Q 46: Lasers I

Time: Thursday 11:00–13:00 Location: HS 3118

Q 46.1 Thu 11:00 HS 3118

High Power UV Laser Systems for Bunched Beam Laser Cooling — •Benedikt Langfeld, Jens Gumm, Tamina Grunwitz, and Thomas Walther — TU Darmstadt, Institut für Angewandte Physik

Laser cooling of bunched relativistic ion beams has been shown (e.g. at GSI Helmholtzzentrum) to be a powerful technique to generate ion beams with small emittances and narrow longitudinal velocity distributions. For highly relativistic (large γ-factors) and intense heavy-ion beams, laser cooling will be very efficient and cooling times of the order of seconds are expected. For these reasons, laser cooling will be the only available cooling method at the planned heavy-ion synchrotron SIS100 at FAIR.

In this talk, we discuss the principle of bunched beam laser cooling using multiple laser beams. We will give an overview of two laser systems that will be used at the SIS100, namely one continuous-wave (cw) laser system and one pulsed picosecond laser system. At the TU Darmstadt, the cw master-oscillator-power-amplifier UV laser system - with two SHG cavities - and the tunable high repetition rate (1-10 MHz) pulsed UV laser system - with a continuously adjustable pulse duration between 50 and 735 ps - are being developed. With these systems, we achieved very high UV output powers of over 2W UV (cw system) and over 4W average power (pulsed system).

Q 46.2 Thu 11:15 HS 3118

Two-cycle laser pulse at 1600 nm from a compact fiber-feedback OPO and OPA combination at 76 MHz repetition rate — •Johann Thannheimer, Abdullah Alabbadi, Tobias Steinle, and Harald Giessen — University of Stuttgart

Compact and powerful few-cycle sources between 1 μm and 2 μm are required to generate mid-infrared light for spectroscopy via intra-pulse difference frequency generation, as well as for ultrafast metrology via electro optic sampling. We demonstrate fiber-based compression down to two optical cycles (12 fs) at 1600 nm with an average power of 570 mW and a repetition rate of 76 MHz. We use an Yb-based pump laser for an optical parametric oscillator which is subsequently amplified to the watt scale using an optical parametric amplifier. The nonlinear frequency broadening and anomalous dispersion which is required for pulse compression, is realized by just coupling the light into a 42-mm-long common single mode fiber. FROG measurements confirm that our system realizes few cycle pulses based on an extremely compact, stable, and low-noise solid-state laser system.

Q 46.3 Thu 11:30 HS 3118

A single-stage dispersion-controlled multipass cell setup to efficiently drive resonant dispersive wave emission. — •Ammar bin Wahid[1], Laura Silletti[1], Teodora F. Grigorova[2], Lorenzo Pratolli[1], Christian Brahms[2], Esmerando Escoto[1], Prannay Balla[1,3], Supriya Rajhans[1,3], Katinka Horn[1], Lutz Winkelmann[1], Vncent Wanie[1], Andrea Trabattoni[1,4], Christoph M. Heyl[1,3], John C. Travers[2], and Francesca Calegari[1] — [1]DESY, Germany — [2]Heriot-Watt University, United Kingdom — [3]Helmholtz-Institute Jena, Germany — [4]Leibniz Universität Hannover, Germany

Yb-based lasers are characterised by their ability to operate at high average power and high repetition rates. However, they are limited by relatively long Fourier transform limit pulse duration, typically spanning from 100 fs up to the few ps regime. To overcome these challenges, multi-pass cells (MPCs) are becoming an increasingly attractive solution. They allow operation at high peak and average power while maintaining high efficiencies (>90%), high compression ratios, compact setup sizes and excellent beam quality. [1][L. Silletti et al.Optics Letters, 48(7), 1842-1845]. Here we present tunable 3fs transform-limited deep-UV light generation by driving resonant dispersive waves (RDWs) in an argon-filled hollow core fibres [2][J.C. Travers et.Nat. Photonics 13, 547-554 (2019)] cascaded by a single-stage dispersion-engineered MPC, which is capable of compressing 150-fs pulses to sub-20-fs durations with scalability from 1kHz up to 200kHz.

Q 46.4 Thu 11:45 HS 3118

8-Fold Energy Upscaling by Divided-Pulse Spectral Broadening in a Multi-Pass-Cell — •Henrik Schygulla[1,2], Nayla Jimenez[1,3,4], Yujiao Jiang[1], Hüseyin Çankaya[1], Ingmar Hartl[1], and Marcus Seidel[1,3,4] — [1]DESY, Hamurg, Deutschland — [2]Uni Hamburg, Deutschland — [3]Helmholtz Institute Jena, Deutschland — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Deutschland

Multi-pass-cells (MPC) offer an excellent spectral broadening method, but a current challenge is its peak power scalability [1]. To resolve this, we divided the input pulse [2] into 8 replicas and demonstrated a corresponding increase of pulse energy after nonlinear compression.

The used laser generated 208fs pulses at 1030nm with a pulse energy of up to 140uJ. The input pulse was divided into 8 replicas using 3 calcite crystals and sent through the MPC for spectral broadening to a 45fs bandwidth limit. Afterwards, the replicas were recombined with an identical set of crystals and compressed via chirped mirrors. A duration of 49fs after compression was measured by FROG. The nonlinear compression performance of a single 17uJ pulse and the 140uJ pulse train was compared: The polarisation cleaning losses for the divided-pulse setting were 5%, the pulse duration remained the same.

These results enable switching laser repetition rates for FLASH pump-probe experiments [3] without compromising the pulse duration.

[1] Viotti et al. Optica 9, 197 (2022); [2] Stark et al. J. Phys. Photonics 4, 035001 (2022); [3] Viotti et al. Rev. Sci. Instr. 94, 023002 (2023)

Q 46.5 Thu 12:00 HS 3118

Intra-Cavity Control of Dual-Comb Soliton Motion inside a single Fiber Laser — •Julia A. Lang[1], Sarah Hutter[2], Alfred Leitenstorfer[2], and Georg Herink[1] — [1]Experimental Physics VIII - Ultrafast Dynamics, University of Bayreuth, Bayreuth, Germany — [2]Department of Physics and Center for Applied Photonics, University of Konstanz, Konstanz, Germany

Ultrafast lasers can exhibit dynamic sequences of multiple solitons. However, understanding and controlling their dynamics or utilizing them practically remains challenging. In this contribution, we introduce a new method for the precise control of relative soliton motion. By employing intra-cavity acousto-optic modulation, we selectively modulate single pulses out of two interlaced harmonically mode-locked frequency combs in an all-fiber Er:fiber laser. Upon external stimuli, the trajectories exhibit rapid and deterministically adjustable behaviour as a result of the interplay of ultrafast nonlinearity and laser gain dynamics. Based on these findings, we demonstrate fast all-optical scanning of picosecond pump-probe delays and programmable free-form soliton trajectories [1].

[1] Lang, J. A., Hutter, S. R., Leitenstorfer, A., & Herink, G. (2023). Controlling Dual-Comb Soliton Motion inside a single Fiber Laser Cavity. arXiv preprint arXiv:2308.13472.

Q 46.6 Thu 12:15 HS 3118

Optical pumped 10μm amplifier — •Bernd Witzel, Paul-Émile Chantrel, Bernard Sévigny, and Michele Piché — Centre d'Optique Photonique et Laser (COPL) and Département de Physique de Génie Physique et d'Optique Université Laval, Québec, Québec, G1V 0A6,Canada

We have demonstrated a high-energy, single-crystal Optical Parametric Oscillator (OPO) pumped directly by a Nd-YAG laser operating at 1064 nm. In our study, we compare this system to a standard Master Oscillator Power Amplifier (MOPA) setup equipped with one OPO and four amplification stages. We achieved pulse energies of 90 mJ at 2 μm for the high-energy OPO and 115 mJ for the MOPA system. The duration of both the signal and idler beams is approximately seven nanoseconds. Both systems allow for wavelength tuning between 1.9 μm and 2.4μm. We aim to explore the feasibility of pumping a 10 μm amplifier and present our initial findings regarding this amplification. The active gas employed in this amplifier is CO_2 under high-pressure. This system is designed for the amplification of 10 μm ultra-short laser pulses with a duration of 200 fs.

Q 46.7 Thu 12:30 HS 3118

Ultraviolet supercontinuum generation using a differentially-pumped glass chip — •Josina Hahne[1,2], Vincent Wanie[3], Pasquale Barbato[4,5], Sergey Ryabchuk[1,2], Ammar Bin Wahid[3], David Amorim[3], Erik P. Månson[3], Andrea Trabattoni[5,6],

Roberto Osellame[5], Rebeca Martínez Vázquez[5], and Francesca Calegari[1,2,3] — [1]Universität Hamburg — [2]The Hamburg Centre for Ultrafast Imaging — [3]CFEL, Hamburg — [4]Politecnico di Milano — [5]CNR-INF, Milano — [6]Leibniz Universität Hannover

UV pulses with a duration of a few- or sub-femtosecond durations are of great interest in the field of ultrafast spectroscopy, since they provide access to the UV-induced electron dynamics in biologically relevant molecules. Sub-3-fs UV pulses have previously been generated by third-harmonic generation in gas cells or resonant dispersive wave emission in hollow capillaries. Here, we present a compact glass chip design which combines a gas cell with two differential pumping stages, providing high gas confinement, to minimize the reabsorption of the generated UV pulses and preserve their temporal duration. The resulting UV pulse energy reaches up to 0.8 uJ in neon (0.2% conversion efficiency). The generated spectra spann from 200 to 325 nm, supporting transform limit durations of 2.1 fs in argon and 1.9 fs in neon. To gain further insight into the nonlinear process, numerical simulations have been performed. Ionisation has been found to be key for the exceptional broadening of the UV pulses due to the spatio-temporal reshaping of the driving field as well as plasma blue shifting.

Q 46.8 Thu 12:45 HS 3118

NOPA rainbow: 10 fs regime pulses tunable over more than an octave — •Ferdinand Bergmeier and Eberhard Riedle — Lehrstuhl f. BioMolekulare Optik, Fakultät f. Physik, LMU München

We combine a contemporary Yb-based 250 fs industrial-grade pump laser with a newly devised and comprehensively engineered noncollinear optical parametric amplifier (NOPA). The NOPA employs easily interchangeable 515 and 343 nm pumping, facilitating fundamental tunability from 390 to 950 nm without any gaps. Output pulse energies of some uJ are reached in a single amplification stage with a clean Gaussian beam shape. The repetition rate can be varied between 1 and 200 kHz without adjustments at constant pulse parameters. A single stage of second harmonic generation (SHG) extends this range down to below 220 nm. The spectral width across all centre wavelengths is sufficient for sub-10 fs pulses. We routinely achieve pulse lengths between 10 and 20 fs. The system has stably run without any adjustments for three months.

To scrutinize the characteristics of the pump laser/NOPA combination, we developed a detector capable of shot-to-shot measurements at a rep rate of 200 kHz. This detector was employed to analyse the shot-to-shot fluctuations and correlation of the NOPA at various repetition rates and pulse picker settings of the pump laser. Beyond the overall rms of the output pulses all relevant nonlinearly generated pulses inside the NOPA were compared and correlated to the pump laser behaviour. It was found that the long-term fluctuations of the NOPA output are below 0.5% at a 0.1% level of the pump laser.