Q 40: Ultrashort laser pulses I

Time: Thursday 10:30–12:30 Location: DO26 207

Q 40.1 Thu 10:30 DO26 207

Watt-level 40 MHz femtosecond optical parametric amplifier coherently seeded by an optical soliton — •Tobias Steinle, Andy Steinmann, Robin Hegenbarth, and Harald Giessen — 4th Physics Institute and Research Center SCOPE, University of Stuttgart, Germany

We report on a femtosecond high-repetition rate optical parametric amplifier that is seeded by an optical soliton from a tapered fiber. Gap-free signal tuning from 1.35 μm to 1.95 μm with up to 1.8 W average power at 1.4 μm and more than 1.1 W up to 1.7 μm is demonstrated. More than half a Watt is generated at the corresponding idler wavelengths from 2.2 μm to 4.5 μm. The system is directly pumped by a 7.4 W Yb:KGW femtosecond oscillator at 41.7 MHz repetition rate. In contrast to supercontinuum-seeded optical parametric amplifiers, soliton-seeding leads to excellent pulse-to-pulse stability, but it introduces a timing-jitter on the millisecond timescale. This timing-jitter can be suppressed by a two-stage concept due to the passive synchronization of both conversion stages. We achieve short time pulse-to-pulse fluctuations of only 0.8% and record long-term stability over 30 min of 0.6%. The system is ideal for pump-probe spectroscopy applications as well as a compact mid-IR broadband source, with the perspective of replacing synchrotron sources for FTIR microscopy.

Q 40.2 Thu 10:45 DO26 207

Spectral broadening of multi-mJ pulses in hollow fibers — •Tamas Nagy — Institut für Quantenoptik, Leibniz Universität Hannover — Laser-Laboratorium Göttingen e.V.

Thank to the fast development of laser technology contemporary fs-amplifier systems can deliver few 10 fs long pulses up to 20 mJ energies at kHz repetition rates. However, numerous applications require few-cycle pulses whose spectral widths are well beyond the gain bandwidths of available laser amplifier materials. In order to solve this problem several methods were developed which can increase the bandwidth. The most successful technique uses self-phase modulation in noble gases filled into hollow fibers. It is working excellent for up to mJ pulse energies but the energy upscaling proved to be surprisingly hard. In this contribution we will overview the key problems, possible solutions and exciting new results achieved in spectral broadening of high-energy pulses.

Q 40.3 Thu 11:00 DO26 207

Modelocking of OPSL Pumped Ytterbium-based Lasers — •Alexander Heuer[1], Kolja Beil[1], Günter Huber[1,2], and Christian Kränkel[1,2] — [1]Institut für Laser-Physik, Universität Hamburg — [2]The Hamburg Centre for Ultrafast Imaging

Optically pumped semiconductor lasers (OPSLs) are viable pump sources for Ytterbium-doped gain materials due to their near diffraction-limited beam profile even at high output power. In particular, Yb:Lu_2O_3 due to its large bandwidth, high laser efficiency, and thermal conductivity is an excellent material for ultrashort pulse generation. We report on a SESAM modelocked Yb:Lu_2O_3 laser pumped by an OPSL capable of delivering 10 W of output power at 976 nm. Slope efficiencies in excess of 70 % and continuous wave output powers of up to 6 W in single-mode operation were achieved. Without dispersion compensation we obtained positively chirped pulses with a duration of 4 ps at 100 MHz repetition rate and 1 W average output power using a 2 mm Yb(3 %):Lu_2O_3-crystal as the gain medium. Implementation of dispersion compensation by means of Gires-Tournois Interferometer (GTI) mirrors for compensation of self-phase modulation should allow for pulse durations below 500 fs maintaining the average power. The results will also be presented at the conference.

Q 40.4 Thu 11:15 DO26 207

Direct generation of 7 fs white light pulses from bulk sapphire without external compression — •Emanuel Wittmann, Maximilian Bradler, and Eberhard Riedle — LS für BioMolekulare Optik, LMU München

Continuum generation in bulk material is a generally applicable method to broaden the spectrum of femtosecond pulses at a variety of repetition rates. It is driven with low μJ range pump pulses. Contrary to the continuum generated in microstructured fibers, the resulting spectrum is smooth and of equal spectral intensity over an octave [1]. The Fourier limit for a possible compression of, e.g., a 800 nm pumped continuum from sapphire, amounts to about 4 fs. Yet, no results have been published that come even close to this limit. In precise investigations of the continuum generation and propagation we now find that the inability to compress the continuum stems from the highly wavelength dependent effective generation locus and propagation. With this understanding, we revert to a 1 mm sapphire plate and optimize the generation onto the output face. The continuum is than imaged into the experiment or autocorrelator with an anastigmatic and achromatic combination of two spherical mirrors. As a result we find visible pulses as short as 7 fs without the use of any external compression scheme. This is quite similar to the celebrated filamentation experiment of Hauri et al. [2]. The broadband visible pulses can be ideally used for seeding noncollinear OPAs (NOPAs).

[1] C. P. Hauri, et al., Appl. Phys. B **79**, 673 (2004).
[2] M. Bradler, P. Baum, E. Riedle, Appl. Phys. B **97**, 561 (2009).

Q 40.5 Thu 11:30 DO26 207

Dynamik und Pulsdauern und in SESAM-modengekoppelten Laseroszillatoren — •Hauke Bensch[1] und Uwe Morgner[1,2,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, D-30167 — [2]Centre for Quantum Engineering and Space-Time Research (QUEST), Welfengarten 1, D-30167 Hannover — [3]Laser Zentrum Hannover, Hollerithallee 8, D-30419 Hannover

Die Energie-Skalierung von passiv modengekoppelten Laseroszillatoren geht nahezu zwangsläufig mit einer Verlängerung der erzielbaren Pulsdauer einher. Die Ursachen dieses störenden Phänomens sind komplex und Maßnahmen dagegen bisher wenig erforscht. Hier werden die Auswirkungen der Fokusgröße auf dem SESAM auf die Pulsdauer und die Modenkoppeldynamik diskutiert. Weiterhin wird die Möglichkeit dargestellt, die cw-Modenkopplung mithilfe einer Regelelektronik zu stabilisieren. Dazu wird ein Aufbau zur stufenlosen Änderung der Fokusgröße vorgestellt, sowie die Möglichkeit einen Resonator modular zu verlängern, um so zusätzlich die Pulsenergie beeinflussen zu können. Ergänzend wird eine Regelelektronik vorgestellt, die den Laserbetrieb gegen Güteschaltung stabilisieren soll, die bei nicht-optimaler Fokussierung auftritt. Eine Kombination aus der Regelelektronik und einem größeren Fokus auf dem SESAM könnte eine wirkungsvolle Maßnahme zur Lösung des Skalierungsproblems bei der Pulsdauer sein.

Q 40.6 Thu 11:45 DO26 207

High-order harmonic generation with mixed infrared laser fields — •Paul Weber, Bernd Schütte, Songhee Han, Marc J. J. Vrakking, and Arnaud Rouzée — Max-Born-Institut, Max-Born-Strasse 2A 12489 Berlin, Germany

High harmonics generation (HHG) in inert gases with a femtosecond laser is an established method for generating ultrashort XUV pulses. Using a longer wavelength driver for the high harmonic generation process allows to extend the maximum photon energy from the XUV range into the soft x-ray regime at the cost of a large decrease of photon flux. To compensate for this low efficiency, we have investigated the possibility to produce a bright high harmonic source in the soft X-ray regime by mixing a near-infrared 800 nm laser field with an additional 1300 nm pulse. We show experimentally the generation of a high photon yield across the whole energy range extending to 180 eV. Optimal phase matching is obtained for a long focus geometry and high pressure (500 mBar) in a neon gas cell. Our experiment investigates in detail how the mixed fields combine for different relative delay times and affect the strong field process leading to high harmonic generation. The possibility to generate bright soft X-ray attosecond pulses with two-color high harmonics generation will be discussed as well.

Q 40.7 Thu 12:00 DO26 207

Direct generation of sub-20 fs pulses tunable from 395 to 950 nm with MHz 1030 nm pumping — Maximilian Bradler, •Bastian Baudisch, and Eberhard Riedle — LS für BioMolekulare Optik, LMU München

Noncollinear optical parametric amplifiers (NOPAs) are now widely used to provide tunable sub-20 fs pulses in the visible and UV for spectroscopic applications. In OPCPAs the principle is used to generate extremely powerful sub-10 fs pulses. The direct generation of pulses tunable in the blue has not yet been demonstrated. We now report sub-20 fs pulses tunable from 393 to 950 nm. The pulses are the signal output of a NOPA pumped with either the second or the third harmonic of a commercial 1030 nm laser with 300 fs duration. Average powers up to 200 mW at 200 kHz and up to 500 mW at 1 MHz are shown. The critical issue to solve was the seed light in the blue as the continuum pumped by 1030 nm only spans to slightly below 500 nm [1,2]. We now use second harmonic pumping of the seed and can such utilize the potential amplification range of the 343 nm pumped NOPA to well below 400 nm. Extremely broadband amplification is found with compression to sub-20 fs. For operation up to 1 MHz special care has to be taken to avoid crystal damage due to two-photon-absorption. By second harmonic generation the range from above 400 nm down to the limit of BBO at 210 nm is accessed in a single conversion stage.

[1] C. Homann, C. Schriever, P. Baum, and E. Riedle, Opt. Express **16**, 5746 (2008).

[2] M. Bradler, P. Baum, E. Riedle, Appl. Phys. B **97**, 561 (2009).

Q 40.8 Thu 12:15 DO26 207

Simultaneous VUV and XUV attosecond pulse generation and characterization for attosecond pump probe experiments

— Davide Fabris[1], William A. Okell[1], Daniel Walke[1], Jost Henkel[2], Manfred Lein[2], •Tobias Witting[1], Jon P. Marangos[1], and John W.G. Tisch[1] — [1]Blackett Laboratory, Imperial College London, London SW7 2AZ, UK — [2]Institut für Theoretis- che Physik and Centre for Quantum Engineering and Space-Time Re- search (QUEST), Leibniz Universität Hannover Appelstraße 2, 30167 Hannover, Germany

We report the generation and characterization of isolated attosecond XUV and VUV pulses generated simultaneously via HHG driven by near single-cycle infrared pulses using an in-line dual gas target system. Neon gas for HHG and a zircon filter was used to select photon energies in the XUV around 90 eV. Krypton gas for HHG and tin and indium filters were used to generate VUV radiation at 15 and 20eV. We characterized both the XUV and VUV pulses independently using the FROG-CRAB technique obtaining a 1.7±0.2 fs pulse using the In filter and a 616±50 as pulse using Sn, while preserving the simultaneously generated 266±10 as isolated XUV pulse. We confirm the experimentally determined pulse lengths by solving the time-dependent Schrödinger equation and investigate the influence of ionization gating in the VUV. The applicability of attosecond streaking for slow photoelectrons is also checked by numerical simulations.