# HK 34: Beschleunigerphysik XII

Convenor: Wolfgang Hillert

Zeit: Dienstag 16:45–19:05 Raum: HG ÜR 9

**Gruppenbericht** HK 34.1 Di 16:45 HG ÜR 9

**Overview of the Munich project for laser-driven X-ray sources** — •Florian Grüner — Am Coulombwall 1, 85748 Garching, Ludwig-Maximilians-Universität München

In the last years great progress has been achieved within the field of laser-plasma accelerators. Energies on the GeV-scale are reached as well as substantial improvements in stability demonstrated. Our group focuses on applications of such laser-driven electron beams and follows two major paths: the near-future goal is the realization of first x-ray pump-probe experiments that exploit the ultra-short electron-bunch length of few femtoseconds only and the ultimate long-term project is a table-top Free-Electron Laser (FEL). Both goals rely on active control of the electron beam transport. We have started developments of miniature quadrupole lenses and show their impact on laser-driven soft X-ray undulator radiation. On the theoretical side our group contributed work on space-charge induced energy chirps. This talk gives an overview of all activities of the Munich group in the new field of laser-driven X-ray sources.

HK 34.2 Di 17:05 HG ÜR 9

**Laser-driven soft-X-ray undulator source** — •Matthias Fuchs[1,2], Raphael Weingartner[1,2], Antonia Popp[1], Zsuzsanna Major[1,2], Stefan Becker[2], Jens Osterhoff[1,2], Isabella Cortrie[2], Benno Zeitler[1,2], Rainer Hörlein[1,2], George D. Tsakiris[1], Ulrich Schramm[3], Tom P. Rowlands-Rees[4], Simon M. Hooker[4], Dietrich Habs[1,2], Ferenc Krausz[1,2], Stefan Karsch[1,2], and Florian Grüner[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Ludwig-Maximilians-Universität, Garching, Germany — [3]Forschungszentrum Dresden-Rossendorf, Germany — [4]University of Oxford, U.K.

Latest developments of laser-wakefield accelerators (LWFA) have led to relatively stable electron beams from cm-scale interaction lengths. These beams are supposed to have ultrashort bunch durations and low normalized transverse emittances, which makes them perfectly suited for driving high-brightness undulator-based X-ray sources on a laboratory scale. We will present an experimental breakthrough: our laser-driven soft-X-ray undulator source. We were able to detect spectrally resolved undulator radiation with a fundamental at 18 nm in 70% of consecutive driver-laser shots, which is a remarkably high reproducibility for an LWFA experiment. This was achieved mainly due to the stable electron beam and our miniature magnetic quadrupole lenses which markedly reduce the divergence and the angular shot-to-shot fluctuations of the electron beam. The lenses act as an effective band-pass filter for the undulator radiation and so decrease the shot-to-shot variation as well as let us tune the wavelength of the radiation.

HK 34.3 Di 17:20 HG ÜR 9

**Space-Charge and Wakefield Effects in a Laser-Plasma Driven Free-Electron Laser** — •Andreas R. Maier[1,4], Atoosa Meseck[2], Sven Reiche[3], and Florian Grüner[1,4] — [1]Ludwig-Maximilians Universität, München — [2]BESSY, Berlin — [3]PSI, Villingen — [4]Max-Planck Institut für Quantenoptik, Garching

Rapid progress in laser-plasma electron accelerators has led to the generation of stable electron beams at the GeV-scale. Recently these beams have been used to generate spontaneous undulator radiation in the soft X-ray range. The unique properties of laser-accelerated electron beams suggest to further extend the concept to a laboratory-size Free-Electron Laser (FEL). A significant reduction in size is expected due to high peak currents on the order of 10 kA. We discuss degrading effects typical for this extreme parameter regime, such as space-charge and resistive wall wakefield induced energy chirps and present possible solutions.

HK 34.4 Di 17:35 HG ÜR 9

**Design Concepts for a Table-Top, bright X-Ray Source based on nonlinear Thomson Backscattering** — •Johannes Wenz, Konstantin Khrennikov, Matthias Heigoldt, Shao-Wei Chou, Antonia Popp, Raphael Weingartner, Matthias Fuchs, Zsuzsanna Major, Florian Grüner, Ferenc Krausz, and Stefan Karsch — Max-Planck Institut für Quantenoptik, Garching, Germany

Recent progress in laser-plasma accelerators has led to improved stability in energy and pointing of laser-driven electron beams. Utilizing these electrons and high power laser systems it is feasible to produce bright X-Ray sources by Thomson backscattering. Such a pulsed light source promises to deliver $> 10^6$ photons, in a pulse duration of $< 10fs$ in the $50-100keV$ energy range. These unique properties are desirable for ultrashort time-resolved X-Ray spectroscopy and medical application.

We present the expected X-Ray source parameters, applying analytical theory. Improvements of the monochromacity by using a temporal shaped laser pulse could result in peak brilliances exceeding the ones of large scale synchrotron radiation sources of $10^{23}$ (photons/sec./mrad$^2$/mm$^2$/0.1% bandw.) Possible implementations are discussed and a first concept of an all-optical setup is presented.

HK 34.5 Di 17:50 HG ÜR 9

**Temporal characterization of laser plasma accelerated electron bunches by CTR** — •Matthias Heigoldt[1], Antonia Popp[1], Svetoslav Bajlekov[2], Johannes Wenz[1], Konstantin Krenikov[1], Shao-Wei Chou[1], Raphael Weingartner[1], Simon Hooker[2], Ferenc Krausz[1], and Stefan Karsch[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Claredon Laboratory, Univeristy of Oxford, Oxford, UK

Laser driven plasma accelerators offer the prospect of a new source of relativistic electron beams. One of the key parameters to be determined is the temporal profile of the electron bunch. Available experimental data show bunch lengths <30fs, however, best estimates still rely on particle-in-cell simulations predicting durations of ~10fs.

We report on progress towards measuring the temporal profile of electron bunches from a laser-wakefield accelerator, based on the detection of coherent THZ radiation emitted at a metal-vacuum boundary. The construction of a broadband (2–40$\mu m$) spectrometer based on pyroelectric detectors as well as a numerical assessment of its capabilities will be presented.

HK 34.6 Di 18:05 HG ÜR 9

**Terahertz Radiation Production and Terahertz Imaging at Chiang Mai University** — •Jatuporn Saisut[1,2], Vitoon Jinamool[1], Noppadon Kangrang[1], Keerati Kusoljariyakul[1], Prissana Tamboon[3], Pathom Wichaisirimongkol[3], Michael W. Rhodes[3], and Chitrlada Thongbai[1] — [1]Department of Physics and Materials Science, Chiang Mai University, Chiang Mai 50200, Thailand — [2]DESY,15738 Zeuthen, Germany — [3]STIR, Chiang Mai University, Chiang Mai 50200, Thailand

Femtosecond electron bunches can be generated from a system consisting of an RF gun with a thermionic cathode, an alpha magnet as a magnetic bunch compressor, and a linear accelerator as a post acceleration section. These short electron pulses can be used to produce high intensity terahertz (THz) radiation. The THz radiation is generated in the form of transition radiation by placing an aluminum foil (Al-foil) in the electron path, representing a transition between vacuum and Al-foil.

In THz imaging system (transmission measurement), THz radiation is focused on a sample which will be scanned using an xy- translation stage controlled by computer. The transmission intensity (IT) will be detected by a room-temperature pyroelectric detector. Computer program is employed to calculate and analyze the intensity at difference points on the sample for terahertz image construction.

The generation of femtosecond electron bunches, the generation of THz radiation, THz imaging system and the recent experimental results will be presented and discussed

HK 34.7 Di 18:20 HG ÜR 9

**Untersuchung kohärenter Synchrotronstrahlung mit Hot Electron Bolometer** — •Vitali Judin[1], Miriam Fitterer[1], Steffen Hillenbrand[1], Nicole Hiller[1], André Hofmann[1], Marit Klein[1], Sebastian Marsching[1], Anka-Susanne Müller[1], Nigel Smale[1], Kiran Sonnad[1] und Pedro Tavares[1,2] — [1]KIT - Karlsruher Institut für Technologie, Karlsruhe, Deutschland — [2]ABTLuS - The Brazilian Association for Synchrotron Light Technology, Campinas, Barzil (on leave)

Die kohärente Synchrotronstrahlung an der Synchrotronstrahlungsquelle ANKA lässt sich mit dem Hot Electron Bolometer (HEB, schneller Detektor für THz-Strahlung) detektieren und untersuchen. Durch die sehr hohe zeitliche Auflösung des Detektors kann man die Signale der einzelnen THz-Pulse, die von den Elektronenpaketen ausgesandt werden, aufnehmen. Dies kann man für die Strahldiagnose ausnutzen. Beispielsweise kann man mit diesem System mit einer einzigen Aufnahme das THz-Signal von Elektronenpaketen mit unterschiedlichen Strömen aufzeichnen und auswerten. Dieser Vortrag gibt einen Überblick über verschiedene mit System durchgeführte Studien.

HK 34.8 Di 18:35 HG ÜR 9

**Ein Bunch Kompressor für TBONE** — •Steffen Hillenbrand, Miriam Fitterer, Nicole Hiller, Marit Klein, Kiran Sonnad, Vitali Judin, Sebastian Marsching, Andre Hofmann, Müller Anke-Susanne und Huttel Erhard — Karlsruhe Institut für Technologie (KIT)

Am Karlsruher Institut für Technologie (KIT) wird eine neue Synchrotronstahlungsquelle für den Bereich von THz bis zum mittleren Infrarot konzipiert. Der TBONE genannte Beschleuniger beruht auf einem Linearbeschleuniger mit anschließendem Bunch-Kompressor. Im folgenden Strahltransportsystem wird die Synchrotronstahlung als Kantenstrahlung erzeugt. Dieser Vortrag stellt das vorläufige Design der Anlage vor und gibt einen kurzen Überblick über die zum Bunch-Kompressor durchgeführten Simulationen.

HK 34.9 Di 18:50 HG ÜR 9

**Recent progress at the Petawatt Field Synthesizer** — •Christoph Skrobol[1,2], Sandro Klingebiel[1], Christoph Wandt[1], Izhar Ahmad[1], Mathias Siebold[1], Sergei A. Trushin[1], Zsuzsanna Major[1,2], Ferenc Krausz[1,2], and Stefan Karsch[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [2]Department für Physik, Ludwig-Maximilians-Universität München, Am Coulombwall 1, D-85748 Garching, Germany

The Petawatt Field Synthesizer (PFS) aims at delivering wave-form controlled, few-cycle laser pulses with petawatt-scale peak power. The PFS design is based on a modified scheme of optical parametric chirped pulse amplification (OPCPA), where short pulses (of the order of 1 ps) are used for both pumping and seeding. The broadband seed pulses (700-1400 nm) are amplified in a series of DKDP crystals, pumped by 515 nm pulses with a total energy of 15-20 J at a repetition rate of 10 Hz. The chirped pulse amplifier chain of the pump laser uses diode pumping and Yb:YAG as the gain material in order to support the 1 ps pulse duration. To ensure a high level of synchronization between pump and seed pulses ($< 100$ fs), both are derived from a common frontend and are thereby inherently optically synchronized. However, along the large optical path difference between the seed and the pump chain additional temporal jitter can be accumulated, which is detrimental to the short-pulse OPCPA scheme. After an introduction to the PFS system, we report on our recent progress in identifying and eliminating the sources of timing jitter in preparation for the OPCPA stages.