) are a novel type of ultrafast semiconductor lasers. They combine gain and absorber in one semiconductor structure, enabling modelocking in a simple straight cavity and the possibility of a quasi-monolithic design. Here we present a substantially improved MIXSEL. We developed QD saturable absorber with low saturation energy, which allow for an antiresonant design. This relaxes the demands on the growth accuracy and avoids narrow resonances in the dispersion. Wafer removal technology enabled us to achieve 660 mW in 23 ps pulses for a heat sink temperature of 10°C. A higher pulse repetition rate of 10 GHz was achieved at lower output power of 200 mW. In both cases the output power was pump limited. Such performance is highly attractive for large-scale application such as optical clocking.

Q 13.8 Mo 18:15 F 342

Sub-20 fs pulse shaping in the UV by an acousto-optical programmable dispersive filter (AOPDF) — •Rafael Probst, Nils Krebs, and Eberhard Riedle — Lehrstuhl für BioMolekulare Optik, LMU München

Ultrashort laser pulses of controlled complex pulse shape are of high interest in innovative fields of research like coherent control of molecular dynamics and 2D spectroscopy. Until recently, direct shaping of femtosecond light pulses was restricted to the visible and IR regime. We apply a newly available very compact (8 x 8 x 4 cm^3) acousto-optic pulse shaper (Dazzler^{TM}) that offers full control over the spectral amplitude and phase at wavelengths deep into the UV (240 - 420 nm). The primary broadband UV pulses are generated by frequency doubling of a NOPA. We characterize the shaped pulses by ZAP-SPIDER, X-FROG and difference frequency cross correlation with visible 13 fs pulses. We demonstrate that intrinsic problems of spatial chirp can be solved through a specially designed optical beam path that properly takes into account aspects of geometric as well as Gaussian optics. This allows us to generate nearly transform limited pulses as short as 16.8 fs at 320 nm and 19.5 fs at 260 nm. Within a temporal shaping window of up to 3 ps we demonstrate full control over the amplitude and phase of the pulses by generating arbitrary pulse shapes, e.g., square pulses and complex pulse sequences. The subpulses were manipulated individually in intensity, temporal delay, chirp, relative phase and central wavelength, demonstrating the remarkable possibilities of the setup.

Q 13.9 Mo 18:30 F 342

Kryogener Doppelpass-Verstärker mit μJ-Pulsenergien — •Nils Pfullmann[1,2], Martin Siegel[1,2], Carsten Clever[1,2] und Uwe Morgner[1,2,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Centre for Quantum Engineering and Space-Time Research (QUEST) — [3]Laserzentrum Hannover (LZH)

Zur Erzeugung von hoher harmonischer Strahlung werden aktuell quasi ausschließlich Verstärkersysteme mit Pulsenergien im mJ-Bereich eingesetzt. Diese haben typischerweise eine Pulswiederholrate im Bereich einiger kHz.

Der hier präsentierte Nachverstärker basiert auf einer Kombination eines Seed-Ti:Saphir-Oszillators mit μJ-Pulsenergien und einem kryogen gekühltem Nachverstärker. Mit dem System ist es möglich, Pulse mit einer Pulsenergie von bis zu 1,9 μJ (1,6 μJ komprimiert), einem Fourierlimit von 100 fs (komprimierte Pulsdauer 207 fs) und einer Pulswiederholrate von 1 MHz zu erzeugen.

Ein einfaches analytisches Modell zeigt eine sehr gute Übereinstimmung mit den experimentellen Daten und erlaubt die Extrapolation des Systems zu noch höheren Pulsenergien.

Mit dem System eröffnen sich vielfältige experimentelle Möglichkeiten im Bereich der Starkfeldphysik, wie z.B. die Erzeugung von harmonischer Strahlung mit Megahertz- Repetitionsraten.

Q 13.10 Mo 18:45 F 342

100 kHz infrared pulse generation up to 5300 nm with novel optical parametric amplifiers — •Maximilian Bradler, Christian Homann, and Eberhard Riedle — Lehrstuhl für BioMolekulare Optik, LMU München

Few-cycle pulses in the Mid-Infrared are interesting for many applications such as time-resolved vibrational spectroscopy or high-field science. The most common approach to produce tunable MIR pulses is difference frequency mixing, e.g., of the NIR signal and idler of an optical parametric amplifier (OPA). However, this requires a compromise between the achievable bandwidth and corresponding pulse length below 100 fs and the overall conversion efficiency, which is typically in the 1 % range. Especially for 100 kHz systems with their limited pulse energy infrared pulse generation asks for new principles to access wavelengths above 3 mum.

Here we present a hybrid approach that yields ultrashort CEP stable MIR pulses up to 5 μm directly as the output of an OPA. We first preamplify selected parts of a supercontinuum generated in YAG in BBO. As pump we use the second harmonic of the laser source. In a second stage we further amplify these pulses in $LiNbO_3$ pumped by the remaining light after SHG. This directly renders idler pulses in the desired wavelength range from 2 to 5 μm. This concept was enhanced by chirp and energy management for the output of the first amplification stage to significantly increase the infrared output.