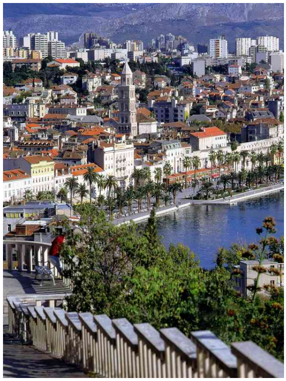
UltrafastOptics
UFO XII

Conference Program

GENERAL INFORMATION

About Brač and Bol. Brač (pronounced "Bratch") is the island of exceptional natural beauty, with many beaches and small traditional towns. An exceptional view can be seen from Vidova Gora (778 m), the highest peak in the Adriatic islands. The largest town is Supetar, with frequent ferry connections to Split. Brač is also famous for its white limestone, used for the facade of the White House. These stones are best visible in the town of Pučišća, where it was used for construction of most of the houses. Bol is the site of one of the most attractive beaches, called "Zlatni rat", and is a popular tourist destination.



About Split. Split is a historical city on the Dalmatian coast, and the second largest city in Croatia. It was founded by the Roman emperor Diocletian (AD 244–313), who built a magnificent palace where he retired after his abdication (AD 305). This palace is at the heart of the present-day city of Split and is one of the best-preserved monuments of the late Roman imperial period, with its peristyle, mausoleum, temple of Jupiter, Roman walls, and gates. The mausoleum of the emperor was transformed into the cathedral of Saint Dujam, patron of the city, in the 7th century. The Roman palace and the neighboring medieval, renaissance, and baroque city have been included on the UNESCO World Heritage Site list since 1971.

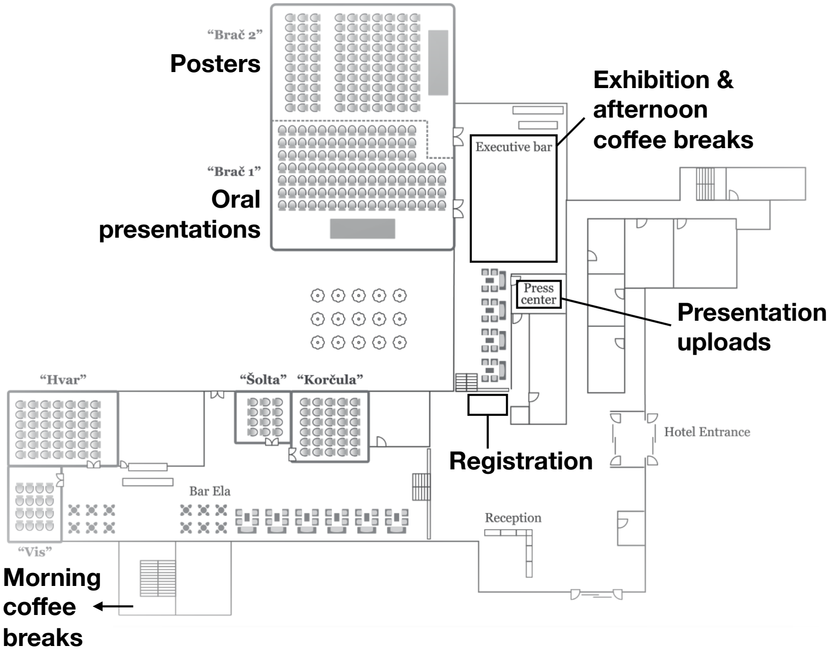
The modern city of Split, which grew out from this palace through centuries, has a population of approximately 250,000 inhabitants and a modern university with about 20,000 students. The city has a number of galleries (including the gallery of the world-famous sculptor Ivan Meštrović, born near Split), a renowned archeological museum, and an opera house. Split is connected by air to major European cities, by roads (a coastal road from Trieste and with a connection to the new Zagreb-Split highway) and by sea to Croatian and Italian harbors on the Adriatic Sea. It is also the primary harbor for ferry connections to the entire Dalmatian archipelago, including the cities of Hvar, Korčula, and Dubrovnik.

The remains of Salonae, the capital of the Roman province of Dalmatia, are located at an archeological site in the immediate vicinity of today's city. Near Split airport, about 25 km from the center of Split, A small, picturesque, medieval and renaissance city of Trogir is located immediately next to Split Airport. Cathedral of St. Lovre in Trogir is considered to be one of the most beautiful cathedrals on the Dalmatian coast. Trogir has also been listed on the UNESCO World Heritage Site list since 1997.

Area Maps

The conference location is Hotel Elaphusa, Put Zlatnog rata 46, 21420 Bol, Croatia. Bol is one of the premier resort towns on the Croatian coast, with its Zlatni rat (Golden Cape) beach being one of the most recognizable attractions. The conference hotel is located near the entrance to the Zlatni rat beach.

HOTEL AND VENUE INFORMATION



- Oral presentations: "Brač 1" hall
- Posters: "Brač 2" hall
- Exhibition: Executive bar
- Coffee breaks: Terrace (morning) and Executive Bar (afternoon)
- Welcome reception: Hotel Elpahusa swimming pool
- Conference dinner: Borak Beach restaurant (located in front of the hotel)
- Conference excursion: boat trip to Hvar island

Registration & Presentation Uploads:
Sun 12–6 pm, Mon-Tue 7:30 am–8:30 am, Wed-Fri 8:00 am–8:30 am

Oral presenters are asked to upload their talks at least 24 hours prior to presentation in the Press Center.

Poster presenters are asked to set up the posters by 8 am on the day of the poster session (Monday/Tuesday) and remove them promptly at the conclusion of poster session (8 pm).

COMMITTEES

Conference Chairs:
Igor Jovanovic, University of Michigan, United States
Bojan Resan, University of Applied Sciences and Arts Northwestern Switzerland

Program Chairs:
Karoly Osvay, University of Szeged & ELI-ALPS, Hungary
Giacomo Coslovich, Stanford Linear Accelerator Center, United States

Local Organizing Committee:
Ticijana Ban, Institute of Physics, Zagreb
Ivica Puljak, University of Split

Program Committee:
Andy Bayramian, Lawrence Livermore National Laboratory, United States
Jens Biegert, ICFO, Spain
Daniele Brida, Université du Luxembourg, Luxembourg
Francesca Calegari, DESY, Germany
Christophe Dorrer, Laboratory for Laser Energetics, United States
Charles Durfee, Colorado School of Mines, United States
Nicolas Forget, Fastlite, France
Alan Fry, SLAC National Accelerator Laboratory, United States
Andy Kung, Academia Sinica, Taiwan
François Légaré, INRS, Canada
Rodrigo Lopez-Martens, ENSTA, France
Zsuzsa Major, GSI, Germany
Inhyuk Nam, PAL-XFEL, Korea
Clara Saraceno, Universität Bochum, Germany
Emma Springate, Rutherford Appleton Laboratory, United Kingdom
Günther Steinmeier, Max-Born-Institut, Germany
Csaba Toth, Lawrence Berkeley National Laboratory, United States
Laszlo Veisz, Umeå Universitet, Sweden
Caterina Vozzi, Politecnico di Milano, Italy
Makina Yabashi, RIKEN, Japan

Program at a Glance

	Sunday 6th October	Monday 7th October	Tuesday 8th October	Wednesday 9th October	Thursday 10th October	Friday 11th October
7:30						
7:45		Registration	Registration			
8:00				Registration	Registration	Registration
8:15						
8:30		Opening				
8:45			Tu 5.1 Krausz, Ferenc	We9.1 Pugzlys, Audrius		F15.1 Simon-Boisson, C.
9:00		M1.1 Mourou, Gérard			Th11.1 Fry, Alan	
9:15			Tu 5.2 Zimin, Dmitry	We9.2 Teisset, Catherine	Th11.2 Shestaev, Evgeny	F15.2 Li, Zhaoyang
9:30		M1.2 Le Blanc, Catherine	Tu 5.3 Duris, Joseph	We9.3 Gebhardt, Martin	Th11.3 Südmeyer, Thomas	F15.3 Sung, Jae Hee
9:45		M1.3 Nadarajan Achary, S.	Tu 5.4 Antonov, Vladimir	We9.4 Stanislauskas, Tomas	Th11.4 Vodopyanov, K.	F15.4 Carpeggiani, Paolo
10:00		Coffee	Coffee	Coffee	Coffee	Coffee
10:15						
10:30		M2.1 Kowlighy, Abijith	Tu 6.1 Carbajo, Sergio	We10.1 Kozina, Michael		
10:45					Th12.1 Porat, Gil	F16.1 Lassonde, Philippe
11:00		M2.2 Steinmeyer, Gunter	Tu 6.2 Stark, Lars Henning		Th12.2 Valentin, Constance	
11:15		M2.3 Schmidt, Bruno	Tu 6.3 Mainz, Roland	We10.2 Eschen, Wilhelm	Th12.3 Guichard, Florent	F16.2 Milchberg, Howard
11:30		M2.4 Fan, Guangyu	Tu 6.4 Yang, Yudong	We10.3 Jelic, Vedran	Th12.4 Cartella, Andrea	F16.3 Leshchenko, V.
11:45		M2.5 Belli, Federico	Tu 6.5 Buberl, Theresa	We10.4 Aumiler, Damir	Th12.5 Ma, Guangjin	F16.4 Dorrer, Christophe
12:00		Group Photo		We10.5 (F) Toth, Csaba		F16.5 Leblanc, Adrien
12:15						F16.6 Steinmeyer, Günter
12:30						Awards/Closing
12:45			Lunch		Lunch	
13:00		Lunch				
13:15						
13:30	Registration					
13:45						
14:00		M3.1 Wedel, Björn	Tu7.1 Kang, Heung-sik			
14:15					Th13.1 Mayer, Aline	
14:30	Short Course 1	M3.2 Qiao, Jie	Tu7.2 Couprie, Marie-E.		Th13.2 Forget, Nicolas	
14:45				Lunch and Excursion	Th13.3 Ouille, Marie	
15:00		M3.3 Carreto, Romain	Tu7.3 Droste, Stefan		Th13.4 Guichard, Florent	
15:15	Vodopyanov, Konstantin	M3.4 Finney, Lauren	Tu7.4 Togashi, Tadashi		Th13.5 Lin, Yu-Chieh	
15:30		M3.5 (F) Aumiler, Damir	Tu7.5 (F) Weeks, Allen		Th13.6 (F) Alisauskas, S.	
15:45		Coffee	Coffee			
16:00	Coffee				Coffee	
16:15		M4.1 Phillips, Christopher	Tu8.1 Hemmer, Michael			
16:30	Short Course 2				Th14.1 Hanna, Marc	
16:45		M4.2 Flemens, Noah	Tu8.2 Buldt, Joachim		Th14.2 Barbiero, Gaia	
17:00		M4.3 Windeler, Matthew	Tu8.3 Gollner, Claudia		Th14.3 Grigorova, Teodora	
17:15	Neely, David	M4.4 Nagymihaly, Roland	Tu8.4 Breitkopf, Sven		Th14.4 Ding, Xiaoyue	
17:30		M4.5 Tóth, Szabolcs	Tu8.5 Maidment, Luke		Th14.5 Liu, Jun	
17:45					Th14.6 (F) Jovanovic, Igor	
18:00		Poster Session 1	Poster Session 2			
18:15						
18:30						
18:45		P1.1, ..., 1.30				
19:00	Reception					
19:15			MP2.1, ..., 2.43			
19:30		Open bar, finger food			Conference Banquet	
19:45		K. Schmidt, Class5				
20:00		S. Butcher, Coherent				
20:15		C. Hönninger, Amplitude				
20:30		K. Weingarten, Tarkas				
20:45		R. Romero, Sphere				

CONFERENCE SESSIONS

Monday, October 7

M1: Ultrahigh Peak-Power Laser Systems and Related Technologies
M2: Generation of Ultrashort Optical Pulses
M3: Applications of Ultrashort Laser Pulses
M4: Science and Technology of Ultrashort Pulse Amplification

Tuesday, October 8

TU5: High Harmonic and Attosecond Pulse Technology and Science
TU6: Coherent Beam Combining and Pulse Synthesis
TU7: Free Electron Laser Technology and Applications
TU8: High Average Power Sources from IR to THz

Wednesday, October 9

WE9: High Average Power Ultrafast Lasers
WE10: Scientific Applications

Thursday, October 10

TH11: High Power Laser Sources from mid-IR to FEL
TH12: High Harmonic and Attosecond Pulse Generation Technology and Science
TH13: Few-Cycle Pulses, Comb Generation, and Carrier-Envelope Phase Control
TH14: Generation of Ultrashort Optical Pulses

Friday, October 11

F15: Ultrahigh Peak-Power Laser Systems and Related Technologies
F16: Novel Methods for Shaping and Measuring Ultrashort Pulses

Ultrafast Coherent Mid-IR Pulses: Generation and Applications
Konstantin Vodopyanov, University of Central Florida

Konstantin L. Vodopyanov obtained his PhD and DSc (Habilitation) from the Oscillations Lab. of Lebedev Physical Institute, led by Nobel Prize winner Alexander Prokhorov, and served an assistant professor at the Moscow Phys-Tech, an Alexander-von-Humboldt Fellow at the University of Bayreuth in Germany, and as a Royal Society postdoctoral fellow and lecturer at Imperial College London. In 1998 he became head of the laser group at Inrad and later director of mid-IR systems at Picarro. In 2003 he returned to academia (Stanford University, 2003-2013) and is now a 21st Century Scholar Chair & Professor of Optics at CREOL, College of Optics & Photonics, Univ. Central Florida. Dr. Vodopyanov is a Fellow of the American Physical Society, Optical Society of America, SPIE – International Society for Optical Engineering, and UK Institute of Physics. His research interests include nonlinear optics, mid-IR and terahertz-wave generation, ultra-broadband frequency combs and their spectroscopic and biomedical applications.

Imaging with Laser-generated Ultrashort X-ray Pulses
David Neely, STFC/RAL/CLF

David Neely undertook his PhD studies at the Queens University of Belfast before moving to the Central Laser Facility, STFC, Oxfordshire, UK in 1992. Using the Vulcan laser which provided combined ns and ps pulses he worked on experiments exploring X-ray lasers, electron acceleration, high harmonic production and plasma diagnostics. David was responsible for the experimental interaction areas of the Gemini and Vulcan PW facility upgrades, attaining PW performance in 2003. He took up a visiting Professorship at the University of Strathclyde in 2007 and the Mitsuyaki Abe Chair, PMRC, Japan in 2008 and continues to collaborate closely with international researchers. His grant funded research interests are in laser driven ion acceleration, fusion studies, plasma diagnostics, secondary source generation and high-power industrial laser applications. He currently holds an STFC fellowship, obtained in 2010 which has enabled a greater concentration on his science interests.

KEYNOTE SPEAKERS

Gérard Mourou, École Polytechnique & University of Michigan
"Passion for Extreme Light"

Gérard Mourou is Professor Haut-Collège at the École polytechnique. He is also the A.D. Moore Distinguished University Emeritus Professor of the University of Michigan. He received his undergraduate education at the University of Grenoble (1967) and his Ph.D. from University Paris VI in 1973. He has made numerous contributions to the field of ultrafast lasers, high-speed electronics, and medicine. But, his most important invention, demonstrated with his student Donna Strickland while at the University of Rochester (N.Y.), is the laser amplification technique known as Chirped Pulse Amplification (CPA), universally used today. CPA revolutionized the field of optics, opening new branches like attosecond pulse generation, Nonlinear QED, compact particle accelerators. It extended the field of optics to nuclear and particle physics. In 2005, Prof. Mourou proposed a new infrastructure ; the Extreme Light Infrastructure (ELI), which is distributed over three pillars located in Czech Republic, Romania, and Hungary. Prof. Mourou also pioneered the field of femtosecond ophthalmology that relies on a CPA femtosecond laser for precise myopia corrections and corneal transplants. Over a million such procedures are now performed annually. Prof. Mourou is member of the U.S. National Academy of Engineering, and a foreign member of the Russian Science Academy, the Austrian Sciences Academy, and the Lombardy Academy for Sciences and Letters. He is Chevalier de la Légion d'honneur and was awarded the 2018 Nobel Prize in Physics with his former student Donna Strickland.

Ferenc Krausz, Max Planck Institut für Quantenoptik
"Attosecond Science: From Tracing Electrons to Cancer Detection"

Ferenc Krausz (born 1962 in Mór/Hungary) earned his degree in Electrical Engineering at the Technical University Budapest (1985). He completed his doctorate in Laser Physics at the Technische Universität (TU) Vienna (1991) where he habilitated in the same research field in 1993, took up assistant professorship in 1998 and full professorship in 1999. In 2003 Ferenc Krausz was appointed Director of the Max-Planck-Institute of Quantum Optics (MPQ) in Garching. In October 2004

he became professor at the Faculty of Physics of Ludwig-Maximilians-Universität (LMU) Munich and has since then held the Chair of Experimental Physics – Laser Physics.
In a series of experiments performed between 2001 and 2004 Ferenc and his team succeeded in producing and measuring attosecond light pulses and applying them for the first real-time observation of atomic-scale electronic motions. These achievements earned him the reputation as the co-founder (along with Paul Corkum) of the field of Attosecond Physics, a scientific discipline devoted to real-time observation and control of electron phenomena, as also acknowledged by their selection as 2015 Thomson Reuters Citation Laureates. More recently, he turned his attention to capitalizing on ultrafast laser techniques for disease detection by the molecular fingerprinting of human bio-fluids.

Alan Fry, SLAC National Accelerator Laboratory
"X-ray Free Electron Lasers: the Versatile, Powerful, and Evolving Tool for Ultrafast Science"

Alan Fry has spent his career developing and using ultrafast lasers in the national lab complex and in industry. He received his B.S. in physics from the University of Utah and his PhD from the University of Rochester. As an undergraduate he worked at Lawrence Livermore National Laboratory on the development of diagnostics for laser-driven x-ray lasers. His graduate and post-doctoral research focused on high-efficiency photocathodes and novel laser systems for the development of superconducting electron accelerators at Fermi National Accelerator Laboratory.
From 1998 to 2010 Alan worked in private industry, first at Positive Light as a technical manager and later at Coherent Inc. as Director of Engineering. Alan and his team developed more than 30 new products for the scientific laser market including DPSS lasers, ultrafast Ti:sapphire amplifiers, OPAs, fiber lasers, and ultrafast diagnostics.
In 2010 Alan joined SLAC National Accelerator Laboratory where he is a Senior Staff Scientist and Division Director for Laser Science and Technology, managing a team of scientists and engineers to develop and support ultrafast laser systems for multiple scientific programs at SLAC, most notably for the Linac Coherent Light Source, the world's first hard X-ray free electron laser.
In 2018 Alan was named as the Project Director for the Petawatt Laser Facility, a large-scale project to upgrade the laser and experimental capabilities of the Matter in Extreme Conditions instrument at LCLS.

INVITED SPEAKERS

- Sergio Carbajo, SLAC National Accelerator Laboratory (USA)
- Marie-Emmanuelle Couprie, Synchrotron SOLEIL (France)
- Wilhelm Eschen, Friedrich-Schiller-University Jena (Germany)
- Marc Hanna, CNRS – Institut d'Optique (France)
- Michael Hemmer, JILA (USA)
- Heung-Sik Kang, Pohang Accelerator Laboratory (Korea)
- Abijith Kowligy, NIST (USA)
- Michael Kozina, SLAC National Accelerator Laboratory (USA)
- Philippe Lassonde, INRS (Canada)
- Zhaoyang Li, Osaka University (Japan)
- Aline Mayer, University of Vienna (Austria)
- Howard Milchberg, University of Maryland (USA)
- Christopher Phillips, ETH Zürich (Switzerland)
- Audrius Pugžlis, TU Wien (Austria)
- Gil Porat, JILA (USA)
- Jie Qiao, Rochester Institute of Technology (USA)
- Christophe Simon Boisson, Thales (France)
- Catherine Teisset, TRUMPF Scientific Lasers (Germany)
- Björn Wedel, Photonic Tools GmbH (Germany)

Facility Invited Speakers

- Skirmantas Ališauskas, DESY (Germany)
- Damir Aumiler, Institute of Physics (Croatia)
- Igor Jovanovic, University of Michigan (USA)
- Csaba Toth, Lawrence Berkeley National Laboratory (USA)
- Allen Weeks, ELI Delivery Consortium (Belgium)

GÉRARD MOUROU: NOBEL PRIZE IN PHYSICS 2018

In 1985, Gérard Mourou and graduate student Donna Strickland, at the University of Rochester, worked together to demonstrate a novel technique for amplifying ultrashort optical pulses to unprecedented power levels.

Their technique, known as Chirped Pulse Amplification (CPA) has revolutionized high-field physics and enabled the study of light-matter interaction in the relativistic regime where the electron velocity becomes a significant fraction of the speed of light. For this advance, Mourou and Strickland shared the 2018 Nobel Prize in Physics with Art Ashkin who was recognized for optical tweezers.

The CPA technique boosts peak power of ultrashort optical pulses to levels exceeding several petawatts (10^{15} W). By stretching the short pulse before amplification, peak power is reduced by several orders of magnitude; this enables amplification to extract all energy stored in the amplifier without causing damage to the nonlinear material. The process of stretching the pulse also introduces a positive chirp, such that high and low frequencies in the pulse spectrum are, respectively, at the back and front of the pulse. After amplification, the pulse is compressed by reversing the chirp, restoring the pulse to its original duration but with orders of magnitude higher peak power.

Mourou and Strickland's original implementation of CPA relied on an optical fiber for stretching the pulse and a pair of diffraction gratings for compressing the amplified pulse. The initial experiments achieved only modest compression and operated at the millijoule level.

Later, Mourou realized that a grating pair with dispersion opposite to that of the compressor grating could create a matched stretcher-compressor to achieve perfect compression. With the new approach, the Rochester group soon achieved a thousand-fold amplification of a picosecond pulse to joule level, creating the first Table Top Terawatt (T3) laser in 1987.

In 1988, Mourou moved his group to the University of Michigan where he became the founding director of the Center for Ultrafast Optical Science (CUOS). It was at Michigan that the technology of CPA matured, finding new applications in science, industry, and medicine.

Sunday, October 6

1:00pm-6:00pm Registration

2:30pm-4:00pm Short Course
"Ultrafast Coherent Mid-IR Pulses: Generation and Applications"
K. Vodopyanov, University of Central Florida (United States)

4:00pm-4:30pm Coffee Break

4:30pm-6:00pm Short Course
"Imaging with Laser-generated Ultrashort X-ray Pulses"
D. Neely, STFC/RAL/CLF (United Kingdom)

6:00pm-8:00pm Welcome Reception

Monday, October 7

7:30am-8:30 am Registration

8:30am-8:45am Conference Opening

M1: Ultrahigh Peak-Power Laser Systems and Related Technologies

Session chair: I. Jovanovic, University of Michigan (United States)

8:45am-9:30am (M1.1)
Keynote: "Passion for Extreme Light"
G. Mourou, École Polytechnique (France)

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 10^{20} eV or the loss of information in black holes. Using wake-field acceleration some of these fundamental

questions could be studied in the laboratory. In addition, extreme light makes possible the study of the structure of vacuum and particle production in "empty" space, which is one of the field's ultimate goal, reaching into the fundamental QED and possibly QCD regimes.
Looking beyond today's intensity horizon, we will introduce a new concept that could make possible the generation of attosecond-zeptosecond high energy coherent pulse, de facto in x-ray domain, opening at the Schwinger level, the zettawatt, and PeV regime; the next chapter of laser-matter interaction.

9:30am-9:45am (M1.2)

"Optimisation of a Petawatt class compressor alignment based on spectrally resolved wave front analysis"

C. Le Blanc, L. Ranc, J. Zou, LULI Ecole Polytechnique CNRS (France); X. Levecq, Imagine Optic (France); F. Druon, Laboratoire Charles Fabry, IOGS (France); D. Papadopoulos, LULI École Polytechnique CNRS (France)

Experiments using highly energetic Ti:Sapphire multi-PW lasers require high overall pulse quality. Delivering ultrashort pulses coupling good temporal and spatial characteristics is one of the crucial parameters leading to achieve multi-PW peak. Focusing a laser pulse with high contrast ratio (>10^10), a large beam size (10's cm), a broadband spectrum (200nm) and high energy (100's J) requires numerous precautions and monitoring. This study presents our theoretical and experimental investigations on a grating compressor alignment using a multi-spectral wavefront sensor. We demonstrate that this technique is capable to optimize a compressor alignment and characterize the spatio-temporal coupling of a PW class laser facility.

9:45am-10:00am (M1.3)

"Contrast improvement of few-cycle laser pulses using nonlinear ellipse rotation"

S. Nadarajan Achary, X. Zhang, P. Fischer, A. A. Muschet, R. Salh, Umea University (Sweden); A. Tajalli, U. Morgner, Institute of Quantum Optics, Leibniz Universität Hannover (Germany); L. Veisz, Umea University (Sweden)

Temporal filtering and spectral broadening are simultaneously achieved, allowing the compression of 20 fs laser pulses down to sub-4 fs duration through the method of nonlinear elliptical polarization rotation in an argon filled hollow-core fiber. The sub-4 fs source provides ~ 35-µJ energy with an internal efficiency >50%, which is more than from the most commonly used pulsecleaning methods. Further, the contrast is improved by 3 orders of magnitude when measured after amplifying the pulses to 16 TW using non-collinear optical parametric chirped pulse amplification with a prospect to even further enhancement.

10:00am-10:30am Coffee Break

M2: Generation of Ultrashort Optical Pulses

Session chair: S. Carbajo, Stanford Linear Accelerator Center (United States)

10:30am-11:00am (M2.1)

"Mid-infrared frequency combs in the time-domain: single-cycle waveforms and quantum noise limited measurement"

A. S. Kowligy, A. J. Lind, National Institute for Standards and Technology and University of Colorado, Boulder (United States); H. Timmers, National Institute for Standards and Technology, University of Colorado, Boulder and Vescent Photonics (United States); D. Lesko, F. Cruz, National Institute for Standards and Technology and University of Colorado, Boulder (United States), P. Schunemann, BAE Systems (United States); J. Biegert, ICFO and ICREA (Spain); S. Diddams, National Institute for Standards and Technology and University of Colorado, Boulder (United States).

We describe the generation of mid-infrared frequency combs across 3-27 μm using intra-pulse difference-frequency generation in quadratic nonlinear crystals. The frequency combs correspond to phase-stable, few-cycle pulse trains in the time-domain, and we demonstrate controllable carrier-envelope phase for these reproducible waveforms exhibiting <15-mrad phase-stability over several-hour time-scales. The radiation is characterized by dual frequency comb electro-optic sampling (EOS), which allows for direct, shot-noise-limited detection of the electric fields at room-temperature using commonplace near-infrared photodetectors at video refresh rates. The combination of low-noise sources and quantum-noise-limited measurement provides a route to explore intrinsic quantum noise at ultrafast time-scales, and we discuss initial results.

11:00am-11:15am (M2.2)

"Demystifying Self-Modelocking"

G. Steinmeyer, Max Born Institute (Germany)

It is commonly believed that synchronization between laser modes can only be achieved in the presence of an effective saturable absorber inside the mode-locked laser cavity. Nevertheless, indications for a threshold-like onset of mode synchronization have been occasionally reported for a number of different lasers and nonlinear optical resonators, yet could not be satisfactorily explained to date. Solving Haus' master equation in the presence of four-wave mixing, cross and self-phase modulation, we explicitly show that mode-locking can occur in the complete absence of saturable absorption. The resulting phase lock can even serve to overcome a significant amount of dispersion-induced dephasing induced by the cold cavity. However, the resulting lock is only dynamically stable, which explains why, so far, all attempted characterization of self-mode-locking methods ended up in measuring a coherent artifact.

11:15am-11:30am (M2.3)

"TW-Peak-Power Post-Compression of 70-mJ pulses from an Yb Amplifier"

B. Schmidt, Few-Cycle Inc. (Canada); G. Fan, P. Carpeggiani, TU Wien (Austria); Z. Tao, Fudan University (China); E. Kaksis, TU Wien (Austria); T. Balciunas, GAP-Biophotonics (Switzerland); G. Coccia, TU Wien (Austria); V. Cardin, F. Légaré, Institut National de la Recherche Scientifique (Canada); A. Baltuška, TU Wien (Austria)

High Harmonic Generation has provided an efficient tool for time-resolved investigations in the UV and soft X-ray spectral range. The intrinsically low efficiency of such frequency up-conversion process results in low UV or soft X-ray flux, which can be increased by improving the repetition rate or the energy per pulse of the IR driver. As in high harmonic generation parameters like the cut-off (highest achievable frequency) and efficiency of conversion are related to the peak power rather than to the energy per pulse, post-compression techniques were widely used for the driving pulses, being the spectral broadening in gas-filled hollow core fiber the most diffuse. Post compression techniques have been limited both in energy per pulse and peak power, thus partially limiting the benefits of energy scaling of the drivers. In this work we compress 70mJ, 220fs, 1030nm pulses from an Yb multi-pass amplifier in a 3m long stretched hollow core fiber in a pressure gradient scheme with neon. As a result, we achieve the compression to 25fs of pulses with the record output energy of 40mJ, resulting in a peak power above 1TW.

11:30am-11:45am (M2.4)

"1-D energy scaling of multi-plate pulse compression to 6 mJ in a compact setup"

G. Fan, TU Wien (Austria); Z. Tao, Fudan University (China); P. Carpeggiani, G. Coccia, TU Wien (Austria); S. Zhang, Z. Fu, Fudan University (China); M. Chen, S. Liu, A. Kung, National Tsing Hua University (China); E. Kaksis, A. Pugžlys, A. Baltuška, TU Wien (Austria).

Spectral broadening via Self-Phase Modulation for pulse post compression has been successfully demonstrated both in gases and solids reaching higher and higher peak powers. The most diffused technique is hollow core fiber compression, which can grant the best performances in terms of pulse duration and energy content, but at the price of a coupling mechanism very sensitive to beam pointing and related instabilities. Alternative systems with non guided focusing geometries into gases or bulk have been successfully demonstrated. The common issue of all these techniques though is the limitation in pulse energy. Given the limits of intensity, for the damage in solids or ionization in gases, and of peak power, causing detrimental self-focusing and filamentation, the handling of higher energies requires looser focusing conditions and hence, to inconveniently large setups. In this work we present a route for energy scaling in external pulse compression based on layered Kerr media combined with 1D focusing geometry, which permits to extend the operation into a multi-mJ energy range within a 1-m-long setup. As a proof of concept, a highly stable 92%- efficient 4-fold compression of 1030-nm pulses is demonstrated.

11:45am-12:00pm (M2.5)

"Strong and weak seeded four-wave mixing in stretched gas-filled hollow capillary fibers"

F. Belli, A. Lekosiotis, J. C. Travers, Heriot-Watt University (United Kingdom)

We report a remarkably efficient experimental scheme for the generation of high energy ultra-short pulses by means of four-wave mixing in long stretched hollow capillary fibers filled with helium. We thoroughly investigate the role of strong and weak seeding fields in a degenerate up-conversion scheme to the deep ultraviolet. In the weak seed regime we demonstrate the tunable emission of up to 30 μJ in ultrashort pulses (~8 fs) in the 250-300 nm range, corresponding to pump energy conversion of up to 30%, from pump pulses with energies readily available from high-average power lasers. In the strong seed regime, we obtain higher pump conversion efficiencies, up to 42%, together with a spectral bandwidth supporting few femtosecond pulses and a record high deepultraviolet pulse energy exceeding 70 μJ. The energy can be further scaled by using stretched hollow-core fibers with larger core diameters.

12:00pm-12:15pm Group Photo

12:15pm-2:00pm Lunch Break

M3: Applications of Ultrashort Laser Pulses

Session Chair: T. Ban, Institute of Physics (Croatia)

2:00pm-2:30pm (M3.1)

"Ultrafast Laser Fiber Beam Delivery Systems – Status Quo and Future Challenges"

B. Wedel, S. Eilzer, Photonic Tools GmbH (Germany)

In 2015, the first industrial fibre beam delivery system for ultrafast lasers using microstructured hollow fibres has been introduced by Photonic Tools. Since this introduction, a representative cross section of all the industrially available ultrafast laser sources has been successfully fibre coupled and a large number of installations has been performed. Transmitting peak powers close to 1 GW and an average power in excess of 200 W covers the laser power range of the industrially available ultrafast lasers. However, there is always the question of the power limitation for an ultrafast fibre beam delivery system. The theoretical and practical power limitations as well as the impact of the laser power and nonlinear effects on the transmitted beam parameters are discussed.

2:30pm-3:00pm (M3.2)

"Ultrafast Lasers Based Optical and Photonic Fabrication"

J. Qiao, Rochester Institute of Technology (United States)

This paper presents computational models, systems and physical processes on using ultrafast lasers to fabricate photonic and optical components. We demonstrated femtosecond-laser- based polishing of Germanium with tunable material removal and achieved optic-quality surface with roughness of ~1 nm, using a Two Temperature Model to investigate the impact of laser parameters. Waveguides are written by a femtosecond laser in Nd:YAG crystals and a mean propagation loss of 0.21 ± 0.06 dB/cm are obtained, which is lower than the previous reported values. Unidirectional pulse propagation equation modeling was performed to study the nonlinear femtosecond laser-mater interaction in silicon and Nd:YAG crystals.

3:00pm-3:15pm (M3.3)

"Laser micromachining of gratings for X-ray interferometry imaging and sub-micron hole patterns"

R. Carreto, B. Lüscher, B. Resan, R. Holtz, FHNW (Switzerland)

We compare micromachining with an F-Theta and axicon lenses using an UV picosecond laser system to obtain a tungsten grating for X-ray interferometry medical imaging and sub-micrometer hole patterns.

3:15pm-3:30pm (M3.4)

"Optical wavefront control for filament-induced breakdown signal enhancement"

L.A. Finney, J. Lin, P. J. Skrodzki, M. Burger, J. Nees, K. Krushelnick, I. Jovanovic, University of Michigan (United States)

We demonstrate that laser wavefront control with a deformable mirror can enhance the signal intensity generated through filament-induced breakdown of a solid metallic copper (Cu) target. In our experiment, we find that the signal optimization through a genetic algorithm is reached after 150 iterations, during which the wavefront is primarily corrected for horizontal coma and the signal from the Cu I 521.8 nm atomic spectral line is nearly doubled. The ability to increase the intensity of spectroscopic signals generated in filament-induced breakdown spectroscopy is an essential component of the effort to extend the detection distance in remote sensing applications.

3:30pm-3:50pm (M3.5)

"Centre for advanced laser techniques (CALT)"

D. Aumiler, Institute of Physics (Croatia)

Centre for Advanced Laser Techniques (CALT) is a strategic research infrastructure project of the Republic of Croatia, funded by the European Regional Development Fund (ERDF). The main goal of the CALT project is to establish a fully equipped, modern scientific research centre specialized in advanced laser and optical techniques. CALT will be located at the Institute of

Physics in Zagreb (IPZg), the only research institution in Croatia to have several larger laser/optical systems and relevant expertise, which are the basis for laser-matter interaction studies. CALT will be set as a collection of state-of-the-art laboratories that will be open to users, where both the infrastructure and the expertise will be at service to Croatian, as well as regional RDI community. A total of over 1200 m2 of fully equipped laboratory space will be available by reconstructing one of the IPZg buildings. CALT's activities; which comprise research, education, and providing access to laser facilities; will address socially important issues through planned research activities in the four domains: Quantum Technology, Plasma Technology, Nano and Bio Systems, and Ultrafast Dynamics.

3:50pm-4:15pm Coffee Break

M4: Science and Technology of Ultrashort Pulse Amplification

Session Chair: A. Pugžlys, TU Wien (Austria)

4:15pm-4:45pm (M4.1)

"Optical parametric chirped pulse amplification with PPLN: high average power sub-two-cycle 2.5 μm pulses"

C. R. Phillips, J. Pupeikis, N. Bigler, P. Chevreuil, S. Hrisafov, L. Gallmann, U. Keller, ETH Zurich (Switzerland)

We present a mid-infrared optical parametric chirped-pulse amplifier (OPCPA) delivering 12.6 W at 100 kHz centered at 2.5 μm. Through a time-gated pulse shaping scheme, the pulses were compressed to 14.4 fs (1.7 cycles). The peak power corresponds to 6.3 GW. The OPCPA system utilizes periodically poled lithium niobate (PPLN) as the amplification medium, due to its capacity to support ultra-broad bandwidths. Some of the challenges to power scaling in this material are discussed. Our on-going efforts towards further power scaling will be presented at the conference.

4:45pm-5:00pm (M4.2)

"Near-fully efficient, back-conversion suppressed optical parametric amplification via a secondary nonlinear wave-mixing channel"

N. Flemens, N. Swenson, J. Moses, Cornell University (United States)

Back-conversion in parametric amplification can be suppressed over the full spatiotemporal pump profile by means of a simultaneously phase-matched wave-mixing process, a general concept allowing nearly full conversion efficiency. A device for ultrafast chirped pulse amplification based on simultaneous parametric amplification and second harmonic generation is presented, and is based on a novel quasi-phase matching scheme for simultaneous phase matching of multiple three-wave mixing processes. A full spatiotemporal analysis predicts pump energy conversion up to 65% for femtosecond pulses and as high as 80% for picosecond pulses.

5:00pm-5:15pm (M4.3)

"High power, 100 kHz repetition rate OPCPA operating at 800 nm and 1.5 - 2.0 µm"

M. K. Windeler, SLAC National Accelerator Laboratory (United States) and Department of Physics, Engineering Physics & Astronomy, Queen's University (Canada); K. Mecseki, F. Tavella, J. S. Robinson, A. R. Fry, SLAC National Accelerator Laboratory (United States); J. M. Fraser, Department of Physics, Engineering Physics & Astronomy, Queen's University (Canada)

Optical parametric chirped pulse amplification (OPCPA) enables high repetition rate amplification due to low thermal absorption in the amplifier medium. Wavelength conversion and extension processes are available to access wavelengths from the XUV to THz at high repetition rates offsetting the conversion efficiency losses. These technologies are used at next generation free electron laser (FEL) facilities, such as the Linac Coherent Light Source (LCLS). Additionally, the higher repetition rate of the system benefits pump-probe experiments for weakly scattering samples and serves a variety of experiments which require attenuation to avoid perturbation and damage of the sample by the X-ray probe. An R&D laser amplifier is demonstrated operating 24 hours a day, 7 days a week with mJ pulse energy to test experimental conditions for optical laser beam delivery at LCLS-II. The laser can be operated in two distinct wavelength ranges. At 800 nm center wavelength we use the second harmonic of an Yb:YAG amplifier system to pump an □88 W OPCPA in BBO crystals. A second tunable version operates between 1.5 – 2.0 µm center wavelength using the fundamental Yb:YAG beam to pump a KTA OPCPA with average output powers in excess of 100 W.

5:15pm-5:30pm (M4.4)

"Conceptual study of a 1 kHz 10 mJ-class mid-IR OPCPA system with thermal aspects"

S. Tóth, R. Nagymihály, ELI-ALPS Ltd (Hungary) and University of Szeged (Hungary); A. Andrianov, Institute of Applied Physics of the Russian Academy of Sciences (Russian Federation); B. Kiss, ELI-ALPS Ltd (Hungary); R. Flender, ELI-ALPS Ltd (Hungary) and University of Szeged (Hungary); M. Kurucz, L. Haizer, ELI-ALPS Ltd (Hungary); E. Cormier, CELIA, Université de Bordeaux – CNRS – CEA (France); K. Osvay, ELI-ALPS Ltd (Hungary)

In this work a conceptual study is presented about a 1 kHz, dual-channel OPCPA system which produces passively CEP-stabilized, sub-30 fs, 10 mJ mid-IR pulses and sub-30 fs, 40 mJ near-IR pulses. The modelled mid-IR laser system consists of eight KTA-based OPCPA stages. Amplification was simulated with an advanced 3D numerical code for OPCPA modelling. It was revealed that the gain curve of KTA, when pumped at 1 µm, can support the amplification of 25 fs pulses in the absence of gain narrowing, which was exploited in the presented conceptual study. This advantageous property of KTA however, comes with the cost of increased heat load on the crystal as the idler spectrum extends to 4.5 µm where the absorption of KTA gets significant. In order to analyze the thermal performance and limitations in the amplifier stages, heat-transfer numerical simulations were carried out in 3D.

5:30pm-5:45pm (M4.5)

"Design study of two-cycle bandwidth, single-color pumped OPCPA chain"

S. Tóth, ELI-ALPS Ltd (Hungary) and University of Szeged (Hungary); T. Stanislauskas, I. Balčiunas, Light Conversion Ltd. (Lithuania); A. Andrianov, Institute of Applied Physics of the Russian Academy of Sciences, (Russian Federation); R. Budriūnas, G. Veitas, Light Conversion Ltd. (Lithuania); J. Csontos, ELI-ALPS Ltd (Hungary); Á. Börzsönyi, ELI-ALPS Ltd (Hungary) and University of Szeged (Hungary); L. Tóth, T. Somoskői, K. Osvay, ELI-ALPS Ltd (Hungary)

ELI-ALPS 1kHz SYLOS laser aims to deliver 15TW, two-cycle pulses for attosecond pulse generation and electron acceleration. One of the main challenges during development of such a laser system is the amplification of two-cycle bandwidth pulses in OPCPA. In this study, broadband NOPCPA schemes were examined using LBO crystal and the technique of spectral multiplexing in BBO crystal sandwich. This examination involved a through investigation of phase-matching properties of the aforementioned schemes and a very accurate, 3D numerical modelling using and advanced OPCPA code. Spectral gain curves calculated from the undepleted pump approximation and numerical results provided by the numerical code show that single LBO crystal and BBO crystal sandwich can support sub-2 cycle Fourier-limited pulse duration. The compressibility of such pulses was also examined numerically and it was shown that the pulses are compressible down to 2.2 cycles. The numerically calculated and experimentally measured spectrum and peak power values were compared and it was found that they are in well agreement.

6:00pm-7:30pm Poster Session 1

7:00pm-8:15pm Industrial Presentations (open bar and finger food)
7:45pm-8:00pm: K. Schmidt, Class5Photonics
8:00pm-8:15pm: S. Butcher, Coherent
8:15pm-8:30pm: C. Hönninger, Amplitude
8:30pm-8:45pm: K. Weingarten, Tarkas Ventures
8:45pm-9:00pm: R. Romero, Sphere Photonics

Tuesday, October 8

7:30-8:30 am Registration

TU5: High Harmonic and Attosecond Pulse Technology and Science

Session Chair: B. Resan, University of Applied Sciences and Arts (Switzerland)

8:30am-9:15am (TU5.1)

Keynote: "Attosecond Science: From Tracing Electrons to Cancer Detection"

F. Krausz, Max Planck Institute of Quantum Optics (Germany)

Born around the turn of the new millennium, attosecond metrology has provided real-time insight into atomic-scale electron motions and light field oscillation, previously inaccessible to human observation. Until recently, this capability has relied on attosecond extreme ultraviolet pulses, generated and measured in complex vacuum systems. Next-generation attosecond metrology is now about to change this state of matters profoundly. Sub-femtosecond current injection into wide-gap materials can directly probe ultrafast electron phenomena in condensed matter systems and can also be used for sampling the electric field of light up to ultraviolet frequencies. Petahertz field sampling draws on a robust solid-state circuitry and routine few-cycle laser technology, opening the door for complete characterization of electromagnetic fields all the way from the far infrared to the vacuum ultraviolet. These fields, with accurately measured temporal evolution, serve as a unique probe for the polarization response of matter. Field-resolved spectroscopy will access valence electronic as well as nuclear motions in all forms of matter and constitutes a generalization of pump-probe approaches. Its implementation with a solid-state instrumentation opens the door for real-world applications, such as early cancer detection by measuring miniscule changes of the molecular composition of blood via field-resolved vibrational molecular fingerprinting.

9:15am-9:30am (TU5.2)

"Gating of optical waveforms by attosecond charge control in solids"

D. Zimin, Max-Planck-Institut für Quantenoptik (Germany) and Department für Physik, Ludwig-Maximilians-Universität (Germany); S. Sederberg, Max-Planck-Institut für Quantenoptik (Germany); S. Keiber, F. Siegrist, M. Wismer, V. S. Yakovlev, Max-Planck-Institut für Quantenoptik (Germany) and Department für Physik, Ludwig-Maximilians-Universität (Germany); I. Floss, C. Lemell, J. Burgdörfer, Institute for Theoretical Physics, Vienna University of Technology (Austria); M. Schultze, Max-Planck-Institut für Quantenoptik (Germany); F. Krausz, Max-Planck-Institut für Quantenoptik (Germany) and Department für Physik, Ludwig-Maximilians-Universität (Germany); N. Karpowicz, Max-Planck-Institut für Quantenoptik (Germany)

Control of the charge dynamics in solids may circumvent current speed limits of electronics and data processing. We show that such control is achieved by the interaction of solids with strong optical pulses.

Attosecond temporal precision and the sub-cycle injection of charge carriers can be obtained by the high non-linearity of the absorption of sub-bandgap photons. The strong dependence of the probability of the carrier injection on the laser electric field in dielectrics allows to temporally confine the carrier excitation to the vicinity of the strongest peak in the optical pulse.
By exposing the quartz samples, with deposited electrodes, by strong short pulses, we can generate a measurable current proportional to the vector potential of the pulse, from the moment of the carrier injection. The current is dependent on the degree of the waveform asymmetry (CEP dependence). In case of the double pulse interaction (one weak and one strong), the current depends on the delay between pulses.
To benchmark the observation, we have measured the optical pulse waveform with the new technique (NPS) and compared it with the established attosecond streaking technique. By comparing the traces of near-infrared waveform, recorded with electro-optic sampling and with the NPS technique, we could extract the characteristic time of carrier injection to be about 90 as.
To show that the method can be used for attosecond physics we performed the non-linear polarization sampling experiment, results of which previously could have been obtained only with a delicate attosecond streaking beamline.

9:30am-9:45am (TU5.3)

"100 gigawatt-class attosecond X-ray laser pulse production and measurement"

J. P. Duris, SLAC National Accelerator Lab (United States)

The X-ray Laser-Enhanced Attosecond Pulse generation experiment (XLEAP) at the Linac Coherent Light Source (LCLS) recently demonstrated production and characterization of isolated sub-femtosecond X-ray pulses, creating new opportunities for attosecond-scale science. The project is the first demonstration of the enhanced SASE scheme whereby a wiggler magnet and chicane are used to generate a femtosecond duration, high-current spike on the electron beam which then lases in the LCLS undulator line to produce sub-femtosecond X-ray pulses. We use angular streaking of photo electrons from X-ray induced ionization in a gas jet to reconstruct the pulse temporal profile and use this to measure durations shorter than 400 as with pulse energies six orders of magnitude larger than pulses from HHG. With the addition of 4 new wiggler magnets, we plan to produce pairs of attosecond pulses with 100s of GW peak powers and variable time delay from 0 to tens of femtoseconds for pump probe experiments investigating valence electronic motion in molecules.

9:45am-10:00am (TU5.4)

"Formation of attosecond pulses in the "water window" range via optically dressed H-/He-like plasma-based X-ray lasers"

V. A. Antonov, Institute of Applied Physics of the Russian Academy of Sciences (Russian Federation) and Prokhorov General Physics Institute of the Russian Academy of Sciences (Russian Federation); I. R. Khairulin, Institute of Applied Physics of the Russian Academy of

Sciences (Russian Federation); O. A. Kocharovskaya, Department of Physics and Astronomy, Texas A&M University (United States)

We show the possibility to produce trains of attosecond pulses in the "water window" range via irradiation of active medium of H-like C^{5+} or He-like C^{4+} recombination plasma-based X-ray laser by a strong optical laser field. The pulses can be shorter than 200 as, while the peak pulse intensity can exceed 10^{12} W/cm^2.

10:00am-10:30am Coffee Break

TU6: Coherent Beam Combining and Pulse Synthesis

Session Chair: G. Porat, JILA (United States)

10:30am-11:00am (TU6.1)

“4D-programmable Ultrafast Laser Architectures and their Applications in Accelerator and FEL Physics”

S. Carbajo, Stanford University, SLAC National Accelerator Laboratory (United States)

We present a power-scalable laser architecture with programmable control of the polarization vector, transverse and longitudinal intensity, and wavefront in the near and far field as a novel tool to probe and control matter. We will discuss this novel architecture in the context of its applications in accelerator physics and free-electron laser technology.

11:00am-11:15am (TU6.2)

“High-power temporal and spatial coherent pulse combination of ultrafast fiber lasers”

L. Stark, M. Müller, J. Buldt, Friedrich-Schiller-University Jena (Germany); A. Klenke, Friedrich-Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany); A. Steinkopff, Friedrich-Schiller-University Jena (Germany); A. Tünnermann, J. Limpert, Friedrich-Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)

Ultrafast high-power laser systems with diffraction-limited beam quality are an indispensable technology in a variety of applications, which usually strongly benefit from higher pulse energies and average powers or inevitably require them. However, the output performance of laser systems is limited. To reach the desired parameters and further scale the output pulse energy and average power of ultrafast lasers, coherent pulse combination is one of the most promising techniques. Basing on this principle, we present two different approaches and most recent experimental results. On the one hand, electro-optically controlled divided-pulse amplification is introduced as a temporal domain coherent pulse combination technique. Here, instead of a single pulse, a pulse burst is amplified and recombined afterwards into a single pulse. The technique is implemented for the first time in a high-energy ytterbium doped fiber laser system using additional spatial combination of 12 fiber amplifiers. The result is a combined signal of 674 W average power and 23 mJ pulse energy, while a sample was compressed to 235 fs pulse duration. On the other hand, a turn-key operable ultrafast high-average power system based on coherent beam combination of 4 fiber amplifiers is presented. The combined output has 3.5 kW average power at a pulse repetition rate of 80 MHz and a pulse duration of 430 fs. Both results, the high pulse energy and the high average power, are to the best of our knowledge the highest values achieved with ultrafast fiber-based laser systems so far.

11:15am-11:30am (TU6.3)

"Fully Stabilized and Controlled Sub-Cycle Optical Pulses from Parallel Parametric Waveform Synthesis"

R. Mainz, G. Rossi, F. Scheiba, Y. Yang, M. Silva Toledo, G. Cirmi, F. X. Kaertner, Center for Free-Electron Laser Science (Germany)

We present, to the best of our knowledge, the first functional passively CEP-stable parametric waveform synthesizer generating custom-sculptured sub-cycle pulses with millijoule level energy. Our source delivers pulses with 0.65 optical cycles in duration centered at 1.8 μm and 600 μJ in energy. A shot-to-shot stable waveform can be synthesized over hours enabling novel prospects in attosecond pulse generation and attosecond spectroscopy.

11:30am-11:45am (TU6.4)

"A parametric waveform synthesizer for attosecond science"

Y. Yang, G. Rossi, R. E. Mainz, F. Scheiba, M. A. Silva-Toledo, DESY (Germany) and Universität Hamburg (Germany); P. Keathley, Massachusetts Institute of Technology (United States); G. Cirmi, F. X. Kärtner, DESY (Germany) and Universität Hamburg (Germany)

We present HHG driven with a sub-cycle, mJ-level parametric waveform synthesizer. The variation of the HHG spectral shape and yield as a function of the relative phase between the synthesizer channels is shown. Photoelectron streaking measurements demonstrate attosecond pulse generation with a duration of ~112 attoseconds.

11:45am-12:00pm (TU6.5)

"Broadband interferometric subtraction of ultrashort pulses"

T. Buberl, Max-Planck-Insitute of Quantum Optics (Germany)

We present a simple, cost-effective method to optically subtract ultrashort pulses spanning a super-octave spectrum (950–2100 nm). Achromatic extinction is achieved in a Mach-Zehnder-like interferometer with an intensity extinction of 6.2×10^{-4} by unbalancing the number of Fresnel reflections off optically denser media in the two interferometer arms. By introducing a methane gas sample in one interferometer arm, we isolate the coherent molecular vibrational emission from the broadband, impulsive excitation. We predict a potential improvement in detectable concentration compared to direct transmission geometry by more than one order of magnitude. The presented concept will benefit sensing applications requiring high detection sensitivity and dynamic range, including time-domain and frequency-domain spectroscopy and affords the potential of separating the nonlinear polarization response of a sample from the linear one, upon excitation with intense laser pulses.

12:00pm-2:00pm Lunch Break

TU7: Free Electron Laser Technology and Applications

Session Chair: G. Coslovich, Stanford Linear Accelerator Center (United States)

2:00pm-2:30pm (TU7.1)

"Realization of Ultra-stable Hard X-ray Free Electron Laser"

H.-S. Kang, Pohang Accelerator Lab (Korea)

The use of electron-beam-based alignment incorporating undulator radiation spectrum analysis, state-of-the-art design of the linac RF and timing system, and the three-chicane bunch-compressor lattice allows reliable operation of PAL-XFEL with unprecedented stability in terms of arrival timing, beam pointing, and intensity jitter. An electron beam arrival timing jitter of smaller than 15 fs, a transverse position jitter of smaller than 10% of the photon beam size, and an FEL intensity jitter of smaller than 5% are consistently achieved. The measured central wavelength jitter is as small as 2.9×10^{-4}, much smaller than the FEL parameter of 5.0×10^{-4}, which is attributed to the small e-beam energy jitter of 0.013%. A distinguishing feature of PAL-XFEL is the unprecedented temporal stability, with the rms timing jitter of ~18 fs between X-ray pulses and optical pulses from a synchronized laser system. This low timing jitter of the electron beam makes it possible to observe Bi(111) phonon dynamics without the need for timing-jitter correction, indicating that PAL-XFEL is an extremely useful tool for hard X-ray time-resolved experiments.

2:30pm-3:00pm (TU7.2)

"Towards Free Electron Laser based on Laser Plasma Accelerators"

M.-E. Couprie, Synchrotron SOLEIL (France)

The laser invention led to the development of free electrons lasers (FEL), that are ultra-short coherent high brightness sources from the infra-red to the X-ray, range, providing a unique tool for matter investigation and to laser plasma acceleration (LPA), that can provide large acceleration gradient in extremely short distances. Combining both of them for developing a laser plasma based free electron laser would provide the qualification of the new acceleration concept and open the path towards compact FELs. Since the LPA electron beam characteristics do not yet reached these currently achieved on conventional accelerators, especially in terms of energy spread and divergence, strategies of beam manipulation have to be developed. A panorama of major progresses is then drawn.

3:00pm-3:15pm (TU7.3)

"High-sensitivity Femtosecond X-ray Optical Cross-Correlator for Next Generation Free-Electron Lasers"

S. Droste, L. Shen, V. White, E. Diaz-Jacobo, R. Coffee, S. Zohar, A. Reid, F. Tavella, M. Minitti, J. Turner, K. Gumerlock, J. Robinson, A. Fry, G. Coslovich, SLAC National Accelerator Lab (United States)

We designed a novel X-ray arrival time monitor that cross-correlates X-ray and 1550 nm optical pulses used in state-of-the-art femtosecond timing distribution systems. We exploit an interferometric detection scheme and etalon effects in thin-film Germanium to achieve unprecedented high sensitivity to soft X-rays. The resolution of the timing measurement is 2.8 fs (rms). The detection scheme is compatible with various wavelengths with the choice of appropriate sample materials.

3:15pm-3:30pm (TU7.4)

"Timing stabilization of synchronized femtosecond laser system for pump-probe experiments in SACLA"

T. Togashi, Japan Synchrotron Radiation Research Institute (Japan) and RIKEN SPring-8 Center (Japan); A. Kon, Japan Synchrotron Radiation Research Institute (Japan); K. Sueda, RIKEN SPring-8 Center (Japan); T. Yabuuchi, S. Owada, T. Katayama, Japan Synchrotron Radiation Research Institute (Japan) and RIKEN SPring-8 Center (Japan); K. Nakajima, RIKEN SPring-8 Center (Japan); S. Matsubara, Japan Synchrotron Radiation Research Institute (Japan); H. Tomizawa, K. Tono, M. Yabashi, Japan Synchrotron Radiation Research Institute (Japan) and RIKEN SPring-8 Center (Japan)

A synchronization system of a femtosecond laser has been developed for pump-probe experiments using X-ray free electron laser (XFEL) and optical laser pulses in a Japanese XFEL facility: SPring-8 Angstrom Compact free-electron LAser (SACLA). This system controls the mode-locked oscillator with a balanced optical-microwave phase detector (BOM-PD) using the 5.7-GHz RF signal from the accelerator of SACLA as a reference. We have evaluated relative timing fluctuation between these pulses using an arrival-timing monitor based on spatial encoding technique with X-ray induced change in optical transmittance of gallium arsenide (GaAs). The timing fluctuation was estimated as ~20 fs r.m.s. in a short period (3 minutes).

3.30pm-3:50pm (TU7.5)

"Turning on the Lights: Transitioning from Construction to Operations at the Extreme Light Infrastructure (ELI)"

A. Weeks, ELI Delivery Consortium

The Extreme Light Infrastructure is transitioning from the Construction Phase to the Operations Phase, marking an important milestone for laser-based research in Europe and researchers around the world. This talk focuses on the two facilities expected to be available to researchers starting in 2020, at ELI-ALPS in Szeged, Hungary and ELI-Beamlines in Dolní Břežany in the Czech Republic. The overall status and objectives of the two facilities are reviewed. In particular, the key challenges to bringing systems online for users, technical and organisational, will be addressed. Performance parameters of the two facilities are state-of-the-art, but must also meet the strict demands and robust quality expectations of an international user facility. In addition to technical challenges, the distribution of the facilities creates logistical and managerial challenges. The legal form of the new international organisation as a European Research Infrastructure Consortium, and its relevance for the scientific users and the access policy, will also be examined.

3:50pm-4:15pm Coffee Break

TU8: High Average Power Sources from IR to THz

Session Chair: M. Hanna, CNRS – Institut d'Optique (France)

4:15pm-4:45pm (TU8.1)

"Novel methods for the generation of mJ-class, multi-cycle THz frequency pulses"

M. Hemmer, JILA (United States)

We present several approaches we investigated to generate THz pulses with energies in the hundreds of microjoule level with potential for scalability to the multi-millijoule level. We detail the cascaded optical parametric amplifier approach, and the chirp and delay method. In addition, we present a simple solution to upscale the aperture of periodically poled lithium niobite crystals, the gain medium of choice for our investigations. For each of the aforementioned method, we present the most recent performances we demonstrated as well as the challenges encountered. The interest for THz pulses with such output format is driven by the demand from a new class of tabletop particle accelerators.

4:45pm-5:00pm (TU8.2)

"Broadband THz radiation with 50 mW average power"

J. Buldt, H. Stark, M. Mueller, C. Jauregui, Friedrich-Schiller-University Jena (Germany); J. Limpert, Friedrich- Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)

Electromagnetic radiation in the THz spectral region is attracting growing interest due to the increasing number of applications in industry, security, biology, medicine and fundamental science. However, a breakthrough in many applications is still hindered by the limitations of available THz sources. This way, THz particle acceleration, the studies of nonlinear effects and material properties, pump-probe experiments, spectroscopy of aqueous samples and many others can significantly profit from novel, highpower sources in the THz gap. The development of THz sources with high average-power, broad bandwidth and high field strength is driven by this demand of the applications. In this paper we present a first step in average-power scaling of broadband, gas-plasmabased THz sources to an unprecedented average power of 50 mW and discuss the scaling of this type of source towards Watt-level average powers.

5:00pm-5:15pm (TU8.3)

"Broadband intense THz pulses generated with a mid-infrared OPCPA pump source"

C. Gollner, TU Wien (Austria); A. Koulouklidis, Science Program, Texas A&M University at Qatar (Qatar) and Institute of Electronic Structure and Laser (IESL) (Greece); M. Shalaby, Swiss Terahertz Research-Zurich (Switzerland) and Key Lab of Terahertz Optoelctronics (China); C. Brodeur, Swiss Terahertz Research-Zurich (Switzerland); V. Fedorov, Science Program, Texas A&M University at Qatar (Qatar) and P. N. Lebedev Physical Institute of the Russian Academy of Sciences (Russian Federation); S. Tzortakis, Science Program, Texas A&M University at Qatar (Qatar) and Institute of Electronic Structure and Laser (IESL) (Greece) and Department of Materials Science and Technology (Greece); V. Shumakova, TU Wien (Austria); A. Baltuška, A. Pugžlys, TU Wien (Austria) and Center for Physical Sciences & Technology (Lithuania)

We report on THz generation driven by a 3.9 µm Optical Parametric Chirped-Pulse Amplifier (OPCPA), via either optical rectification (OR) in organic crystals or in two-color plasma filaments. In both cases, THz generation benefits from the long wavelength of the mid-IR driving pulses, resulting in higher THz pulse energy, higher saturation fluences and larger spectral bandwidth, as compared to conventional VIS and near-IR pump sources. In the case of THz generation by two-color mid-IR plasma filaments, an outstanding optical to THz conversion efficiency of 2.34% could be achieved, which is more than an order of magnitude higher as compared to short-wavelength driving pulses. The exceptionally high conversion efficiency results in THz pulse energies of 0.185 mJ and broad spectral bandwidth of 15 THz. THz generation by OR in organic crystals pumped by 3.9 µm pulses is prominent due to an extraordinary high optical damage threshold and saturation fluences. No damage of the electro-optic crystal was observed for pump fluences exceeding 120 mJ/cm^2, which outpaces conventional near-IR pump sources by an order of magnitude. Whereas the conversion efficiency only starts to saturate at pump fluences of > 60 mJ/cm^2, THz energy densities of 1.6 mJ/cm^2 can be achieved.

5:15pm-5:30pm (TU8.4)

"Yb-doped fiber laser system with 1kW, 10mJ and <300fs pulse for the generation of TW class few-cycle pulses"

S. Breitkopf, S. Hädrich, M. Kienel, Active Fiber Systems GmbH (Germany); P. Jojart, ELI-ALPS, ELI-HU Non-Profit Ltd. (Hungary); Z. Varallyay, K. Osvay, ELI-ALPS (Hungary); P. Simon, Laser-Laboratorium Göttingen e.V. (Germany); T. Nagy, Max- Born- Institute for Nonlinear Optics and Short Pulse Spectroscopy (Germany); A. Blumenstein, Laser-Laboratorium Göttingen e.V. (Germany); R. Klas, Institute of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena (Germany) and Helmholtz-Institute Jena (Germany); J. Buldt, H. Stark, E. Shestaev, Institute of Applied Physics (Germany); T. Eidam, Active Fiber Systems GmbH (Germany); J. Limpert, Institute of Applied Physics (Germany) and Helmholtz-Institute Jena (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering, (Germany)

We present a 10-mJ and 1-kW, sub 300-fs CPA system with excellent beam quality (M2=1.1). To achieve such parameter-set, the output of 16 main-amplifier channels is coherently combined using a polarization-based filled-aperture scheme. The system exhibits excellent long-term stability of 0.3%

RMS power fluctuations over >9hours and is a major part of the ELI-ALPS HR2 laser system. It will be combined with a nonlinear pulse compression unit that aims to achieve 5 mJ pulse energy at 100 kHz pulse repetition rate (i.e. 500 W of average power) and with pulse durations of 6 fs, i.e. a terawatt class laser. In addition to the CPA system we present first promising experimental results on compression of high energy pulses with high average power in a long stretched capillary setup. In a first proof-of-principle experiments, 5 mJ pulses at 100 kHz (500 W average power) are spectrally broadened in a 4 m long capillary to a bandwidth supporting <17 fs pulses. Further experimental results towards the achievement of the HR2 pulse parameters will be presented at the conference.

5:30pm-5:45pm (TU8.5)

"Table-top high energy 7µm OPCPA for strong field physics"

U. Elu, D. Sanchez, T. Steinle, L. Maidment, ICFO – The Institute of Photonic Sciences (Spain); K. Zawilski, P. Schunemann, BAE Systems (United States); G. Matras, C. Simon-Boisson, THALES Optronique S.A.S. (France); J. Biegert, ICFO –The Institute of Photonic Sciences (Spain) and ICREA (Spain)

We present the development of a 0.75 mJ pulse energy, 7 µm OPCPA at 100 Hz with an intermediate chirp inversion stage permitting compression with 93.5% efficiency in bulk BaF_2 to 188 fs duration (8 optical-cycles). The output is used to generate high harmonics in ZnSe spanning the near infrared into the visible spectral region, reaching harmonic order 13. The high intensity, passively carrier-to-envelope phase stable mid-infrared pulses make this table-top source a key enabling tool for strong field physics and keV-level coherent x-ray sources.

6:00pm-8:00pm Poster Session 2 (open bar, finger food)

Wednesday, October 9

8:00am-8:30am Registration

WE9: High Average Power Ultrafast Lasers

Session Chair: A. Fry, Stanford Linear Accelerator Center (United States)

8:30am-9:00am (WE9.1)

"Amplified programmable frequency-tunable fs pulse bursts: from THz synthesis to strong-field molecular applications"

A. Pugžlys, Center for Physical Sciences & Technology (Lithuania); T. Flöry, V. Stummer, E. Kaksis, I. Astrauskas, P. Malevich, TU Wien (Austria); A. Baltuška, TU Wien (Austria) and Center for Physical Sciences & Technology (Lithuania); G. Krizsán, G. Polónyi, J. Fülöp, University of Pécs and ELI-ALPS (Hungary)

We demonstrate fully controllable fs multimillijoule pulse bursts with the energy handling, throughput efficiency and frequency resolution substantially exceeding that achievable in spatial-light-modulator and interferometric techniques. Our phase-controlled pulse-burst amplification is based on differential pathlength stabilization between the master oscillator and the amplifier cavities. This technique boosts the safe level of extractable burst energy and suppresses fluctuations in various burst-mode applications. The demonstrated proof-of-concept experiments include coherent control of nitrogen-ion emission via multiple-pulse excitation and generation of tunable narrowband THz pulses via optical rectification.

9:00am-9:30am (WE9.2)

"High-Power Ultrafast Industrial Thin-Disk Lasers"

C. Teisset, C. Grebing, C. Herkommer, S. Klingebiel, P. Kroetz, K. Michel, S. Prinz, C. Wandt, T. Metzger, TRUMPF Scientific Lasers (Germany)

TRUMPF Scientific Lasers manufactures customized ultrafast systems based on TRUMPF industrial thin-disk laser components. These laser sources combine ease of operation with robustness and tailored output specifications. In this contribution, we present different commercial ultrafast solutions based on regenerative amplifiers with up to 200 mJ of pulse energy and more than 1 kW of average power. In parallel, significant progress in thin-disk based multipass arrangements has led to multikilowatt average output powers. This paper will review the latest advancement in the development of a 1-J multipass thin-disk amplifier. In addition, concepts for nonlinear compression to reach pulse durations below 50 fs will be discussed.

9:30am-9:45am (WE9.3)

"Performance scaling of ultrafast two micron fiber CPA systems and high-power nonlinear pulse compression to the sub-2 cycle regime"

M. Gebhardt, Friedrich-Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany); C. Gaida, Friedrich-Schiller-University Jena (Germany); T. Heuermann, Friedrich-Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany); Z. Wang, C. Jauregui, Friedrich-Schiller-University Jena (Germany); J. Antonio-Lopez, A. Schülzgen, R. Amezcua- Correa, CREOL, University of Central Florida (United States); J. Rothhardt, Helmholtz-Institute Jena (Germany) and Friedrich-Schiller- University Jena (Germany); J. Limpert, Friedrich-Schiller-University Jena (Germany) and Helmholtz-Institute Jena (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering (Germany)

High repetition rate sources of energetic, few-cycle pulses are useful tools for strong-field science and high-harmonic generation (HHG). Concerning HHG, a carrier wavelength beyond the well-explored near infrared spectral region is very attractive for increasing the phase-matched photon-energy cut-off. In particular, driving laser wavelengths spanning 1-2 μm make it possible to access the highly application relevant spectral region between 300 eV and 500 eV. In this contribution, we report on the current status and on the future prospects of ultrafast thulium-doped fiber laser systems operating around 1.9 μm wavelength. Average power scaling to 1 kW and peak power scaling to several GW is presented, together with the demonstration of 100 fs pulses emitted directly from a high energy fiber laser. Using a gas-filled, anti-resonant hollow-core fiber, nonlinear selfcompression of the pulses from a thulium-doped fiber CPA is investigated at 392 kHz repetition rate. We have achieved a record average power of 44 W, 5 GW of peak power and sub-two cycle pulse duration with a spectrum spanning 1.0-2.2 μm. Based on these results, we discuss future performance scaling and applications of the laser source.

9:45am-10:00am (WE9.4)

"Performance test results of ELI-ALPS SYLOS lasers"

T. Stanislauskas, I. Balčiunas, Light Conversion Ltd (Lithuania); J. Adamonis, Ekspla (Lithuania); R. Budriūnas, G. Veitas, Light Conversion Ltd (Lithuania); D. Lengvinas, Ekspla (Lithuania); D. Gadonas, Light Conversion Ltd (Lithuania); S. Tóth, J. Csontos, Á. Börzsönyi, L. Tóth, T. Somoskői, K. Osvay, ELI-ALPS Ltd (Hungary)

We report on the recently delivered performance test results of ELI-ALPS Single Cycle Laser (SYLOS) lasers, which will be the drivers of three beamlines for attosecond pulse generation and one for electron acceleration. The current parameters of the main SYLOS laser system reached a peak power of 4.9 TW and 2.17-cycle (6.4 fs) pulses at 1 kHz repetition rate. The reliability was demonstrated with 12 hours long-term measurement periods for three consecutive days without substantial adjustments. Exceptional energy stability of 0.72%, CEP stability of 220 mrad and pointing stability of 0.4 μrad was recorded during these long-term runs. SYLOS will be sharing the load of the four beamlines with a smaller system called SYLOS Experiment Alignment laser, which has similar output parameters to SYLOS laser, except the 10 Hz repetition rate and without CEP-stability. The performance test results of this system is also reported.

10:00am-10:30am Coffee Break

WE10: Scientific Applications

Session Chair: M.-E. Couprie, Synchrotron SOLEIL (France)

10:30am-11:00am (WE10.1)

"Terahertz-induced Nonlinear Phonon Dynamics"

M. E. Kozina, SLAC National Accelerator Lab (United States); M. Fechner, Max Planck Institute for the Structure and Dynamics of Matter (Germany); P. Marsik, Department of Physics, University of Fribourg (Switzerland); T. van Driel, J. M. Glownia, SLAC National Accelerator Lab (United States); C. Bernhard, Department of Physics (Switzerland); M. Radovic, Swiss Light Source, Paul Scherrer Institut (Switzerland); D. Zhu, SLAC National Accelerator Lab (United States); S. Bonetti, eDepartment of Molecular Sciences and Nanosystems, Università Ca' Foscari Venezia (Italy) and Department of Physics, Stockholm University (Sweden); U. Staub, Swiss Light Source, Paul Scherrer Institut (Switzerland); M. Hoffmann, SLAC National Accelerator Lab (United States)

We report measurements of the structural response of a thin film of SrTiO3 (STO) under strong excitation with singlecycle terahertz (THz) fields using ultrafast x-rays. STO has a known soft phonon that is in close resonance with the central frequency of the THz driving field. For weak THz fields, we observe atomic motion which we associate with resonant phonon excitation. As we increase the THz field strength, we detect both a saturation in the soft mode excitation amplitude as well as the appearance of several new frequencies closely matched to known higher-frequency phonons in STO. Combining DFT calculations with measured x-ray diffraction measurements, we are also able to extract the soft mode phonon potential.

11:00am-11:30am (WE10.2)

"Table-top Coherent Diffractive Imaging using a Fiber Laser Driven High-order Harmonic Source"

W. Eschen, G. Tadesse, R. Klas, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany) and Helmholtz-Institute Jena (Germany); V. Hilbert, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany) and Helmholtz- Institute (Germany); F. Tuitje, Friedrich-Schiller-Universität, Institute of Optics and Quantum Electronics (Germany); M. Steinert, D. Schelle, A. Nathanael, F. Schrempel, V. Schuster, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany); M. Zürch, Fritz Haber Institute (Germany); T. Pertsch, H. Gross, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany); C. Spielmann, Friedrich-Schiller-Universität, Institute of Optics and Quantum Electronics (Germany); A. Tünnermann, J. Limpert, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany) and Helmholtz-Institute (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); J. Rothhardt, Friedrich-Schiller-Universität, Institute of Applied Physics (Germany) and Helmholtz-Institute Jena (Germany)

Laser development in the recent years has pushed the coherent XUV flux of high-harmonic generation to values that are comparable to synchrotrons. This development enables Coherent Diffractive Imaging experiments on a lab scale that were before only possible at large scale facilities. In this contribution we present our latest results on table-top lensless XUV-Imaging. Achieving record-high resolutions using a high-order harmonic source at 18 nm with two

different imaging modalities. Using the Fourier Transform Holography (FTH) method a record resolution of 23 nm was demonstrated. With the more general ptychographic method we were able to resolve features down to a size of 45 nm. Further, we show our recent advances towards imaging at the technological relevant wavelength of 13.5 nm which will in future enable actinic inspection of lithography masks.

11:30am-11:45am (WE10.3)

"Ultrafast single-cycle far-infrared pulses for imaging pump-probe dynamics on the atomic scale"

V. Jelic, University of Alberta (Canada) and Michigan State University (United States); Y. Luo, P. H. Nguyen, J. A. M. Calzada, D. Mildenberger, Y.-J. Liu, F. A. Hegmann, University of Alberta (Canada)

Recent progress in THz-pulse-coupled scanning tunneling microscopy (THz-STM) has demonstrated that ultrafast single-cycle far-infrared transients can non-resonantly control electron tunneling at sub-nanometer length scales and sub-picosecond timescales. The THz pulse electric field couples to the atomically sharp tip of the STM, generating a spatially and temporally localized ultrafast tunnel current that can be used to explore the dynamics of atoms and molecules on surfaces. In the work presented here, hundreds of electrons are rectified across the tunnel junction per THz pulse, while imaging a photoexcited GaAs(110) surface with a spatial resolution of 3 Å and a temporal resolution of 500 fs. The STM topography image and ultrafast THz-STM image are acquired simultaneously as the tip is raster scanned across the sample surface.

11:45am-12:00pm (WE10.4)

"Laser cooling of atoms with an optical frequency comb"

D. Aumiler, N. Šantić, D. Buhin, D. Kovačić, I. Krešić, T. Ban, Institute of Physics (Croatia)

We report on laser cooling of neutral rubidium atoms by using a single mode of a frequency comb. Cooling is achieved on a dipole-allowed transition at 780 nm in a one-dimensional retro-reflected beam geometry. Temperatures are measured using standard time-of-flight imaging. We show the dependence of the temperature on the cooling time, intensity and detuning of the frequency comb. The lowest temperature achieved is approximately equal to the Doppler temperature and is limited by the intensity of the comb mode driving the cooling transition. Additionally, we verify the analogy between frequency comb and continuous-wave laser cooling. Our work is a step towards laser cooling of atoms with strong cycling transitions in the vacuum ultraviolet, such as hydrogen, deuterium and antihydrogen, where generation of continuous-wave laser light is limited by current laser technology. Achieving efficient cooling at these wavelengths would significantly improve the precision of optical frequency standards, enable measurements of fundamental constants with unprecedented accuracy, improve tests of charge, parity, and time reversal symmetry, and open the way to achieving quantum degeneracy width new atomic species.

12:00pm-12:20pm (WE10.5)

“The BELLA Center: Ultrahigh Intensity Laser Facility for Users to Study High Field Interactions in Laser-Plasma Science”

C. Toth, K. Nakamura, A. J. Gonsalves, S. Steinke, J. Bin, H. Tsai, T. M. Ostermayr, C. G. Geddes, S. K. Barber, J. van Tilborg, T. Schenkel, C. B. Schroeder, E. H. Esarey, Lawrence Berkeley National Lab (United States)

The BELLA Center provides several CPA laser beamlines for the development and application of laser-plasma accelerators (LPAs), and enables multi-beam experimental opportunities combining photons and particles for users. Recent results include the production and characterization of electron beams at 0.01-8 GeV, and low-divergence ion beams at a few MeV. Femtosecond, keV-band betatron radiation is also generated from the acceleration process. Development of a source of femtosecond quasi-monoenergetic MeV Thomson photons is underway.

12:45pm-7:00pm Excursion

Thursday, October 10

8:00am-8:30am Registration

TH11: High Power Laser Sources from mid-IR to FEL

Session Chair: M. Hemmer, JILA (United States)

8:30am-9:15am (TH11.1)

Keynote: "X-ray Free Electron Lasers: the Versatile, Powerful, and Evolving Tool for Ultrafast Science"

A. Fry, Stanford Linear Accelerator Center (United States)

The X-ray Free Electron Laser (XFEL) has developed over the past 10 years into a powerful and versatile tool in the forefront of ultrafast science at the national lab facility scale. Several features distinguish XFELs from conventional ultrafast laser sources and x-ray sources: 10^10 higher peak brightness than synchrotrons, tunable photon energy over 2 orders of magnitude for atom-specific interactions, tunable pulse duration from 100s of femtoseconds to 100s of attoseconds, tunable spectral bandwidth, pulse repetition rates up to MHz, multiple pulses with variable separation and photon energy, and exquisite synchronization with ultrafast lasers for pump-probe experiments. Based on the outstanding scientific results in numerous fields, major investments in XFEL facilities are being pursued, bringing advances in all areas of XFEL core capabilities and driving innovative new capabilities driven by overwhelming scientific demand. Furthermore, the rapid developments in XFEL capabilities have driven advances in the areas of technology that are required to take full advantage of XFELs - notably high-precision timing and synchronization, and significant advances in ultrafast optical lasers.

9:15am-9:30am (TH11.2)

"100 µJ, 100 kHz, CEP-stable high-power few-cycle fiber laser"

E. Shestaev, Friedrich-Schiller-University Jena, Institute of Applied Physics (Germany); D. Hoff, A. M. Sayler, Institut für Optik und Quantenelektronik (Germany); S. Hädrich, F. Just, T. Eidam, Active Fiber Systems GmbH (Germany); P. Jójárt, Á. Szabó, Z. Várallyay, K. Osvay, ELI-ALPS, ELI-HU Non-Profit Ltd. (Hungary); G. G. Paulus, Institut für Optik und Quantenelektronik (Germany); A. Tünnermann, Friedrich-Schiller-University Jena, Institute of Applied Physics (Germany) and Fraunhofer Institute for Applied Optics and Precision Engineering IOF (Germany); J. Limpert, Friedrich-Schiller-University Jena, Institute of Applied Physics (Germany) and Active Fiber Systems GmbH (Germany) and Helmholtz-Institute Jena (Germany)

We present a CEP-stable Yb:fiber-based laser system delivering 100 µJ few-cycle pulses at the repetition rate of 100 kHz. The CEP stability of a free-running system amounts to 340 mrad (10 Hz…50 kHz) measured on a pulse-to-pulse basis with a Stereo-ATI phase meter. A slow loop from the ATI to the AOM acting as a pulse picking device has been implemented, allowing for suppression of CEP fluctuations below 300 Hz. To the best of our knowledge, this is the highest performance in terms of CEP stability achieved from a fiber-based high-power few-cycle laser to date.

9:30am-9:45am (TH11.3)

“Frontiers in high power ultrafast thin-disk lasers operating in the sub-100-fs regime”

T. Südmeyer, N. Modsching, J. Drs, J. Fischer, C. Paradis, F. Labaye, M. Gaponenko, Univ de Neuchâtel (Switzerland); C. Kränkel, Center for Laser Materials, Leibniz-Institut für Kristallzüchtung (Germany); V. J. Wittwer, Univ de Neuchâtel (Switzerland)

The thin-disk laser (TDL) concept is highly beneficial for ultrafast oscillators operating in the sub-100-fs regime: excessive nonlinearities from the gain material are suppressed by the thin gain geometry, and the TDL pumping scheme circumvents the need for dichroic mirrors with high pump transmission in the laser cavity. In this way, Kerr lens mode-locked (KLM) TDLs can operate with nearly transform-limited soliton pulses in a strongly self-phase modulation (SPM) broadened regime, featuring an optical bandwidth that can be several times larger than the bandwidth of the employed gain material, reaching so far down to 30-fs pulses. We discuss the current state-of-the-art and present in detail the design and optimization of an $Yb:Lu_2O_3$ oscillator, which generates pulses with a duration of 95 fs at 21.1 W average power and 47.9 MHz repetition rate. Unlike to usual KLM TDL oscillators, an operation at the edge of the stability zone in continuous-wave operation is not required. The average power is nearly twice as high as previous sub-100-fs laser oscillators. We expect that further power scaling towards power levels in excess of hundred Watt will be soon be achieved.

9:45am-10:00am (TH11.4)

“Frequency divide-and-conquer approach to producing few-cycle mid-IR transients and multi-octave combs”

K. L. Vodopyanov, Q. Ru, CREOL (United States); P. G. Schunemann, BAE Systems (United States); S. Vasilyev, IPG Photonics—Southeast Technology Center (United States); S. B. Mirov, University of Alabama at Birmingham (United States); A. V. Muraviev, CREOL (United States)

We present a new technique for extending few-cycle optical pulses and broadband phase-coherent frequency combs to the mid-IR range (2.5–18 micrometers) – based on subharmonic optical parametric oscillation (OPO), a reverse of the second harmonic generation process, where the frequency comb of a pump laser is transposed to half its frequency and simultaneously spectrally augmented, thanks to an enormous parametric gain bandwidth at degeneracy.

10:00am-10:30am Coffee Break

TH12: High Harmonic and Attosecond Pulse Generation Technology and Science

Session Chair: C. Toth, Lawrence Berkeley National Laboratory (United States)

10:30am-11:00am (TH12.1)

"Phase-matched extreme-ultraviolet frequency-comb generation"

G. Porat, JILA (United States); C. M. Heyl, JILA (United States) and Department of Physics, Lund University (Sweden); S. B. Schoun, C. Benko, JILA (United States); N. Dorre, University of Vienna, Faculty of Physics, VCQ &, QuNaBioS (Austria); K. L. Corwin, Department of Physics, Kansas State University (United States); J. Ye, JILA (United States)

Extreme ultraviolet (XUV) laser radiation is commonly produced via high-harmonic generation (HHG) in gases. The lasers that drive this process typically operate at low pulse repetition rates (<100 kHz). Under these operating conditions, the plasma generated by each laser pulse clears the generation volume before the next pulse arrives. Therefore, each laser pulse interacts with fresh plasma-free gas, where phase-matching facilitates efficient HHG. However, applications requiring high counting statistics or frequency-comb precision make high repetition rates (>10 MHz) necessary. Unfortunately, at high repetition rates, plasma accumulates in the XUV generation region and prevents phase-matching, resulting in low HHG efficiency. We use high-temperature gas mixtures to increase the gas translational velocity, thus reduce plasma accumulation and facilitate phase-matching. We experimentally achieve phase-matched HHG at a repetition rate of 77 MHz, generating record power of ~2 mW at 97 nm and ~0.9 mW at 67 nm.

11:00am-11:15am (TH12.2)

"Optics-free focusing and spectral filtering of XUV harmonic beams"

C. Valentin, K. Veyrinas, CNRS/CELIA (France); D. Descamps, CEA/CELIA (France); F. Burgy, C. Péjot, F. Catoire, CNRS/CELIA (France); E. Constant, CNRS/ILM (France); E. Mével, Université Bordeaux/CELIA (France)

High harmonics generated in gas by few mJ femtosecond laser beam provide a coherent and ultrafast XUV source. By characterizing the intensity profile and wavefront of XUV high-order harmonics generated in a gas jet, we establish the possibility of focusing XUV beams to micrometer spot size and efficient spectral filtering without using any XUV optics.

11:15-am-11:30am (TH12.3)

"Efficient ultrafast, high energy sub-2 cycle driver at 150 kHz"

F. Guichard, L. Lavenu, M. Natile, Y. Zaouter, Amplitude Systèmes (France); M. Hanna, X. Délen, P. Georges, Laboratoire Charles Fabry (France)

We present a hybrid dual-stage nonlinear compression scheme allowing to compress 330 fs-pulses generated from a high-energy fiber amplifier down to 6.8 fs pulse duration, with an overall transmission of 61%. This high transmission is obtained by using a first compression stage based on a gas-filled multipass cell, and a second stage based on a large-core gas-filled capillary. The source output is fully characterized in terms of spectral, temporal, spatial, and short- and long-term stability properties. The system's compactness, stability, and high average power makes it ideally suited to drive high photon flux XUV sources through high harmonic generation.

11:30am-11:45am (TH12.4)

"A beamline combining attosecond-XUV and sub-2-fs deep-UV pulses"

A. Cartella, University of Hamburg (Germany); V. Wanie, Center for Free-Electron Laser Science (Germany) and Institut National de la Recherche Scientifique (Canada); M. Galli, Center for Free-Electron Laser Science (Germany) and Institute for Photonics and Nanotechnologies CNR-IFN (Italy) and Department of Physics, Politecnico di Milano (Italy); L. Colaizzi, Center for Free-Electron Laser Science (Germany); D. Pereira Lopes, Department of Physics Politecnico di Milano (Italy); E. P. Månsson, A. Trabattoni, K. Saraswathula, Center for Free-Electron Laser Science (Germany); F. Frassetto, L. Poletto, Institute for Photonics and Nanotechnologies CNR-IFN (Italy); F. Légaré, Institut National de la Recherche Scientifique (Canada); S. Stagira, M. Nisoli, Politecnico di Milano Department of Physics (Italy) and Institute for Photonics and Nanotechnologies CNR-IFN (Italy); R. Martinez Vazquez, R. Osellame, Institute for Photonics and Nanotechnologies CNR-IFN (Italy); F. Calegari, University of Hamburg (Germany) and Center for Free-Electron Laser Science (Germany) and Institute for Photonics and Nanotechnologies CNR-IFN (Italy)

Few-cycle deep ultraviolet pulses are generated by frequency up-conversion of 5-fs near infrared pulses in argon using a laser micromachined fused silica gas cell. The spectrum extends from 210 to 340 nm, with a 1.45-fs transform limited pulse duration. The measured pulses (150 nJ energy, 1.9 fs duration) are synchronized with isolated attosecond XUV pulses, enabling new pathways for the attosecond spectroscopy of bio-relevant molecules.

11:45am-12:00pm (TH12.5)

"Waveform-dependent relativistic high-order harmonics and field-driven plasma surface dynamics"

G. Ma, Peking University Shenzhen Institute and PKU-HKUST Shenzhen-Hong Kong Institution (China) and Center for Free-Electron Laser Science, DESY (Germany); D. Kormin, Max-Planck-Institut für Quantenoptik (Germany) and Ludwig- Maximilian-Universität München (Germany); A. Borot, W. Dallari, B. Bergues, Max-Planck-Institut für Quantenoptik (Germany); M. Aladi, I. B. Foldes, Wigner Research Centre for Physics, Hungarian Academy of Sciences (Hungary); J. He, Peking University Shenzhen Institute and PKU-HKUST Shenzhen-Hong Kong Institution (China); L. Veisz, Max-Planck-Institut für Quantenoptik (Germany) and Department of Physics, Umeå University (Sweden)

Attosecond XUV-pump XUV-probe experiments demand high brightness attosecond light source benefitting from state-of-the-art ultrashort ultraintense laser technology. Current most promising route towards high energy attosecond light source is through relativistic high-order harmonic generation from plasma surfaces. In this paper, we investigate waveform-dependent relativistic high-order harmonic generation from plasma surfaces, and use spectral interferometry to understand its generation process. The unique interpretation has allowed access to unrevealed temporal structure of the generated few-pulse attotrain with evidence supporting a well-isolated

attosecond pulse. It also provides a way to measure field-driven plasma surface motion in its generation process.

12:00pm-2:00pm Lunch Break

TH13: Few-Cycle Pulses, Comb Generation, and Carrier-Envelope Phase Control

Session Chair: G. Steinmeyer, Max-Born-Institut (Germany)

2:00pm-2:30pm (TH13.1)

"Leveraging novel nonlinear devices for gigahertz frequency combs"

A. S. Mayer, University of Vienna (Austria); C. R. Phillips, D. Waldburger, L. M. Krüger, A. Klenner, ETH Zurich (Switzerland); A. R. Johnson, Columbia University (United States); K. Luke, Cornell University (United States); X. Ji, Y. Okawachi, M. Lipson, A. L. Gaeta, Columbia University (United States); C. Langrock, M. M. Fejer, Stanford University (United States); U. Keller, ETH Zurich (Switzerland)

This paper summarizes our recent results on frequency combs from compact modelocked solid-state lasers with gigahertz (GHz) pulse repetition rates. In particular, we present novel approaches to leverage nonlinear optical devices for frequency conversion processes that can be achieved at the low pulse energies (i.e. picojoules) inherently provided by these high-repetition rate lasers. We are focusing on three different nonlinear platforms/processes, that each have enabled new milestones for high-repetitionrate frequency combs:(i) supercontinuum generation (SCG) in silicon nitride waveguides to enable the stabilization of GHz-frequency combs centered at 1 μm, (ii) parametric frequency conversion in periodically poled lithium niobate (PPLN) waveguides to extend the wavelength coverage into the mid-infrared, and (iii) an aperiodically poled lithium niobate (APPLN) device that allowed us to push the repetition rate of semiconductor-saturable-absorber-(SESAM) modelocked solid-state lasers to 10 GHz using a simple straight-cavity configuration.

2:30pm-2:45pm (TH13.2)

"High-average-power mid-infrared source for spectroscopy and strong-field physics at 100 kHz"

N. Forget, N. Thiré, R. Maksimenka, Y. Pertot, O. Albert, Fastlite (France); G. M. Greetham, E. Springate, M. Towrie, Central Laser Facility (United Kingdom)

We present a 100 kHz, high-power, optical parametric chirped-pulse amplifier (OPCPA) with both wavelength tunability from 1.4 μm to 3.9 μm and carrier-envelope phase stability at ~1.75 μm and ~3.1 μm.

2:45pm-3:00pm (TH13.3)

"Relativistic-intensity waveform-controlled near-single-cycle pulses from a stretched hollow fiber compressor"

M. Ouillé, A. Vernier, F. Böhle, M. Bocoum, S. Haessler, J. Faure, R. Lopez-Martens, ENSTA Paristech (France); T. Nagy, Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (Germany); A. Blummenstein, Laser-Laboratorium Göttingen e.V (Germany); P. Simon, Laser-Laboratorium Göttingen e.V. (Germany); D. Gustas, ENSTA Paristech (France)

We present a laser source delivering TW peak power waveform-controlled 1.5-cycle light fields that can be focused down to relativistic intensity at 1 kHz repetition rate. These pulses are generated via post-compression of high-temporal-contrast 25-fs pulses from a Ti:Sapphire double chirped pulse amplifier in a stretched-hollow-fiber compressor scaled for high peak power. The unique capabilities of this source are demonstrated by observing CEP effects in laser wakefield acceleration of relativistic electrons for the first time.

3:00pm-3:15pm (TH13.4)

"Sub-50 fs fs efficient nonlinear compression of a 100 W amplifier"

F. Guichard, A. Chambinaud, J. Pouysegur, M. Cormier, A. Odier, Y. Zaouter, Q. Mocaer, C. Hönninger, E. Mottay, Amplitude Systèmes (France)

We present a high-power70W, sub-50 fs, 400 µJ source at a high repetition rate of 200 kHz. This source is based on the high-efficiency nonlinear compression of an industrial grade 100 W, 450 fs amplifier through a gas-filled multipass cell (MPC) scheme. The system's compactness, stability, and high average power makes it ideally suited to develop tabletop, high-flux XUV sources.

3:15pm-3:30pm (TH13.5)

"Sub-optical-cycle shortwave infrared pulses generation in a cascaded degenerate optical parametric amplifier"

Y.-C. Lin, Y. Nabekawa, K. Midorikawa, RIKEN (Japan)

Shortwave infrared pulses of 4.86 fs (0.86 optical cycles) centered at 1.7 µm are successfully generated in a BBO based cascaded degenerate optical parametric amplifier, which is pumped by a home-built red femtosecond laser system.

3:30pm-3:50pm (TH13.6)

"Highly Flexible Pump-Probe Laser for the Soft-X-Ray Free Electron Laser FLASH"

S. Alisauskas, N. Schirmel, T. Lang, B. Manschwetus, J. Zheng, T. Hülsenbusch, I. Hartl, U. Große-Wortmann, C. Mohr, F. Peters, A. Swiderski, DESY (Germany)

We report on an OPCPA-based ultrafast pump-probe laser system, which was recently added to the FLASH2 beamline of the superconducting, high repetition-rate XUV and soft X-ray free-electron laser (FEL) FLASH. The laser system is highly flexible in pulse-duration, center-wavelength and repetition-frequency to serve the various demands of pump-probe experiments.

3:50pm-4:15pm Coffee Break

TH14: Generation of Ultrashort Optical Pulses

Session Chair: C. Teisset, TRUMPF Scientific Lasers (Germany)

4:15pm-4:45pm (TH14.1)

"Nonlinear pulse compression using multi-pass cells"

M. Hanna, L. Lavenu, G. Jargot, N. Daher, X. Delen, Lab Charles Fabry (France); F. Guichard, Y. Zaouter, Amplitude Laser Group (France); P. Georges, Lab Charles Fabry (France)

We describe experiments that take advantage of nonlinear propagation of pulses in multi-pass cells, with the aim to perform temporal compression. Propagation in the cell induces a spatial homogenization of the nonlinear phase, while allowing to retain the accumulation of B-integral in the time domain. We will discuss two experiments done (i) with a gas-filled cells in conjunction with a gas-filled capillary, in normal dispersion regime and (ii) with a cell including a solid-state nonlinear medium, in anomalous dispersion regime. Overall, these techniques allow both excellent power efficiency and energy scaling of pulse compression setups.

4:45pm-5:00pm (TH14.2)

"Sub-10 fs, 45 W, 3 ŒºJ pulses from a Yb:YAG thin-disk oscillator"

G. Barbiero, Ludwig-Maximilians-Universität München (Germany) and Max-Planck-Institut für Quantenoptik (Germany); R. N. Ahmad, Ludwig-Maximilians-Universität München (Germany); H. Wang, Ludwig-Maximilians-Universität München (Germany) and Max-Planck-Institut für Quantenoptik (Germany); F. Köttig, Max-Planck-Institut für die Physik des Lichts (Germany); J. Brons, TRUMPF Laser GmbH (Germany); D. Schade, F. Tani, Max-Planck-Institut für die Physik des Lichts (Germany); P. S. Russell, Max-Planck-Institut für die Physik des Lichts (Germany) and Friedrich-Alexander-Universität Erlangen-Nürnberg (Germany); F. Krausz, Ludwig-Maximilians-Universität München (Germany) and Max-Planck-Institut für Quantenoptik (Germany); H. Fattahi, Max- Planck-Institut für Quantenoptik (Germany)

Nonlinear temporal compression of a 265 fs, 100 W, Yb:YAG Kerr-lens mode-locked thin-disk oscillator to generate sub-10 fs, 45 W pulses at 16 MHz repetition rate is presented.

5:00pm-5:15pm (TH14.3)

"Dispersion tuning of nonlinear dynamics in gas-filled capillary fibres"

T. Grigorova, C. Brahms, F. Belli, J. C. Travers, Heriot-Watt University (United Kingdom)

We experimentally investigate the different regimes of optical nonlinear dynamics that can be accessed in hollow capillary fibres by tuning the zero-dispersion wavelength. We pump a 3 m long, 250 μm diameter, argon-filled hollow capillary fibre with 10 fs pulses at 800 nm. By changing the gas pressure, the zero-dispersion wavelength can be tuned from the vacuum ultraviolet to the infrared. For anomalous dispersion at the pump wavelength, typical soliton and soliton-plasma dynamics are observed, such as self-compression, dispersive-wave emission, soliton blue-shifting and ionization-induced pulse splitting. Normal pump dispersion leads to the generation of 3-octave supercontinua and emission of dispersive waves in higher-order modes.

5:15pm-5:30pm (TH14.4)

"Adiabatic four-wave mixing for ultrafast sources in optical fibers"

X. Ding, Cornell University (United States); K. Harrington, University of Bath (United Kingdom); D. Heberle, N. Flemens, W. Chang, Cornell University (United States); T. Birks, University of Bath (United Kingdom); J. Moses, Cornell University (United States)

Ultrabroadband optical pulses that are compressible down to femtosecond duration with controlled phase and amplitude profile attract considerable interest due to their wide range of scientific and industrial applications. Proposed and demonstrated in the past decade, the concept of adiabatic frequency conversion (AFC) using quadratic nonlinear crystals has received attention due to its ability to simultaneously achieve octave-spanning bandwidth, near-100% efficiency, and phase and amplitude control over the generated ultrafast pulse. However, because of the limited choice of materials, requirement of quasi-phasematching, and lack of waveguiding, applications using AFC have a limited range. We recently proposed the concept of adiabatic fourwave mixing (AFWM) in cubic nonlinear media, generalizing AFC to optical fibers and on-chip waveguides. In this paper, we report the first experimental realization of AFWM using a short tapered photonic crystal fiber to convert sub-100-fs pulses from near-IR to mid-IR wavelengths, demonstrating that broadband, highly efficient AFC can be realized with a simple fiber design. Moreover, we show that AFWM can achieve orders of magnitude larger bandwidth than standard phase-matched four-wave mixing, while having high photon conversion efficiency across the entire conversion bandwidth. With a large range of optical fiber platforms available, we expect AFWM will find wide use for both low- and high-energy ultrafast applications.

5:30pm-5:45pm (TH14.5)

"Generation and single-shot characterization of femtosecond pulses with high temporal contrast"

J. Liu, Shanghai Institute of Optics and Fine Mechanics (China)

High temporal contrast are critically important for an ultra-intense laser pulse. Here we proposed femtosecond fourwave mixing processes for the generation of laser pulses with high temporal contrast and for the application of single-shot characterization of the temporal contrast. By using self-diffraction (SD) process, more than 500 uJ first-order SD pulse with a temporal contrast of 1012 was generated, where a temporal contrast improvement of about 107 was achieved in a single stage which verifies the nice pulse cleaning ability of the SD process. We also demonstrate the generation of 100-μJ-level four-wave mixing signals in a thin glass plate. The generated high-energy CFWM signals are innovatively used as clean sampling pulses of a cross-correlator for single-shot temporal contrast measurement. With a simple homemade setup, the cross-correlator was proved a single-shot measurement ability with a dynamic range of 1010, temporal resolution of about 160 fs and temporal window of 50 ps. This is the first demonstration in which both the dynamic range and the temporal resolution of a single-shot temporal contrast measurement are comparable to those of a commercial delay-scanning cross-correlator. Moreover, a new idea for improving the dynamic-range of a single-shot temporal contrast measurement using novel temporal contrast reduction techniques is proposed.

5:45pm-6:05pm (TH14.6)

"Zettawatt-Equivalent Ultrashort Pulse Laser System (ZEUS) at the University of Michigan"

I. Jovanovic, G. Kalinchenko, C. Kuranz, A. Maksimchuk, J. Nees, A. G. R. Thomas, L. Willingale, K. Krushelnick, University of Michigan (United States)

The University of Michigan's Gérard Mourou Center for Ultrafast Optical Science (CUOS) has a tradition of leadership in the development of intense laser technology and its scientific and industrial applications. The new dual-beamline 3 PW ZEUS (Zettawatt-Equivalent Ultrashort pulse laser System) facility, to be constructed in the next four years, represents a considerable advance over the current HERCULES laser in CUOS. ZEUS will allow exploration of nonlinear quantum electrodynamics in relativistic plasmas and electron-positron pair production mechanisms. Further experiments enabled by this facility will include pump-probe experiments using femtosecond x-rays to probe material dynamics, the production of GeV ion beams and "exotic" particles such as pions and muons, the exploration of vacuum polarization effects, and relativistic astrophysical shocks. Once completed, the ZEUS laser system will be the highest-power laser system in the US and will be a user facility for US scientists and wider international research community.

6:30pm-8:30pm Conference Banquet/Dinner

Friday, October 11

8:00am-8:30am Registration

F15: Ultrahigh Peak-Power Laser Systems and Related Technologies

Session Chair: Christophe Dorrer, Laboratory for Laser Energetics (United States)

8:30am-9:00am (F15.1)

"10 petawatt lasers for extreme light applications"

C. Simon-Boisson, Thales LAS France SAS (France)

For extreme physics applications, 10 PW (or more) lasers are required. We report here on the performance of the 10 PW beamlines installed at ELI Nuclear Physics site of Magurele and based on amplification in TiSa crystals. The laser system is based laser is based on a double CPA configuration with a hybrid CPA/OPCPA for the front end. The output of first CPA is sent to the next stage which is an XPW filter which allows to increase the temporal contrast of the pulses by 4 orders of magnitude. Then the output beam is sent to an optically-synchronised dual-stage BBO OPCPA whose role is to provide a further improvement of the contrast ratio by an additional 3-4 orders of magnitude. The second CPA incorporates 5 TiSa amplification stages. The spectral amplitude optimization is ensured through the insertion of spectral filters to compensate spectral effects of the amplification. The final 3-pass amplifier is pumped by multiple lasers to allow distribution of pump energy between the different passes of the beam in the Ti:Sa crystal in order to eliminate transverse lasing effects. Finally the beam is sent to the final compressor equipped with meter-size gold-coated compression gratings. At the output of final amplifier we have measured an energy per pulse of 332 J. We have measured on our diagnostics bench a pulse duration of 22.3 fs. Then the projected energy after the compressor (based on 73% measured efficiency) is 242 J which leads to a potential peak power of 10.9 PetaWatt.

9:00am-9:30am (F15.2)

"A possible chance and a potential challenge for 3-fs 100-petawatt lasers"

Z. Li, Osaka University (Japan); N. Miyanaga, Institute for Laser Technology (Japan); J. Kawanaka, Osaka University (Japan)

By using wide-angle non-collinear optical parametric chirped amplification (WNOPCPA), a single-optical-cycle 100 petawatt laser is demonstrated in simulation, which provides a possible chance for sub-exawatt lasers. A spatiotemporal coupling distortion (STCD) induced by imperfect compression grating wave-fronts is introduced, which is a potential challenge for peak power/intensity scaling of femtosecond petawatt lasers.

9:30am-9:45am (F15.3)

"Ultraintense Ti:sapphire laser with an intensity of 5.5x10^{22} W/cm^{2}"

J. H. Sung, Gwangju Institute of Science and Technology (Korea) and Institute for Basic Science (Korea); J. Yoon, Institute for Basic Science (Korea, Republic of) and Gwangju Institute of Science and Technology (Korea); H. Lee, Institute for Basic Science (Korea); S. Lee, C. Nam, Institute for Basic Science (Korea) and Gwangju Institute of Science and Technology (Korea)

Ultrahigh intensity laser pulses were produced by correcting the wavefront of a multi-PW Ti:sapphire laser and by tightly focusing the laser pulses. The wavefront of the PW laser pulses was corrected using two adaptive optics (AO) systems installed before and after the pulse compressor. When a 3-PW laser pulse was focused with an f/1.6 off-axis parabolic mirror (OAP) after the wavefront correction, the measured focal spot size (FWHM) was 1.5 μm × 1.8 μm, resulting in a peak intensity of 5.5×10^{22} W/cm^{2}.

9:45am-10:00am (F15.4)

"Generation of 0.3-TW few-cycle driver pulses via efficient cascaded Raman frequency down conversion"

G. Coccia, P. Carpeggiani, G. Fan, TU Wien (Austria); Z. Tao, Fudan University (China); E. Kaksis, A. Pugžlys, TU Wien (Austria); V. Cardin, F. Légaré, Institut National de la Recherche Scientifique (Canada); B. Schmidt, Few-Cycle Inc (Canada); A. Baltuška, TU Wien (Austria)

Energy efficient wavelength scaling of ultrashort, near IR laser pulses would be highly beneficial for several applications. For example, the generation of few-cycle, CEP stable, long wavelength IR fields via difference frequency generation of two phase-locked pulses at shifted frequencies. Directly driving with red-shifted pulses of those strong field applications where the ponderomotive potential, with its well known λ^2 dependence, has a key role, such as in high harmonic generation or filamentation. Reaching atomic and molecular resonances in the proximity of the laser fundamental frequency and its harmonics. So far, optical parametric amplification allowed to produce frequency tunable laser sources, but at the price of low conversion efficiency. Stimulated Raman Scattering frequency shifter have been demonstrated, but both their efficiency and the resulting peak power are also limited. In this work, we demonstrate a single-stage, singe-pulse, frequency down conversion of 10mJ, 220 fs pulses at 1030nm via cascaded rotational stimulated Raman scattering in a nitrogen-filled hollow core fiber. The pulses are red-shifted to 1230nm with more than 80% efficiency, and are subsequently compressed by ordinary chirp mirrors to less than 20fs, resulting in a peak power of 0.3 TW.

10:00am-10:30am Coffee Break

F16: Novel Methods for Shaping and Measuring Ultrashort Pulses

Session Chair: K. Osvay, ELI-ALPS (Hungary)

10:30am-11:00am (F16.1)

"Frequency domain nonlinear optics: concept and applications"

P. Lassonde, INRS-emt (Canada)

We use the concept of frequency domain nonlinear optics (FNO) to address various challenges related to the development of ultrafast laser sources. We find that FNO is a framework opening the door to novel nonlinear interaction schemes involving broadband, ultrashort pulses. Among the principal applications, we have achieved amplification of two-cycle pulses at 1800nm up to 2.5 TW and we have shown pulse shaping of deep-UV pulses at 207 nm. The fundamental principle of FNO involves an ultrashort pulse undergoing a nonlinear process as its frequency components are projected spatially onto a frequency axis after optical Fourier transformation. This way, the nonlinear process applies independently over discrete frequencies rather than acting on the whole spectrum at once. After nonlinear conversion, the resulting field is recombined linearly to time domain. This overall operation enables for example to synthesize fields inaccessible with conventional time-domain interactions. FNO is achieved optically by using a pair of gratings and mirrors/lenses in a 4f-configuration, like in a pulse shaper apparatus, and by placing nonlinear crystals at the position corresponding to the Fourier plane of this optical arrangement. While the fundamental concept is simple, it offers various design opportunities useful for instance for developing and scaling ultrashort laser sources based on optical parametric amplification, as well as for frequency conversion purposes.

11:00am-11:30am (F16.2)

"Spatio-temporal optical vortices"

Z. Zahedpour, S. W. Hancock, H. M. Milchberg, University of Maryland (United States)

We image the amplitude and phase of spatio-temporal optical vortex (STOV)-carrying pulses fully in the space and time domain in a single shot. We also demonstrate linear generation of a STOV- carrying pulse and demonstrate its injection and nonlinear propagation in transparent media.

11:30am-11:45am (F16.3)

"Relativistic harmonics D-scan for on-target temporal characterization of intense optical pulses"

V. Leshchenko, Ludwig-Maximilians-Universität München (Germany) and The Ohio State University (United States); A. Kessel, O. Jahn, M. Krueger, A. Münzer, S. Trushin, Ludwig-Maximilians-Universität München (Germany); L. Veisz, Umea University (Sweden); Z. Major, Ludwig-Maximilians-Universität München (Germany) and GSI Helmholtzzentrum fuer Schwerionenforschung GmbH (Germany); S. Karsch, Ludwig-Maximilians-Universität München (Germany)

Accurate knowledge of the on-target pulse intensity is one of key prerequisites for the correct interpretation of highfield experiments due to their high sensitivity to the exact value of the pulse peak intensity caused by the nonlinearity of underlying processes. There are three parameters determining the peak intensity: pulse energy, spatial and temporal energy distribution. While the detection of pulse energy and spatial profile are well established, the unambiguous temporal characterization of intense optical pulses remains a challenge especially at relativistic intensities and a few-cycle pulse duration. We report on the progress in the temporal characterization of intense laser pulses and present the relativistic surface second harmonic generation dispersion scan (RSSHG-D-scan) -- a new approach allowing direct on-target temporal characterization of high-energy few-cycle optical pulses at up to relativistic intensities.

11:45am-12:00pm (F16.4)

"Characterization of spatiotemporal coupling with multispectral imaging"

C. Dorrer, S. Bahk, Laboratory for Laser Energetics (United States)

We have developed diagnostics based on multispectral imaging to characterize spatiotemporal coupling in broadband optical pulses. The wavefront of the source under test is reconstructed from spectrally resolved experimental traces that are simultaneously measured by a multispectral camera. This approach to spatiotemporal metrology has been demonstrated with an apodized imaged Shack–Hartmann wavefront sensor and a checkerboard spatial shearing interferometer. The pulse front tilt and radial group delay introduced by test components are accurately reconstructed from the spatially and spectrally resolved phase. This concept allows for single-shot spatiotemporal metrology, which is important for the characterization of ultrafast and high-energy laser systems.

12:00pm-12:15pm (F16.5)

"Phase-matching-free pulse retrieval based on transient absorption in solids"

A. Leblanc, P. Lassonde, Institut National de la Recherche Scientifique (Canada); S. Petit, J. Delagnes, CELIA (France); E. Haddad, Institut National de la Recherche Scientifique (Canada); G. Ernotte, Joint Attosecond Science Laboratory, NRC of Canada and U of Ottawa, Ottawa, Ontario, Canada (Canada); M. Bionta, V. Gruson, Institut National de la Recherche Scientifique (Canada); B. Schmidt, Institut National de la Recherche Scientifique (Canada) and few-cycle Inc. (Canada); H. Ibrahim, Institut National de la Recherche Scientifique (Canada); E. Cormier, CELIA (France); F. Légaré, Institut National de la Recherche Scientifique (Canada)

We report a novel metrology tool to characterize femtosecond pulses. It is free of phase matching, enabling to measure pulses with ultra-broadband spectra and very low energy at the limit of the spectrometer detection. Transient absorption in solids is used to switch the transmissivity of a thin sample by photoexcitation with a pump pulse. The transmission drop is probed with the pulse to be characterized which is measured with a spectrometer in function of the pump-probe delay. This frequency resolved optical switching dataset can be described mathematically by a ptychographic equation and therefore the temporal profiles (in amplitude and phase) of both the optical switch and the probe pulse can be extracted with a phase retrieval algorithm. The only spectral limitation of this technique is the transmission spectrum of the solid sample. For instance, by using zinc selenide, it has the capability to characterize pulses with a spectrum spanning from 0.5 to 20µm, denoting more than 4 octaves. This approach was demonstrated experimentally by measuring the profiles of pulses centered at 0.8, 1.5, 1.75, 4, and 10µm, among which the ones centered at 0.8 and 10µm are few-cycle. At 0.8, 1.5, and 1.75µm, it was compared to conventional SHG-FROG measurements, as illustrated on Figure 1 with 7.5fs pulses at 0.8µm. Furthermore, the robustness of this technique was shown by measuring identical pulses with different solid samples and with different pump pulse durations.

12:15pm-12:30pm (F16.6)

"Active f-to-2f interferometer for carrier-envelope phase locking"

G. Steinmeyer, R. Liao, Max-Born-Institute (Germany); Y. Song, M. Hu, Tianjin University (China)

Providing optical gain at 1030 nm with an Yb:fiber amplifier, the signal in the infrared arm of the f-to-2f interferometer is boosted prior to second-harmonic generation. This amplification significantly increases the photon numbers in the detected beat note signal, enabling superior signal-to-noise ratios and improving the residual phase noise in carrier-envelope phase locking of a Ti:sapphire laser. An out-of-loop measurement with a second the f-to-2f interferometer indicates a residual phase jitter of 15 mrad, which corresponds to a timing jitter of only 6 attoseconds and constitutes a new record stabilization results. More imporatantly, however, the active the f-to-2f interferometer opens up an avenue towards carrier-envelope phase locking of currently unstabilizable oscillators and comb sources.

12:30pm-1:00pm Awards/Conference Closing

Monday, October 7

Poster Session 1
6:00pm – 7:30pm

P1.1 Xiao, Xuan (University of Michigan, United States)
Progress in development of an ultrafast power-scalable long-wave infrared parametric source

P1.2 Hua, Yi (DESY, Germany)
Tunable ultrafast Yb-fiber laser for efficient seeding of cryogenic Yb:YLF amplifiers

P1.3 Von Bergmann, Hubertus (Laser Research Institute, South Africa)
Large-aperture CO_2 amplifiers for mid-IR picosecond laser system

P1.4 Springer, Ramon (Friedrich-Alexander-University Erlangen-Nürnberg, Germany)
Simulation of Gain Narrowing for Near-Infrared Ultrashort Pulses

P1.5 Lin, Ming-Wei (National Tsing Hua University, Tajvan)
Nonlinear pulse compression of OPCPA at 1.55 ¬µm by multiple plate continuum

P1.6 Dansette, Pierre-Marc (EKSPLA, Lithuania)
Second harmonic generation in lithium triborate with temperature gradients

P1.7 Šuminas, Rosvaldas (Vilnius University, Lithuania)
Filamentation and supercontinuum generation in polycrystalline strontium barium niobate (SBN) using infrared femtosecond laser pulses
P1.8 Marcinkevičiūtė, Agné (Vilnius University, Lithuania)
Influence of color centers on filamentation and supercontinuum generation in alkali metal halides NaCl and KBr

P1.9 Špacek, Alexandr (ELI Beamlines, Czech Republic)
Considerations in modelling supercontinuum in bulk and numerical investigation of the stability of highly nonlinear processes

P1.10 Pipinyte, Ieva (Vilnius University, Lithuania)
Femtosecond infrared synchronously pumped optical parametric oscillator based on PPKTP crystal

P1.11 Whittlesey, Mathew (University of Michigan, United States)
Design and demonstration of Thomson scattering laser architecture for generation of quasi-monoenergetic gamma photons at multi-kHz

P1.12 Kurucz, Mate (ELI-ALPS, Hungary)
High-accuracy single-shot CEP noise measurement at arbitrary repetition rate

P1.13 Lemons, Randy (Colorado School of Mines, United States)
Self-referenced carrier-envelope phase stabilization of Er:Yb:glass lasers

P1.14 Fellinger, Jakob (University of Vienna, Austria)
Single cavity dual-comb generation from a polarization-maintaining nonlinear-amplifying-loop-mirror modelocked dual-color Yb:fiber laser

P1.15 Brochard, Pierre (University of Neuchatel, Switzerland)
Extraction and amplification of an optical comb line using an auxiliary continuous-wave laser in a feedforward scheme

~~P1.16 Seo, Meenkyo (Max Planck POSTECH/Korea Research Initiative, Germany/Korea)~~
~~*Generation of intense single-cycle pulse in the air based on all solid state system*~~ (WITHDRAWN)

P1.17 Natile, Michele (Amplitude Laser Group, France)
Nonlinearly compressed CEP-stable YDFA delivering 60 Œ°J, 80 fs at 1030 nm

P1.18 Shehzad, Atif (University of Neuchatel, Switzerland)
Investigation of the Noise Properties of the Offset Frequency in a Quantum Cascade Laser Frequency Comb

P1.19 Mainz, Roland (Center for Free-Electron Laser Science, Germany)
Phase Stabilization in a Sub-Cycle Parametric Waveform Synthesizer

P1.20 Vincenti, Henri (CEA Saclay, France)
Achieving extreme light intensities using optically-curved plasma mirrors

P1.21 Khazanov, Efim (Institute of Applied Physics, Germany)
Five-fold compression of 250 TW laser pulses

P1.22 Wilson, Derrek (Advanced Laser Light Source and few-cycle inc., INRS, Canada)

Technical Aspects of Generating Intense Few-Cycle Pulses in the Long-Wave Infrared

P1.23 Novák, Jakub (ELI Beamlines, Czech Republic)
The current commissioning results of the Allegra kilohertz ultra-fast high-energy laser system at ELI-Beamlines

~~P1.24 Fritsch, Kilian (Helmut-Schmidt-Universität / Universität der Bundeswehr Hamburg, Germany)~~
~~*All solid-state intra-pulse Raman shifting of high-power 1 µm, microjoule-level femtosecond pulses at multi-megahertz repetition rate*~~ (WITHDRAWN)

P1.25 M. Namboodiri (Deutsches Elektronen-Synchrotron DESY, Germany)
Thermal investigation of nonlinear crystals for high power ultrashort MID-IR OPCPA pumped at 1µm

P1.26 Saltarelli, Francesco (ETH Zurich, Switzerland)
High average power modelocked thin-disk lasers: nonlinearity management and power scaling to 350 W

P1.27 Burger, Milos (University of Michigan, United States)
Free-propagating femtosecond laser filamentation for standoff excitation of uranium

P1.28 Plavšin, Ivana (Agricultural Institute Osijek, Croatia)
Elemental LIBS analysis of wheat samples using nJ femtosecond laser

P1.29 Pabst, Linda (Laserinstitute Hochschule Mittweida, Germany)
Selective ablation of ultrathin aluminium film on silicon substrate using ultrashort pulse laser radiation

P1.30 Chowdhury, Enam (Ohio State University, United States)
Time resolved few cycle pulse laser damage/ablation of thin film coatings

Tuesday, October 8

Poster Session 2
6:00pm – 8:00pm

P2.1 Forget, Nicolas (Fastlite, France)
A phase-only pulse shaper for multi-octave light sources

P2.2 Kim, Kyung Taec (IBS / GIST, Korea)
Temporal characterization of laser pulses in a multi-octave wavelength range

P2.3 Kane, Daniel (Mesa Photonics LLC, New Mexico)
Removal of time smearing artifact in PG FROG

P2.4 Escoto, Esmerando (MBI für Nichtlineare Optik und Kurzzeitspektroskopie, Germany)
Third-generation pulse characterization with FROG and d-scan

P2.5 Jafari, Rana (Georgia Institute of Technology, United States)
100% reliable frequency-resolved optical gating pulse retrieval algorithmic approach

P2.6 Bock, Stefan (Helmholtz-Zentrum Dresden-Rossendorf, Germany)
Characterization of measurement devices for temporal laser pulse contrast with high dynamic range

P2.7 Jones, Travis (Georgia Institute of Technology, United States)
Simple and sensitive intensity-and-phase pulse measurement

P2.8 Doudet, Ivan (PHASICS SA, France)
High vacuum compatible wave front sensor for focal spot diagnostics and optimization

P2.9 Skrodzki, Patrick (University of Michigan, United States)
Millisecond optical guiding in the wake of 800- and 400-nm ultrafast laser-driven filaments

P2.10 Heberle, Dylan (Cornell University, United States)
Understanding chromatic aberrations in 4f few-cycle pulse shapers

P2.11 Cho, Wosik (Gwangju Institute of Science and Technology, Korea)

Temporal characterization of laser pulses through tunneling ionization from low-ionization-potential gases

P2.12 Alonso, Benjamín (University of Salamanca, Spain)
Compact in-line interferometry for the temporal measurement of polarized ultrashort laser pulses

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