K 2: Laser Systems

Time: Tuesday 14:00–15:45 Location: f428

K 2.1 Tue 14:00 f428

Femtosecond 100 W-level OPCPAs from 800 nm to 2 μm — Robert Riedel[1], Michael Schulz[1], Ivanka Grguraš[1], Torsten Golz[1], Jan H. Buss[1], and •Mark J. Prandolini[1,2] — [1]Class 5 Photonics GmbH, Notkestr. 85, 22607 Hamburg, Germany — [2]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

High power and high repetition rate lasers are critical for many applications in the physical, chemical, and biological sciences. Previously, laser sources from x-ray to THz were driven from Ti:Sapphire lasers at 800 nm with limited bandwidth (Fourier limited pulse of 20 fs), and more importantly limited power levels; power levels 40 W and above require large complex cooling systems. Optical parametric chirped-pulse amplification (OPCPA) together with bulk crystal white-light-generation (WLG) opens up the possibility of high power lasers (well above 100 W), with wavelength tunable and broadband (for example, $<$ 10 fs at 800 nm), requiring no complex cooling with a compact design. Recently, 100 W-level OPCPAs are now commercially available from Class 5 Photonics GmbH from 800 nm to 2 μm.

K 2.2 Tue 14:15 f428

A thin-disk pumped OPCPA system delivering >4 TW pulses — •Martin Kretschmar[1], Johannes Tümmler[1], Bernd Schütte[1], Andreas Hoffmann[1], Björn Senfftleben[1], Mark Merö[1], Mario Sauppe[1,2], Daniels Rupp[1,2], Marc Vrakking[1], Ingo Will[1], and Tamas Nagy[1] — [1]Max-Born-Institut, Max-Born-Straße 2A ,Berlin — [2]ETH Zürich, John-von-Neumann-Weg 9, Zürich

Nonlinear optical interactions can already be studied in the XUV spectral window, where free electron lasers serve as a reliable source for intense XUV pulses. On a laboratory scale, the generation of intense XUV pulses is realized through high harmonic generation (HHG), calling for driving lasers delivering pulses in the Terawatt (TW) regime.

Here, we present an optical parametric chirped pulse amplification (OPCPA) system delivering >40 mJ near infrared pulses with a pulse duration below 8 fs, which corresponds to a peak power well exceeding 4 TW. The parametric amplification process is pumped by two home-built thin-disk lasers operating at 100 Hz with a pump pulse duration below 10 ps. The TW pulses are applied for HHG, enabling the generation of near μJ level XUV pulses, which can drive nonlinear strong field processes [1] and are a potential source for attosecond pump-probe experiments.

[1] Senfftleben et al., arXiv:1911.01375

K 2.3 Tue 14:30 f428

Influence of the dispersion in a doubly resonant optical parametric oscillator — •Christian Markus Dietrich[1,2], Ihar Babushkin[1,2,3], José R.C. Andrade[1,2], Han Rao[1,2], and Uwe Morgner[1,2] — [1]Leibniz University Hannover, Institute for Quantum Optics, Hannover, Germany — [2]Cluster of Excellence PhoenixD, Hannover, Germany — [3]Max Born Institute, Berlin, Germany

We present measurements and a numerical model of the spectral behaviour of a doubly resonant optical parametric oscillator (DROPO) in relation to the intracavity second and third order dispersion. DROPOs can be interesting light sources for comb generation and spectroscopy. In a DROPO the signal and idler wavelengths are both resonant and need to fulfill a proper phase relation, which is influenced by the dispersion of the cavity. This leads to complex length detuning characteristics in the optical spectrum. Self phase locking of the DROPO to the pump appears at degeneracy and proper length tuning. By using this effect, phase-stable multi-color light fields can be generated which are promising for high harmonic generation and other effects. Our experimental work is explained by a numerical model solving the coupled differential equations for the two orthogonal polarization directions in the amplifier crystal. Even though the model is restricted to one spatial dimension only, it can help for understanding the complex pulsing dynamics in a DROPO.

K 2.4 Tue 14:45 f428

Pump Combiner with Chirally Coupled Core Fibers for Single Frequency All Fiber Amplifier — •Eike Brockmüller[1,2], Sven Hochheim[1], Peter Wessels[1], Joona Koponen[3], Tyson Lowder[4], Steffen Novotny[3], Jörg Neumann[1], and Dietmar Kracht[1] — [1]Laser Zentrum Hannover e.V., Laser Development Department, Hollerithallee 8, 30419 Hannover, Germany — [2]Universität zu Lübeck, Ratzeburger Allee 160, 23562 Lübeck, Germany — [3]nLight Oy, Sorronrinne 9, 08500 Lohja, Finland — [4]nLIGHT Inc., 5408 NE 88th Street, Vancouver, WA 98665, USA

To increase its sensitivity, the next generation of gravitational wave detectors requires single frequency lasers in a linearly polarized TEM_{00}-mode with high output power. It was shown that fiber based amplifier systems can meet these requirements with low complexity. However, they are limited by the nonlinear effect of stimulated Brillouin scattering (SBS). The concept of a chirally coupled core (3C®) fiber allows single-mode operation with a large mode area core and therefore raises the limit for the onset of SBS. A key element of such an amplifier setup is the pump combiner. We present the development of a pump combiner using a side-pumping technology in which the pump light is coupled into an active 3C® fiber with the key advantage of an uninterrupted signal core and without the need of an additional fusion splice in the amplifier setup. This should lower the complexity, reduce power losses and increase the robustness of the amplifier system, which further emphasizes the high potential of fiber amplifiers as laser sources for the next generation of gravitational wave detectors.

K 2.5 Tue 15:00 f428

15 W Er^{3+}:Yb^{3+}-codoped fiber laser for in-band Er^{3+} pumping — •Marian Dürbeck, Phillip Booker, Omar de Varona, Michael Steinke, Peter Wessels, Jörg Neumann, and Dietmar Kracht — Laser Zentrum Hannover e.V., Hollerithallee 8, D-30419 Hannover, Germany

Single-frequency Er^{3+}:Yb^{3+}-codoped fiber amplifiers in MOPA configuration are promising candidates to fulfil the challenging requirements of 1.5 μm laser sources for the third generation of interferometric gravitational wave detectors (GWDs). However, typical high-power pump sources only come with high NA and thus require long double-clad fiber lengths favourable for non-linearities such as SBS. On the other hand, single-mode core-pumping sources only come in the form of a cascaded Raman laser with high complexity designs. In this work, we demonstrate a low-complexity and single-mode Er^{3+}:Yb^{3+}-codoped fiber laser centered around 1530 nm and off-peak pumped at 915 nm, as a pump source for core-pumped amplifiers. We optimized the laser resonator by testing different commercially available SM-Er^{3+}:Yb^{3+} fibers and their respective lengths with different outcoupler reflectivites. We characterized the laser for up to 15.5 W of output power (stability, noise-performance, spectrum and beam profile) with a slope-efficiency of 42.2 % and confirmed the absence of detrimental Yb^{3+}-ASE by optical spectrum measurements.

K 2.6 Tue 15:15 f428

Attosecond streaking of an infrared parametric waveform synthesizer — •Fabian Scheiba[1], Giulio Maria Rossi[1], Roland E. Mainz[1], Yudong Yang[1,2], Miguel A. Silva-Toledo[1], Phillip D. Keathley Keathley[3], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2] — [1]Center for Free-Electron Laser Science CFEL and Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany and Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

Synthesis of optical fields based on optical parametric amplifiers (OPAs) is a promising approach for energy- and wavelength-scalable sources. Here, a NIR ((0.65-0.95) μm) and IR ((1.2-2.2) μm) spectral channel with a relative phase stability of 70 mrad are synthesized to a >1.5 octave spanning pulse with a measured CE-phase stability of 233 mrad, a central wavelength of 1.4 μm and a FWHM duration down to 2.8 fs. The full spatio-temporal stabilization allows for the generation of continuous XUV spectra via high harmonic generation (HHG) in gases with an energy stability of 5.9% rms. Attosecond streaking experiments visualize the measured electric field waveforms generated and prove the excellent long-term pulse-to-pulse stability as well as versatility in shaping the synthesized waveforms to non-sinusoidal fields in the sub-cycle limit.

K 2.7 Tue 15:30 f428

High-harmonic generation control with intense, infrared, synthesized waveforms — •Miguel A. Silva-Toledo[1], Roland E. Mainz[1], Yudong Yang[1,2], Giulio Maria Rossi[1], Fabian Scheiba[1], Guangjin Ma[1], Phillip D. Keathley[3], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2] — [1]Center for Free-Electron Laser Science (CFEL) and Deutsches Elektronen-Synchrotron (DESY), Notkestraße 85, 22607, Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Research Laboratory of Electronics, Massachussets Institute of Technology, Cambridge, Massachussets 02139, USA

Sub-cycle shaping of light fields driving high-harmonic generation (HHG) allows full amplitude- and phase-control of coherent extreme ultraviolet (XUV) to soft X-ray radiation. Here, we show such control in the XUV regime via tailored driver pulses, delivered by an optical parametric amplification-based waveform synthesizer. Synthesis is achieved by combining near-infrared (NIR) (0.65 - 1.0 μm, $\sim$ 6 fs, $\sim$ 150 μJ) and infrared (IR) (1.2 - 2.2 μm, $\sim$ 8 fs, $\sim$ 500 μJ) pulses. Upon variation of the CEP and relative phase between NIR and IR pulses, we modulate the spectrum and yield of attosecond pulse trains and of isolated attosecond pulses (IAPs). Attosecond streaking measurements characterize the driver pulses and IAPs. Experimental observations are also combined with macroscopic HHG simulations. Our study will facilitate research on optimal driver fields for efficient soft X-ray HHG.