P 10: Laser Plasmas I

Time: Tuesday 14:00–16:00 Location: KI 1.174

Invited Talk P 10.1 Tue 14:00 KI 1.174

Self-consistent theory of radiation friction losses in ultraintense laser-plasma interaction — •Tatyana Liseykina[1,2], Sergey Popruzhenko[3,4], and Andrea Macchi[5,6] — [1]Institut für Physik, Universität Rostock, Germany — [2]Institute of Computational Technologies, SD RAS, Novosibirsk, Russia — [3]Max-Planck-Institut für Physik komplexer Systeme, Dresden — [4]National Research Nuclear University, Moscow Engineering Physics Institute, Russia — [5]CNR, National Institute of Optics, Pisa, Italy — [6]Department of Physics, University of Pisa, Italy

In the interaction of laser pulses of extreme intensity with high-density, thick plasma targets, collective effects lead to very strong radiation friction losses. We present a classical model for this regime, based on the Zel'dovich solution [1] for the electron motion in the presence of a steady electric field. This improves our previous modeling [2] by making the radiation losses self-consistent with the electron dynamics. The model predicts that in the present context the classical regime of radiation friction is applicable up to intensities still beyond the capabilities of next generation facilities.

[1] Zel'dovich Ya B., Sov. Phys. Usp. 18 79-98 (1975)
[2] Liseykina T., Popruzhenko S., Macchi A., NJP 18, 072001 (2016)

P 10.2 Tue 14:30 KI 1.174

Calorimetry techniques for ultra-intense laser-plasma experiments — •Maria Molodtsova[1,2], Anna Ferrari[1], Alejandro Laso Garcia[1], Arie Irman[1], Benjamin Lutz[1,2], Josefine Metzkes-Ng[1], Irene Prencipe[1], Manfred Sobiella[1], Daniel Stach[1], David Weinberger[1,2], and Thomas Cowan[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Technische Universität Dresden, Germany

With ultra-high intensity short-pulse lasers generating plasma, new extreme states of matter can be created, and new concepts for particle acceleration, material science, and fusion energy can be explored. A critical component is the characterization of relativistic electrons that are accelerated and transported in the material of the target, generating ultra-intense bremsstrahlung.

Measuring the bremsstrahlung spectrum is a crucial aspect of plasma diagnostics. In this work it is showed how calorimetric techniques, based on longitudinally resolved measurements of energy deposition, are especially suitable for the reconstruction of the photon spectra.

Multi-layered scintillator calorimeters with different readouts are under development at Helmholtz-Zentrum Dresden-Rossendorf for this purpose. Prototypes have been tested at the ELBE facility both at the γELBE beamline with a well-known bremsstrahlung spectrum and in a laser-plasma environment at DRACO.

P 10.3 Tue 14:45 KI 1.174

Electron acceleration mechanisms in ultrashort pulse-plasma-interactions — •Florian Kleeschulte, Bastian Hagmeister, Dirk Hemmers, and Georg Pretzler — Heinrich-Heine-Universität Düsseldorf

When ultrashort, intense laser pulses interact with solid surfaces, intense electron pulses are ejected into the vacuum and obtain substantial kinetic energies. In this contribution, we present a thorough analysis of the different mechanisms acting together to accelerate electrons to energies almost two orders of magnitude higher than the ponderomotive potential (U_P). In the presented experiments, we have managed to reach kinetic energies above 400 keV with an U_P of only 7.4 keV when using aluminum as a solid density target. These results were reproduced by numerical simulations, which allowed a detailed investigation of the underlying effects. We show that ponderomotive heating, elastic scattering inside the target, and post-acceleration in the space-charge fields act together for generating the unexpectedly high electron energies.

P 10.4 Tue 15:00 KI 1.174

Super-intense single attosecond pulse generation from plasma self-generated gate — •Suo Tang, Naveen Kumar, and Christoph h. Keitel — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69126, Heidelberg, Germany

We present the generation of an isolated super-intense pulse with extremely short duration (< 20 as) in the interaction of solid with ultra-relativistic laser. The generated pulse is characterized with stable phase $\psi = \pm\pi/2$ at the pulse center and slowly decaying exponential spectrum transiting from ROW scaling to CSE scaling. Hole boring effect, as a robust plasma self-generated gate [1], isolates the most efficient pulse emission at the beginning of ion motion by producing an ultra-broadband coherent spectrum. Collision effects also contribute to the attosecond pulse isolation by affecting the intensity of the generated harmonics. Radiation reaction force reduces the phase fluctuation in high frequency components and thus can also affect the intensity of the emitted attosecond pulse.

[1] S. Tang, N. Kumar, and C. H. Keitel, Phys. Rev. E **95**, 051201 (2017)

P 10.5 Tue 15:15 KI 1.174

Plasma Diagnostics with sub-15-fs time resolution via pump-probe experiments — •Michael Stumpf, Christian Greb, Julian Wegner, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

We present a novel experimental setup using a pump-probe technique for observing the expansion of a laser-produced plasma in its early stage. Therefore, the probe beam is reflected at the evolving plasma and then imaged onto the detector by an achromatic lens. The generated phase shift is measured with a Mach-Zehnder interferometer and evaluated using Fourier Transformation. The whole apparatus has exceptional resolution in time (sub-15-fs), space (2 μm) and phase (0.3 rad). As an example, we present an experiment in which the plasma was generated by a laser pulse (pulse-duration 9 fs, maximum intensity $2.4{\cdot}10^{17}$ W/cm^2) focused onto an aluminum mirror. The probe beam was then reflected off the expanding plasma with various delays. To calculate the phase shift, the data from reflection on the plasma is compared with a clean reflection on the metallic mirror. The results illustrate the early-stage plasma expansion with unprecedented temporal resolution.

P 10.6 Tue 15:30 KI 1.174

Seeded Self-Modulationalong the Proton Bunch at AWAKE — •Fabian Batsch[1,2,3], Karl Rieger[2,3], Joshua Moody[2], Edda Gschwendtner[1], and Patric Muggli[1,2] — [1]CERN, Genva, Switzerland — [2]Max-Planck-Institut für Physik, München, Deutschland — [3]Technische Universität München

The AWAKE experiment uses the seeded self-modulation (SSM) to drive large amplitude wakefields in a plasma. The seed for the wakefields is a sharp ionizing front located near the middle of the proton bunch. It is created by an intense laser pulse ionizing Rubidium (Rb). For electron acceleration, the electron bunch must be injected into the accelerating and focusing phase of the wakefields, approximately 100 plasma periods behind the seed laser position. Here, we show that by using a replica of the intense laser pulse we can determine precisely the position (timing) of the proton micro-bunches with respect to the ionizing laser pulse. Since the relative phase of the wakefields is tied to the proton micro-bunches, this method can be used to determine experimentally the delay between the ionizing laser pulse and the proton bunch so that the electrons can be injected into the accelerating and focusing phase of the wakefields. The results presented also show that the timing of the micro-bunches is stable against variations of the proton input parameters. They show as well the difference between seeded and unseeded self- modulation.

P 10.7 Tue 15:45 KI 1.174

Laser-based Diagnostics of Plasma Wakefields in AWAKE — •Anna-Maria Bachmann[1], Patric Muggli[2], and Valentin Fedosseev[1] — [1]CERN, Geneva, Switzerland — [2]Max-Planck Institute for Physics, Munich, Germany

The Advanced Wakefield Experiment AWAKE aims on developing a new plasma wakefield accelerator using a high energy proton beam as a driver. The 400 GeV proton bunch from CERN SPS propagates through a 10 m long rubidium plasma, created by an ionizing 4 TW laser pulse. The relativistic ionization front seeds the self-modulation process. The seeded self-modulation (SSM) transforms the bunch in a train of bunchlets driving wakefields in the plasma. Electrons will be injected and accelerated in the wakefields. AWAKE relies on the micro bunching of the long proton bunch. The modulation of the proton bunch also corresponds to a modulation of the electron plasma density. So far, there are no plasma diagnostics installed in AWAKE. We therefore investigate the possibility of measuring spectral modulation of a CW laser beam propagating perpendicularly to the wakefields to determine some of the wakefields characteristics. Wakefields period information will appear in the position of satellites in the spectrum of transmitted laser light, whereas wakefields amplitude information will be in the satellites intensity.