

A 37: Advanced Concepts for High Peak Power Ultrafast Lasers I

Time: Friday 11:00–13:20

Location: e415

Invited Talk

A 37.1 Fri 11:00 e415

Exawatt laser concepts for extreme field science — ●CHRIS BARTY — Lawrence Livermore National Laboratory, Livermore, CA, USA

This presentation will review worldwide, high-intensity laser activities and introduce new concepts that will enable extension of existing petawatt laser capabilities to the exawatt scale. Modern inertial confinement fusion lasers based on Nd:glass have amplification bandwidths that are capable of supporting pulses of less than a picosecond in duration. With the implementation of chirped pulse amplification (CPA), it is possible for beam lines at the National Ignition Facility at the Lawrence Livermore National Laboratory, the Laser Mega-Joule (LMJ) facility in Bordeaux, France, the LFEX laser at the Institute for Laser Engineering in Osaka, Japan and the Omega EP facility at the Laboratory for Laser Energetics in Rochester, New York to create petawatt peak power laser pulses of nominally 1-ps duration and 1-kJ energy [1]. While these systems are at the forefront of present high-energy, high-peak power capabilities, they utilize only a small fraction of the potential of the underlying Nd:glass laser amplification system and as such are very inefficient. A single beam line at the NIF, for example, has a stored energy in excess of 25 kJ. This presentation describes short pulse amplification architectures based on chirped *beams* [2], novel pulse compressors and existing beam phasing technologies that are capable of extracting the full, stored energy of a NIF or NIF-like beam line and in doing so produce from one beam line a near-diffraction-limited, laser pulse whose peak power would be in excess of 200 petawatts or 0.2 exawatts. This architecture is well suited to either low-f-number focusing or to multi-beam, dipole focusing concepts [3]. With dipole focusing, it is anticipated that a single beam line of a large-aperture, mixed-glass exawatt-scale system will be capable of reaching intensities in excess of 1026 W/cm² or more than 5 orders of magnitude beyond that possible from existing CPA based PW systems at NIF, LMJ, LFEX and Omega EP. At such intensities proton motion becomes relativistic during interactions with the laser pulse. Full extraction of beam line energy will also be enabling to full scale demonstration of fast ignition concepts, etc.

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[1] D. Zuegel, S. Borneis, C. P. J. Barty, B. Legarrec, C. Danson, N. Miyanaga, P. K. Rambo, C. Le Blanc, T. J. Kessler, A. W. Schmid, L. J. Waxer, J. H. Kelly, B. Kruschwitz, R. Jungquist, E. Moses, J. Britten, I. Jovanovic, J. Dawson, and N. Blanchot, "Laser challenges for fast ignition," *Fusion Science and Technology* 49, 453-482 (2006) [2] C. P. J. Barty *Optical Chirped Beam Amplification and Propagation.* US Patent #6,804,045 B2, (2004) University of California. [3] A. Gonoskov, A. Bashinov, I. Gonoskov, C. Harvey, A. Ilderton, A. Kim, M. Marklund, G. Mourou, and A. Sergeev *Phys.Rev.Lett.* 113, 014801 (2014)

Invited Talk

A 37.2 Fri 11:50 e415

Generation of short pulses with ultra-high temporal contrast at the PHELIX petawatt facility — ●VINCENT BAGNOUD — GSI-Darmstadt, Darmstadt, Germany

With the construction of laser facilities capable of delivering peak powers at the 10-petawatt level, the temporal contrast of short laser pulses has received a growing interest in the last decade. The standard am-

plification scheme based on chirped-pulse amplification (CPA) is long known to introduce temporal pedestals and artifacts that can be detrimental to experiments and their proper understanding. In the last 10 years, several technical solutions have been proposed to overcome this limitation with good success. The crossed-polarized wave cleaning technique associated with a double CPA laser system can be found now in several implementations and is available commercially from several vendors. An alternative method based on a fast OPA is also available at various facilities like the OMEGA EP laser in the US or the PHELIX facility in Germany. In this talk, I will cover the general problematic of temporal contrast at petawatt-class laser facilities from the requirements to the current limitations. The latest results obtained with the fast OPA at the PHELIX laser where a nanosecond contrast of 10^{-12} is routinely achieved will also be presented.

Invited Talk

A 37.3 Fri 12:20 e415

Petawatt lasers for particle acceleration at HZDR Dresden — ●ULRICH SCHRAMM — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Focal intensities far beyond 10¹⁸ W/cm² have allowed for the development of compact laser plasma based particle accelerators. Applications are envisioned in the fields of cancer therapy or ultra-fast probing with energetic photons. However, such applications require peak power in the Petawatt range as well as average power.

Here, the development and status of the two Petawatt projects at the HZDR will be presented, one based on the upscaling of established Ti:Sapphire technology, the other on the energy efficient approach of exploiting directly diode laser pumped Yb:CaF₂. Special emphasis will be given on diagnostics concepts that allow for online monitoring of crucial parameters of these pulses as, e.g., temporal pulse contrast.

Invited Talk

A 37.4 Fri 12:50 e415

High-intensity few-cycle pulses with ultrahigh temporal contrast — ●STEFAN KARSCH^{1,2}, ALEXANDER KESSEL¹, CHRISTOPH SKROBOL¹, MATHIAS KRÜGER¹, CHRISTOPH WANDT¹, SANDRO KLINGEBIEL¹, OLGA LYSOV¹, IZHAR AHMAD¹, SERGEI TRUSHIN¹, VYACHESLAV LESHCHENKO¹, ZSUZSANNA MAJOR^{1,2}, and FERENC KRAUSZ^{1,2} — ¹Max-Planck-Institut für Quantenoptik — ²Ludwig-Maximilians-Universität München

Increasing the single-shot photon flux of attosecond XUV-pulses by surface harmonic generation calls for novel few-cycle laser sources: Here, the XUV radiation is generated by reflecting a few-cycle pulse from a relativistically oscillating plasma surface driven by the pulse itself. This requires few-cycle light pulses with intensities well above 10¹⁹ W/cm² and a temporal contrast that prevents target expansion before the arrival of the main pulse.

The Petawatt Field Synthesizer (PFS) project at the MPQ follows a novel approach to generate energetic, ultrabroadband light pulses with unprecedented temporal contrast. By employing a chain of optical parametric amplifiers pumped by 1-ps green laser pulses from a purpose-built, diode-pumped high-energy CPA laser we ensure that no premature light can reach the target outside the 1-ps pumping window. The high-contrast requirements also call for a high-energy, temporally clean octave-bandwidth seed in the 700-1400 nm range.

We report on the status of the three project branches, namely the seed generation and optical synchronization, the pump laser development and finally the OPA amplification and dispersion control.