AKBP 4: FEL, Seeding and Thomson Scattering

Zeit: Montag 16:45–19:00 Raum: F.10.01 (HS 4)

AKBP 4.1 Mo 16:45 F.10.01 (HS 4)

Seeding at FLASH – Challenges and perspectives — Joern Boedewadt[1], Ralph Assmann[1], Nagitha Ekanayake[1], Bart Faatz[1], Ingmar Hartl[1], Rosen Ivanov[1], Tim Laarmann[1], Jost Mueller[1], Kirsten Elaine Hacker[3], Shaukat Khan[3], Robert Molo[3], Sven Ackermann[1], Philipp Amstutz[2], Armin Azima[2], Markus Drescher[2], Leslie Lamberto Lazzarino[2], Christoph Lechner[2], Theophilos Maltezopoulos[2], •Tim Plath[2], and Jörg Rossbach[2] — [1]Deutsches Elektronen-Synchrotron (DESY), Hamburg — [2]Universität Hamburg, Hamburg — [3]DELTA, Dortmund

Free-Electron Lasers (FELs) operated in the self-amplified spontaneous emission (SASE) mode start from shot-noise. The chaotic behaviour of this statistical process entails limited longitudinal coherence and spectral shot-to-shot stability of the emitted photon pulse. These drawbacks can be overcome by seeding the FEL process with an external light field.

The linear accelerator at the FLASH user facility drives two undulator beamlines, FLASH1 and FLASH2.

At FLASH1, the seeding experiment comprises two electro-magnetic undulators, three chicanes, and a variable-gap undulator system. Thanks to this variable infrastructure, the FLASH1 seeding beamline is an ideal test bed to study different seeding schemes and to learn from experiments for the design of FLASH2 seeding.

In this contribution we report on current activities at FLASH1 and possible seeding options for the second FEL beamline FLASH2.

AKBP 4.2 Mo 17:00 F.10.01 (HS 4)

High energy narrow bandwidth light generation from inverse Thomson scattering with ultralow-emittance underdense photocathode plasma wakefield accelerated electron bunches — •Paul Scherkl[1], Alexander Knetsch[1], Oliver Karger[1], Georg Wittig[1], Grace Manahan[2], and Bernhard Hidding[1,2] — [1]Department of Experimental Physics, University of Hamburg, Germany — [2]SUPA, Scottish Center for the Application of Plasma Accelerators (SCAPA) , University of Strathclyde, UK

Thomson scattering of light from fast moving electrons is a well-known and established technique as a high energy light source. Resulting X-Ray and γ-Ray radiation is used in many areas of science, industry and medicine, since it is intense and provides high photon energies with narrow bandwidth.

The achievable Thomson scattered light bandwidth strongly depends on electron beam emittance.

The underdense photocathode plasma wakefield acceleration scheme (Trojan horse, TH) is a promising method in order to generate ultralow emittance, ultrabright electron bunches. A low bandwidth inverse Thomson scattering light source scheme is presented based on 3D particle in cell simulations and 3D time and frequency resolved Thomson scattering simulations.

AKBP 4.3 Mo 17:15 F.10.01 (HS 4)

Experimental Design of Optical Free-Electron Lasers in the Traveling-Wave Thomson-Scattering geometry — •Klaus Steiniger[1,2], Michael Bussmann[1], Arie Irman[1], Axel Jochmann[1], Richard Pausch[1,2], Fabian Roeser[1], Roland Sauerbrey[1], Ulrich Schramm[1,2], and Alexander Debus[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden — [2]TU Dresden, 01062 Dresden

Traveling-Wave Thomson-Scattering (TWTS) realizes optical free-electron lasers (OFEL) from the extreme ultraviolet to the X-ray range with existing electron accelerators and high-power laser systems. In TWTS ultrashort laser pulses and relativistic electron bunches are utilized in a side-scattering geometry where laser pulse and electron bunch direction of motion enclose an interaction angle. The laser electric field thereby provides the optical undulator field for radiation generation. When the electrons traverse the laser beam cross-section, TWTS provides continuous overlap of electrons and laser pulse by employing a laser pulse-front tilt. Long optical undulators are thus realized in TWTS allowing for microbunching of the electron beam leading to the realization of TWTS OFELs. We present the scaling laws for the electron beam and laser pulse requirements to operate TWTS OFELs and show with example scenarios that TWTS OFELs can be realized with existing radio-frequency electron accelerators such as ELBE at HZDR as well as laser-wakefield accelerated electrons. We detail the necessary equipment in a TWTS OFEL experiment and discuss how current experimental limitations affect the design of TWTS OFEL setups.

AKBP 4.4 Mo 17:30 F.10.01 (HS 4)

Upgrade of the short-pulse facility at DELTA: employing the EEHG and femtoslicing techniques — •Fin Hendrik Bahnsen, Max Bolsinger, Svenja Hilbrich, Markus Höner, Holger Huck, Maryam Huck, Shaukat Khan, Carsten Mai, Arne Meyer auf der Heide, Robert Molo, Helge Rast, Gholamreza Shayeganrad, and Peter Ungelenk — Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany

At the 1.5-GeV synchrotron light source DELTA, operated by the TU Dortmund University, a short-pulse facility employing a laser-induced modulation of the electron energy provides sub-picosecond synchrotron radiation pulses in the VUV regime using coherent harmonic generation (CHG). Significantly shorter wavelengths can be reached using the echo-enabled harmonic generation (EEHG) technique. Femtoslicing, another method employing laser-induced energy modulation, allows to reach even shorter wavelengths but with much lower photon flux. At DELTA, an upgrade of the short-pulse facility including EEHG and femtoslicing is planned for the next years. The design of new undulators and magnetic chicanes as well as simulations of the EEHG and femtoslicing process will be presented.

AKBP 4.5 Mo 17:45 F.10.01 (HS 4)

Free-Electron-Lasers based on High-Brightness Electrons from Underdense Photocathode Plasma Wakefield Accelerator. — •Gregor Hurtig[1], Georg Wittig[1], Alexander Knetsch[1], and Bernhard Hidding[1,2] — [1]Department of Experimental Physics, University of Hamburg, Germany — [2]2SUPA, Scottish Center for the Application of Plasma Accelerators (SCAPA) , University of Strathclyde, UK

Free Electron Lasers (FEL) are outstanding instruments for natural, material and life sciences and engineering. The FEL process and output depends strongly on the driving electron bunch parameters such as current and beam emittance, energy, and (slice) energy spread. Thanks to the GV/m-scale accelerating fields, plasma accelerators can reach high electron energies in compact setups, but beam quality until recently could not compete with large state-of-the-art facilities such as LCLS, FLASH, XFEL etc.

A potential, hybrid breakthrough method to produce electron bunches with emittance, current and brightness orders of magnitude better than at mentioned facilities is the underdense photocathode plasma wakefield acceleration scheme ('Trojan Horse'). In addition, the high degree of control and tunability of accelerated electron beam properties allows for flexibility in choosing the appropriate FEL process, undulator structure etc. Trojan Horse accelerated electron beams are analyzed based on 3D particle in cell simulations, and FEL simulations using state-of-the-art codes such as GENESIS and Puffin are presented and ongoing and future R&D is highlighted.

AKBP 4.6 Mo 18:00 F.10.01 (HS 4)

Ultrashort VUV Synchrotron Radiation Pulses for Pump-Probe Experiments at DELTA — •Arne Meyer auf der Heide, Fin Hendrik Bahnsen, Max Bolsinger, Svenja Hilbrich, Markus Höner, Holger Huck, Maryam Huck, Shaukat Khan, Carsten Mai, Robert Molo, Helge Rast, Gholamreza Shayeganrad, and Peter Ungelenk — Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany

Since 2011, the coherent harmonic generation (CHG) principle is employed to produce ultrashort VUV pulses at the short-pulse facility of the 1.5-GeV synchrotron light source DELTA operated by the TU Dortmund University. CHG is based on the interaction of ultrashort laser pulses with electrons in an undulator to generate coherent radiation at harmonics of the laser wavelength. Studies to characterize the CHG pulses were performed and the facility was prepared for pump-probe experiments. However, in standard user mode, an RF phase modulation is applied to increase the electron beam lifetime which leads to a significant loss of efficiency of the laser-electron interaction. Recently, methods to avoid this difficulty have been found, allowing CHG operation while the RF phase modulation is applied.

AKBP 4.7 Mo 18:15 F.10.01 (HS 4)

Femtosecond level synchronization of titanium sapphire laser and microwave reference for external injection experiments at REGAE. — •Mikheil Titberidze[1,2], Holger Schlarb[3], Benno Zeitler[1,2], Andreas Maier[1,2], Klaus Flöttmann[3], Thorsten Lamb[3], Cezary Sydlo[3], Matthias Felber[3], Ewa Janas[4], Irene Dornmair[1,2], and Florian Grüner[1,2] — [1]University of Hamburg, Institute for Experimental Physics, Hamburg 22607, Germany — [2]Center for Free-Electron Laser Science (CFEL), Hamburg 22607, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg 22607, Germany — [4]Warsaw University of Technology, Warsaw 00-665, Poland

Laser driven plasma accelerators are offering high gradient (10-100 GV/m), high quality (low emittance, short bunch length) electron beams, which can be suitable for future compact, bright and tunable light sources. In the framework of the Laboratory for Laser-and beam-driven plasma Acceleration (LAOLA) collaboration at Deutsches Elektronen-Synchrotron (DESY) the external injection experiment for injecting electron bunches from a conventional RF accelerator into a linear plasma wave is in progress. External injection experiments at REGAE (Relativistic Electron gun for Atomic Exploration) require sub-20 to 50 fsec precision synchronization of laser and electron beams in order to perform a beam scan into the plasma wave by varying the delay between electron beam and laser pulses. Here we present current and new optical to microwave femtosecond level synchronization schemes and preliminary results in comparison.

AKBP 4.8 Mo 18:30 F.10.01 (HS 4)

Demonstration of SASE suppression through a seeded microbunching instability — •Christoph Lechner[1], Sven Ackermann[2], Armin Azima[1], Jörn Bödewadt[2], Günter Brenner[2], Martin Dohlus[2], Markus Drescher[1], Nagitha Ekanayake[2], Torsten Golz[2], Kirsten Hacker[3], Katja Honkavaara[2], Shaukat Khan[3], Tim Laarmann[2], Leslie Lamberto Lazzarino[2], Torsten Limberg[2], Theophilos Maltezopoulos[1], Velizar Miltchev[1], Robert Molo[3], Tim Plath[1], Juliane Rönsch-Schulenburg[1], Jörg Rossbach[1], Evgeny Schneidmiller[2], Nikola Stojanovic[2], and Mikhail Yurkov[2] — [1]University of Hamburg, Hamburg — [2]DESY, Hamburg — [3]TU Dortmund University, Dortmund

Collective effects and instabilities due to longitudinal space charge and coherent synchrotron radiation can degrade the quality of the ultra-relativistic, high-brightness electron bunches needed for the operation of free-electron lasers (FELs). In this contribution, we demonstrate the application of a laser-induced microbunching instability to manipulate the electron bunch properties and selectively suppress FEL lasing. A significant decrease of photon pulse energies was observed at the FEL user facility FLASH in coincidence with overlap of 800 nm laser pulses and electron bunches within a modulator located approximately 40 meters upstream of the undulators. We discuss these effects in the framework of longitudinal space charge amplification [E.A. Schneidmiller and M.V. Yurkov, Phys. Rev. ST Accel. Beams 13, 110701 (2010)] and present experimental results.

AKBP 4.9 Mo 18:45 F.10.01 (HS 4)

Optical free-electron lasers on table-top with Traveling-wave Thomson scattering — •Alexander Debus[1], Klaus Steiniger[1,2], Michael Bussmann[1], Richard Pausch[1,2], Tom Cowan[1], Arie Irman[1], Axel Jochmann[1], Roland Sauerbrey[1], and Ulrich Schramm[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden

Optical FELs (OFELs) based on Traveling-wave Thomson scattering (TWTS) optimally exploit the high spectral photon density in high-power laser pulses by spatially stretching the laser pulse and overlapping it with the electrons in a side scattering setup. The introduction of a laser pulse-front tilt provides for interaction lengths appropriate for FEL operation. With careful dispersion control, electrons witness an undulator field of almost constant strength and wavelength over hundreds to thousands of undulator periods, thus giving enough time for self-amplified spontaneous emission (SASE) to seed the FEL instability and the realization of large laser gains.

We provide an overview on the differences between TWTS OFELs, head-on OFEL designs and magnetic undulator FELs. In this dicussion we emphasize the respective impact on transverse coherence, quantum recoil and space-charge.