AKBP 7: Synchrotron Radiation and FELs

Time: Thursday 9:30–12:45 Location: MOL 213

AKBP 7.1 Thu 9:30 MOL 213

Numerical Simulations on the Effect of Broadband Microbunching on the Radiation Spectra of Short Undulators — •Paul Volz and Atoosa Meseck — HZB, Berlin

It is known that microbunched beams emit coherently in spectral ranges shorter than the bunch length when traversing insertion devices. However, the impact of a broadband microbunching on the spectrum of a short undulator has not yet been investigated. The presented work tests these effects numerically using WAVE. The spectra of smooth, Gaussian bunches are compared to bunches with microstructure in energy spread, longitudinal and transversal distribution. Coherent amplification can be observed in the microbunched case.

AKBP 7.2 Thu 9:45 MOL 213

Transverse resonant island buckets and their implementation at BESSY II as a bunch seperation scheme — •Felix Kramer, Paul Goslawski, Andreas Jankowiak, and Markus Ries — Helmholtz-Zentrum Berlin, Berlin, Germany

Electron storage ring operation close to a resonance can be used to generate a second stable island orbit winding around the standard orbit. These orbits can be well separated allowing users to choose their radiation source point from one or the other orbit and provide the possibility to fulfill conflicting user demands simultaneously. At BESSY II resonant island operation at sufficient life time and stability for top up mode has been realized and tested under user operation conditions. Theoretical investigations on transverse resonant island buckets in general and the latest results of the implementation of a resonant island operation mode at BESSY II will be presented.

AKBP 7.3 Thu 10:00 MOL 213

Time-resolved energy spread studies at the ANKA storage ring — •Benjamin Kehrer[1], Edmund Blomley[2], Miriam Brosi[1], Erik Bründermann[2], Nicole Hiller[4], Michael J. Nasse[2], Manuel Schedler[1], Patrik Schönfeldt[2], Marcel Schuh[1], Paul Schütze[3], Markus Schwarz[1], Nigel J. Smale[2], Johannes L. Steinmann[1], and Anke-Susanne Müller[1,2] — [1]LAS, KIT, Karlsruhe, Germany — [2]IBPT, KIT, Karlsruhe, Germany — [3]DESY, Hamburg, Germany — [4]PSI, Villinge, Switzerland

Recently, a new setup for measuring the beam energy spread has been commissioned at the ANKA storage ring at the Karlsruhe Institute of Technology. This setup is based on a fast-gated intensified camera and detects the horizontal profiles of individual bunches in a multi-bunch environment on a single-turn base. As the radiation source point is located in a dispersive section of the storage ring, this allows time-resolved studies of the energy spread. These studies are of particular interest in the framework of short-bunch beam dynamics and the characterization of instabilities. The system is fully synchronized to other beam diagnostics devices allocated in various places along the storage ring, such as the single-shot electro-optical spectral decoding setup or the turn-by-turn terahertz detection systems. Here we discuss the results of the synchronous measurements with the various systems with special emphasis on the energy spread studies.

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AKBP 7.4 Thu 10:15 MOL 213

Ultrashort VUV Synchrotron Radiation Pulses at DELTA — •M. Suski[1], F.H. Bahnsen[1], M. Bolsinger[1], B. Büsing[1], S. Cramm[2], S. Döring[2,3], M. Gehlmann[2,3], F. Götz[1], S. Hilbrich[1], S. Khan[1], M. Jebramcik[1], N.M. Lockman[1], C. Mai[1], A. Meyer auf der Heide[1], R. Niemczyk[1], M. Plötzing[2,3], L. Plucinski[2], B. Riemann[1], G. Shayeganrad[1], P. Ungelenk[1], S. Xiao[3], U. Bovensiepen[3], and C.M. Schneider[2,3] — [1]Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany — [2]Peter Grünberg Institute, PGI-6, FZ-Jülich GmbH, Jülich, Germany — [3]Experimental Physics, University of Duisburg-Essen, Duisburg, Germany

The 1.5-GeV synchrotron light source DELTA, operated by the TU Dortmund University, provides femtosecond pulses in the VUV regime using the coherent harmonic generation (CHG) technique. A laser-induced energy modulation of electrons in a thin slice of the electron bunch is converted into a density modulation corresponding to the laser wavelength, which gives rise to coherent radiation at harmonics of the laser wavelength. Measurements with a single-shot spectrometer based on a gated image-intensified CCD camera were carried out in order to better understand and optimize the CHG radiation. Furthermore, a proof-of-principle pump-probe experiment employing the CHG radiation has been performed.

AKBP 7.5 Thu 10:30 MOL 213

Self-consistently modeling Traveling-Wave Thomson-Scattering Optical Free-Electron Lasers — •Alexander Debus[1], Richard Pausch[1,2], Klaus Steiniger[1,2], Daniel Albach[1], Markus Loeser[1], Ulrich Schramm[1,2], Mathias Siebold[1], and Michael Bussmann[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden

Traveling-Wave Thomson-Scattering (TWTS) provides optical undulators with hundreds to thousands of undulator periods from high-power, pulse-front tilted lasers pulses. These allow to realize optical free-electron lasers (OFELs) with state-of-the-art technology in electron accelerators and laser systems.

TWTS employs a side-scattering geometry where laser and electron propagation direction of motion enclose the interaction angle. Tilting the laser pulse front with respect to the wave front by half the interaction angle ensures continuous overlap over the whole laser pulse width while the electrons cross the laser beam path.

Scaling laws and analytical models allow identifying experimentally promising FEL regimes in feasible setup geometries. However, self-consistently including all non-ideal effects in 3D FEL simulations is desirable for predicting TWTS-OFEL designs with quantitative performance and tolerance characteristics suitable for engineering an optimal proof-of-principle experiment. In this talk we outline the challenges of existing FEL codes that cannot cope with the non-collinear geometry of TWTS-OFELs, show how we solve these using the particle-in-cell code PIConGPU as 3D-FEL code and present first results.

AKBP 7.6 Thu 10:45 MOL 213

Design of Optical Setups for High-Yield Optical Undulators in the Traveling-Wave Thomson-Scattering geometry — •Klaus Steiniger[1,2], Daniel Albach[1], Alexander Debus[1], Markus Loeser[1], Richard Pausch[1,2], Fabian Roeser[1], Ulrich Schramm[1,2], Matthias Siebold[1], and Michael Bussmann[1] — [1]Helmholtz-Zentrum Dresden-Rosendorf, Bautzner Landstraße 400, 01328 Dresden — [2]Technische Universität Dresden, 01062 Dresden

Traveling-Wave Thomson-Scattering (TWTS) can realize ultra-compact, inherently synchronized and highly brilliant light sources from the ultraviolet to the hard X-ray range. In TWTS ultrashort laser pulses and relativistic electron bunches are utilized in a side-scattering geometry where their directions of motion enclose an interaction angle. By tilting the laser pulse-front TWTS ensures continuous overlap of laser and electrons while these traverse the laser cross-sectional area. This enables interaction over hundreds to thousands of optical undulator periods, enough to allow for optical free-electron laser (OFEL) operation. After shortly introducing the TWTS geometry, the design of optical setups to form laser pulses for TWTS is presented in the talk. This setup strategy provides laser dispersion compensation during interaction, required due to angular dispersion of the laser pulse, which is especially relevant when building compact, high-yield hard X-ray TWTS sources in large interaction angle setups. Determining parameters of TWTS setups is illustrated in examples of an ultraviolet TWTS OFEL and a hard X-ray TWTS sources.

15 min. break

AKBP 7.7 Thu 11:15 MOL 213

Diagnostics of laser-induced THz radiation at DELTA — •Carsten Mai[1], Fin Hendrik Bahnsen[1], Max Bolsinger[1], Benedikt Büsing[1], Fabian Götz[1], Svenja Hilbrich[1], Shaukat Khan[1], Marc Andre Jebramcik[1,2], Nils Maris Lockmann[1], Arne Meyer auf der Heide[1], Raffael Niemczyk[1], Bernard Riemann[1], Gholamreza Shayeganrad[1], Mateusz Suski[1], Peter Ungelenk[1], and Dennis Zimmermann[1] — [1]Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany

— [2]now at: CERN, Geneva, Switzerland

Coherent ultrashort THz pulses induced by a laser-electron interaction are routinely produced and observed at DELTA, a 1.5-GeV synchrotron light source operated by the TU Dortmund University. In the past, spectral measurements of the radiation were limited to the frequency range above 1 THz. Recently, first spectra were measured using a newly built polarizing Fourier-transform spectrometer which also covers the sub-THz regime. Studies of the temporal evolution of the spectrum during several revolutions of the energy-modulated electrons are presented. Furthermore, a setup currently being commissioned for electro-optical measurements of the THz field is discussed.

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AKBP 7.8 Thu 11:30 MOL 213

Studies of the micro-bunching instability in multi-bunch operation at the ANKA storage ring — •Miriam Brosi[1], Edmund Blomley[2], Erik Bründermann[2], Michele Caselle[3], Benjamin Kehrer[1], Andreas Kopmann[3], Florian Rämisch[1], Lorenzo Rota[3], Manuel Schedler[2], Patrik Schönfeldt[2], Marcel Schuh[1], Markus Schwarz[1], Johannes L. Steinmann[1], Marc Weber[3], and Anke-Susanne Müller[1,2] — [1]LAS, KIT, Karlsruhe — [2]IBPT, KIT, Karlsruhe — [3]IPE, KIT, Karlsruhe

The test facility and synchrotron light source ANKA at the Karlsruhe Institute of Technology (KIT) operates in the energy range from 0.5 to 2.5 GeV and can generate brilliant coherent synchrotron radiation in the THz range employing a dedicated bunch length-reducing optic at 1.3 GeV beam energy. The high degree of spatial compression leads to complex longitudinal dynamics and to time evolving sub-structures in the longitudinal phase space of the electron bunches. The results of the micro-bunching instability are time-dependent fluctuations and strong bursts in the radiated THz power. To study these fluctuations in the emitted THz radiation simultaneously for each individual bunch in a multi-bunch environment, fast THz detectors are combined with KAPTURE, the dedicated Karlsruhe Pulstaking and Ultrafast Readout Electronics system, developed at KIT. In this contribution we present measurements conducted to study possible multi-bunch effects on the characteristic bursting behavior of the micro-bunch instability.

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AKBP 7.9 Thu 11:45 MOL 213

Comprehensive Analysis of Micro-Structure Dynamics in Longitudinal Profiles — •Tobias Boltz, Miriam Brosi, Erik Bründermann, Florian Rämisch, Patrik Schönfeldt, Markus Schwarz, Minjie Yan, and Anke-Susanne Müller — KIT, Karlsruhe, Germany

Operating with short electron bunches at Synchrotron Light Sources can induce micro-structures inside the bunches, which intensify the emission of Coherent Synchrotron Radiation (CSR) in the wavelength range comparable to the size of the micro-structures. Dynamic variations of these micro-structures, however, lead to fluctuations in the intensity of the emitted CSR. Such phenomena have been observed at various facilities including ANKA, KIT. Using the in-house developed simulation code, Inovesa, the dynamics of the micro-structures in the longitudinal profiles have been investigated with the help of machine learning techniques. In this contribution we present possible categorization of these micro-structures and their correlations to the CSR intensity.

AKBP 7.10 Thu 12:00 MOL 213

Progress of the EEHG upgrade at the DELTA short-pulse source — •Benedikt Büsing[1], Fin Hendrik Bahnsen[1], Max Bolsinger[1], Fabian Götz[1], Svenja Hilbrich[1], Shaukat Khan[1], Marc Jebramcik[1,2], Nils Lockman[1], Carsten Mai[1], Arne Meyer auf der Heide[1], Raffael Niemczyk[1], Bernard Riemann[1], Eric Schneider[1], Gholamreza Shayeganrad[1], Mateusz Suski[1], Peter Ungelenk[1], and Dennis Zimmermann[1] — [1]Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany — [2]now at: CERN, Geneva, Switzerland

At DELTA, a 1.5-GeV synchrotron light source operated by the TU Dortmund University, a short-pulse source based on coherent harmonic generation (CHG) is used to generate sub-picosecond synchrotron radiation pulses in the VUV regime, which result from micro-bunching at the center of an electron bunch due to laser-electron interaction. Shorter wavelengths are achievable with the so-called echo-enabled harmonic generation (EEHG) technique by adding a second laser-electron interaction. The current short-pulse source will be modified to include the EEHG scheme. The status of the upgrade project will be presented.

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AKBP 7.11 Thu 12:15 MOL 213

Investigation of the laser-plasma interaction with the method of small- angle x-ray scattering (SAXS) at an XFEL — •Melanie Rödel[1], Alexander Pelka[1], Thomas Kluge[1], Alejandro Laso Garcia[1], Emma McBride[2], Christian Rödel[2], Irene Prencipe[1], Nicholas Hartley[1], Dominik Kraus[1], Christian Gutt[3], Ulrich Schramm[1], and Thomas Cowan[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]SLAC National Laboratory, Stanford, USA — [3]Universität Siegen, Siegen, Germany

The combination of ultra-intense lasers with x-ray free-electron lasers (XFELs) opens up a variety of applications in plasma and shock physics. Many phenomena during the laser-target interaction happen on short time scales in the range from femto- to picoseconds and length scales of tens of nanometers to a few micrometers. Unlike the ultra-short, highly coherent x-ray pulse, optical methods or conventional continuous x-ray sources cannot probe the dynamics of the bulk material with sufficient temporal and spatial resolution. Here we will show the potential of SAXS in combination with short-pulse laser experiments. With this method it is possible to draw conclusions about the electron density distribution in the target by analyzing the XFEL diffraction pattern in the vicinity of the direct beam. A setup to perform such SAXS experiments was developed and optimized during a beamtime at the Matter in Extreme Conditions instrument (MEC) at the Linear Coherent Light Source (LCLS) in Stanford. We will discuss the setup and present a preliminary analysis of the data obtained during this experiment.

AKBP 7.12 Thu 12:30 MOL 213

Predicting SAXS images beyond single scattering — •Marco Garten — HZDR, Dresden, Deutschland — TU Dresden, Dresden, Deutschland

Laser-generated solid density plasmas can be used to produce highly energetic electrons and ions. Diagnosing properties within those plasmas at nm length scales and down to fs time scales plays a crucial role in understanding the involved processes. This has only recently become feasible through the advent of X-Ray Free Electron Lasers (XFELs). XFELs now make experimental techniques like Small Angle X-Ray Scattering (SAXS) applicable to solid density plasmas.

We present a scalable GPU-based software framework for simulating photon scattering processes of X-ray beams in matter using Monte-Carlo methods. These simulations enable us to produce synthetic SAXS signals from the interaction of a modeled X-ray pulse with an arbitrarily complex, 3D electron density distribution obtained e.g. from detailed particle-in-cell simulations. Our new framework allows for single and multiple scattering and is extendable to include complex physics processes like ionization, atomic excitation and de-excitation to further enhance its predictive capability.