Q 45: Ultrashort Laser Pulses I

Time: Thursday 11:00–13:00 Location: a310

Q 45.1 Thu 11:00 a310

Fast-tunable femtosecond broadband ring cavity NOPO with intracavity SFG in visible — •Yuliya Khanukaeva[1], Tino Lang[2], Ayhan Tajalli[1], Thomas Binhammer[3], and Uwe Morgner[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany — [2]Deutsches Elektronen-Synchrotron DESY, D-22607 Hamburg, Germany — [3]VENTEON Laser Technologies GmbH, D-30419 Hannover, Germany

We present a femtosecond fast tunable source that is able to simultaneously deliver NIR and VIS pulses in the range of 680-950 nm and 400-500 nm correspondingly. The source is based on intracavity sum frequency generation (SFG) in an ultrafast singly-resonant ring cavity non-collinear optical parametric oscillator (NOPO) pumped by the second harmonic of a home-built thin-disk laser. The NOPO employs a BBO crystal as gain medium and a KDP crystal for the intracavity SFG between the signal and remaining IR pump, both in a non-collinear configuration. The tuning concept is based on a ultra-broadband phase-matching that allows tuning the wavelength over the whole range just by varying the cavity length without changing the phase matching angle of the OPO crystal. When both outputs are used at the same time the source provides up to 1 W output at 925 nm and 200 mW of SFG at 485 nm, whereas without IR output coupling up to 450 mW has been recorded in the VIS.

Q 45.2 Thu 11:15 a310

Dual Yb^{3+}:Lu_2O_3 thin-disk oscillator with SESAM mode-locking — •Bernhard Kreipe, Jana Kampmann, Luise Beichert, and Uwe Morgner — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

We present a multi-crystal oscillator based on two Yb^{3+}:Lu_2O_3 thin-disks in a symmetrically coupled cavity. The multi-pass geometry of the resonator with 16 passes per round trip enables high outcoupling of the intracavity power greater than 25 %. By splitting the power of a conventional broadband diode to both thin-disks, we achieve more than 50 W of output power in cw operation at 210 W of pump power with a slope efficiency of 40 %. Also the transfer of this power-scaling approach to the pulsed regime in the context of a SESAM mode-locked chirped-pulse oscillator is investigated.

Q 45.3 Thu 11:30 a310

Rapidly, electronically tunable fiber-based optical parametric oscillator — •Maximilian Brinkmann, Sarah Janfrüchte, Sven Dobner, and Carsten Fallnich — Institute of Applied Physics, University of Münster, Germany

We present a fiber-based optical parametric oscillator (FOPO) synchronously pumped by an amplified laser diode at a wavelength of 1030 nm, with a repetition rate of about 1 MHz and a pulse duration of 10 ps. The FOPO consisted of 10 cm of highly nonlinear photonic-crystal fiber to frequency-convert the pump pulses via four-wave mixing and about 200 m of single-mode fiber to form the resonator. Due to dispersion in the fiber resonator, the fed back signal pulse was temporarily stretched, such that only a narrow spectral part of it overlapped with the next pump pulse and was amplified. Via this dispersion filtering, output idler pulses with a bandwidth of about 3 nm, a temporal duration of about 5 ps and a pulse energy up to 20 nJ could be produced. By changing the repetition rate of the pump laser diode by about 2 kHz, the wavelength of the output pulses could be tuned between 1130 and 1310 nm. As this tuning mechanism was solely based on electronical means, we were able to tune the FOPO with a speed of 8 μs per wavelength step, independent of the width of the step, which is several orders of magnitude faster than achieved with similar FOPOs tuned via a mechanical delay line or with temperature-controlled OPOs. Due to the rapidly and widely tunable wavelength and the high energy of its output pulses, the FOPO should be well suited for coherent Raman or multi-photon microscopy.

Q 45.4 Thu 11:45 a310

Mode-locking maps for a giant chirp oscillator — •Paul Repgen, Florian Schepers, Tim Hellwig, and Carsten Fallnich — University of Münster, Institute of Applied Physics, Correnssstraße 2, 48149 Münster

We present a systematic and fully-automated characterization method to analyze the possible output states of a giant chirp oscillator (GCO)[1]. Our GCO is a long-cavity (2.6 MHz repetition rate, 6.6 nJ pulse energy) Ytterbium-doped fiber oscillator, mode-locked by a nonlinear amplifying loop mirror (NALM). An approximately 70 m long single-mode fiber in the resonator induces an up-chirp to the pulse due to normal dispersion, resulting in an output pulse with an autocorrelation duration of 133 ps which can be compressed to an autocorrelation duration of 169 fs using an external grating compressor. Within our examination, we scan the pump power of the amplifier fiber as well as the NALM and record the mean power, repetition rate, spectrum, and the pulse energy fluctuations of the different operation states. Based on these data „mode-locking maps“ can be generated that can be subsequently used to directly compare different laser configurations (e.g. after changes of resonator length or output coupler position, etc.) and thereby allow to choose the optimal setup for the desired application.

[1] Erkintalo M., et al., *Opt. Express* **20**, 22669 (2012).

Q 45.5 Thu 12:00 a310

Efficient narrowband terahertz generation in periodically poled lithium niobate — •Frederike Ahr[1,2], Sergio Carbajo[1,2,3], Jan Schulte[1,2], Xiaojun Wu[1,3], Koustuban Ravi[1,4], Damian Schimpf[1,3], and Franz X. Kärtner[1,2,3,4] — [1]Center for Free Electron Laser Science, and Deutsches Elektronen Synchrotron, Notkestraße 85, 22607 Hamburg, Germany — [2]Department of Physics, University of Hamburg, Luruper Chausee 149, 22761 Hamburg, Germany — [3]The Hamburg Center of Ultrafast Imaging, Luruper Chausee 149, 22761 Hamburg, Germany — [4]Department of Electrical and Computer Engineering, and Research Laboratory of Electronics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, USA

We report a record optical-to-terahertz energy conversion efficiency for narrowband terahertz (THz) radiation in the frequency range of 0.1 to 1 THz via optical rectification in periodically poled lithium niobate (PPLN). The efficiency was optimized by cryogenically cooling the PPLN crystals to reduce THz absorption and by spectrally filtering the pulses from a Ti:sapphire regenerative amplifier. Tuning of the THz frequency was verified by measuring via electro-optic sampling the temporal waveforms and the corresponding spectra of THz pulses generated by PPLNs of different poling periodes and corresponding phase-matching conditions. We achieved an energy conversion efficiency of 0.12%, which is two orders of magnitude higher than preceding studies with similar geometries, at a frequency of 560 GHz in a cryogenically cooled PPLN with a domain period of 212μm.

Q 45.6 Thu 12:15 a310

Resolving the evolution of femtosecond modelocking via real-time spectroscopy at 90 MHz — •Georg Herink[1,2], Bahram Jalali[2], Claus Ropers[1], and Daniel S. Solli[1,2] — [1]IV. Physik, Friedrich Hund Platz 1, 37077 Göttingen — [2]Department of Electrical Engineering, University of California, Los Angeles

Kerr-lens mode-locking (KLM) arises from noise and each starting event is highly stochastic and non-repetitive [1]. Conventional forms of time-resolved spectroscopy are incapable to trace the process with single-shot resolution over long record intervals. Here, we present real-time spectroscopy of the mode-locking transition in a KLM oscillator over 900,000 consecutive pulses. This is enabled by the Time-Stretch Dispersive Fourier Transformation (TS-DFT) and real-time electronic sampling [2,3]. We resolve the dynamics over the entire buildup with features on various timescales, i.e., the noisy onset of mode-locking milliseconds before the establishment of a femtosecond pulse, rapid spectral broadening and wavelengths shifts within few hundred roundtrips. In addition, we identify a previously unreported beating process via the Kerr nonlinearity which governs the spectral broadening. This process can be employed as a time-resolved probe of the intracavity nonlinearity. We expect that the results stimulate further theoretical analysis of mode-locking and establish real-time spectroscopy as a diagnostic tool for novel ultrashort sources and nonlinear systems.

[1] U. Keller, Nature 424, 831 (2003). [2] A. Bhushan, F. Coppinger, B. Jalali, Electronics Letters 34, 839 (1998). [3] D. Solli, G. Herink, B. Jalali, C. Ropers, Nature Photonics 6, 463 (2012).

Q 45.7 Thu 12:30 a310

Full characterization of few-cycle pulses using cross-polarized

wave generation d-scan technique — •Ayhan Tajalli[1], David Zuber[1], Bruno Chanteau[1], Martin Kretschmar[1], Heiko Kurz[1], Milutin Kovacev[1], Uwe Morgner[1,2], and Tamas Nagy[1,3] — [1]Institut Für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover — [2]Laserzentrum Hannover e.V., 30419 Hannover — [3]Laser Laboratorium Göttingen e.V., 37077 Göttingen

Femtosecond pulse sources are considered as backbone of various fields of fundamental studies and applications e.g. strong field physics, time-resolved optical microscopy and micro-machining. This technology requires the ability for full characterization of the ultrashort pulses. Different techniques such as FROG or SPIDER have been devised in last decades for this purpose; however, they suffer from rather complex setups or accurate calibrations. Here, we demonstrate a new version of dispersion scan (d-scan) pulse characterization scheme for phase retrieval of ultrashort optical pulses based on cross-polarized wave (XPW) generation nonlinearity. Degenerate four wave mixing process relaxes the phase matching constraints and hence is applicable for extremely wide wavelength range. We fully characterize 7-15 fs pulses in the near-IR region delivered from spectrally broadened amplified pulses in a noble gas-filled hollow-core fiber and compare the results with a state of the art FROG characterization device.

Q 45.8 Thu 12:45 a310

Analysis and measurement of spatiotemporal couplings in noncollinear optical parametric amplifiers — •Achut Giree[1,2], Federico J. Furch[1], Mark Mero[1], Gunnar Arisholm[3], Claus Peter Schulz[1], and Marc J.J. Vrakking[1] — [1]Max Born Institute, Max-Born-Str. 2A, D12489, Berlin, Germany — [2]Amplitude Technologies, 2-4 rue du Bois Chaland CE 2926, 91029 Evry, France — [3]Norwegian Defence Research Establishment (FFI), PO Box 25, NO-2027 Kjeller, Norway

Noncollinear optical parametric amplifiers (NOPAs) are capable of delivering high energy, high repetition rate few-cycle pulses and are becoming increasingly more attractive in attosecond science. The high repetition rate (>>10 kHz) allows a significant increase in data acquisition speed and therefore is particularly important for electron-ion coincidence detection techniques where the necessary event rates are <<1 per pulse for unambiguous identification of electrons and their ionic partners. However, NOPAs may suffer from unwanted couplings between temporal and spatial coordinates of the electromagnetic field induced by the noncollinear geometry, known as spatiotemporal distortions. This ultimately limits the maximum achievable intensity at focus. In this work, we present a numerical study of spatiotemporal couplings in a NOPA based on the Sisyfos software and discuss possible ways to minimize the distortions. Additionally, we propose a real time technique to measure the spatiotemporal distortions based on spatially resolved spectral interferometry which serves as a tool to reduce them during NOPA alignment.