P 11: Laser plasma and laser applications 1

Time: Wednesday 11:00–13:00 Location: b302

Invited Talk P 11.1 Wed 11:00 b302

Visualizing the Dynamics of a Plasma-Based Particle Accelerator — •Malte Kaluza — Institut für Optik und Quantenelektronik, Max-Wien-Platz 1, 07743 Jena — Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena

Relativistic plasmas generated by high-power laser pulses are a potential candidate for future compact electron accelerators. In a plasma-electron accelerator, the driving laser pulse generates a high-amplitude plasma wave forming the electric field structure (the "wakefield") which can trap and accelerate electrons to several GeV energies over distances of a few centimeters only. The properties of the generated electron pulses (spectrum, pulse duration, lateral dimensions) strongly depend on the parameters and the evolution of this accelerating structure. Therefore, a complete understanding of the physical phenomena underlying the acceleration process is mandatory to improve the controllability of the electron pulses, which will determine their potential applicability in the future.

This presentation will give a short introduction to laser wakefield accelerators, discuss transverse optical probing as a diagnostic tool [1, 2] and present experimental results on the characterization and evolution of the electron pulses [3] and of the plasma wave [4,5].

[1] M. B. Schwab et al., Applied Physics Letters 103, 191118 (2013) [2] M. C. Downer et al., Reviews of Modern Physics 90, 035002 (2018) [3] A. Buck et al., Nature Physics 7, 543 (2011) [4] A. Sävert et al., Physical Review Letters 115, 055002 (2015) [5] E. Siminos et al., Plasma Physics and Controlled Fusion 58, 065004 (2016)

P 11.2 Wed 11:30 b302

Imaging of low-electron-density plasma using short-wave Infrared (SWIR) and mid-infrared (MIR) pulses — •Yinyu Zhang[1,2], Mingzhuo Li[2], Matthias Kübel-Schwarz[1,2], Carola Zepter[1,2], Yu Zhao[1,2], Alexander Sävert[1,2], Malte C. Kaluza[1,2], and Gerhard G. Paulus[1,2] — [1]Helmholtz Insitute, Jena, Germany — [2]Institute of Optics and Quantum Electronics, Jena, Germany

Laser-driven plasma-based accelerators (LPA) are of great interest as they are able to efficiently accelerate charged particles to hundreds of MeV, or even to the multi-GeV energy range [1, 2] on a table-top scale. For a LPA, a low electron density is preferred as it allows for a longer acceleration distance and thus higher particle energies [3]. However, the diagnostic of the plasma using transverse shadowgraphy becomes challenging because the refractive index variation for the imaging decreases due to the low electron density. In order to increase the contrast of plasma shadowgraphs, the wavelength of the probe pulses should be increased. Here, we present the imaging of low electron density plasmas at 1.8 μm and 3.6 μm. [1] E. Esarey, et. al., Rev. Mod. Phys. 81 (2009) [2] S. M. Hooker, et. al., Nat. Phy. 7 (2013) [3] W. Lu, et. al., Phys. Rev. ST Accel. Beams 10 (2007).

P 11.3 Wed 11:45 b302

Laser Harmonic Generation on a Plasma Blister on the Surface of a Solid — •Bastian Hagmeister and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

The interaction of an intense femtosecond laser pulse (10^{17} W/cm^2) with solids is well understood but there are still new effects to explore. The nonlinear process of harmonic generation depends strongly on the conditions of the pre-plasma and the laser pulse contrast. Typically, the pedestal of an intense laser pulse disturbs this process, however, in some cases it transforms the setting.
In the following, we show that harmonics can be generated on the surface of a plasma blister with high efficiency. This plasma blister is generated by the amplified spontaneous emission (ASE) accompanying the laser pulse. The ASE hits the surface of the solid a few nanoseconds before the laser pulse and generates the plasma blister. By adjusting the delay between the laser pulse and the ASE, the blister size can be modified. Due to this expansion, the harmonics, which arise on the blister surface, have a different direction from harmonics generated on the target surface.

P 11.4 Wed 12:00 b302

Ion Spectroscopy of Single-Digit-fs Laser Pulse Plasmas with respect to different Laser Parameters — •Jan Riedlinger, Bastian Hagmeister, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

The exposure of solids to high intensity sub-10-fs laser pulses creates an extremely transient high temperature plasma, of which many properties are not fully predictable today, in contrast to plasmas created with longer laser pulses. One example is the achieved ionization state as well as the energy distribution of the emitted ions. We performed measurements to characterise the ion emission of such plasmas. We present here experimental results for a set of varied laser parameters, such as intensity, pulse energy and duration as well as different solids as target materials, to attain a better understanding of plasma formation and the subsequent dynamics. Most of all, the peak intensity has been examined over multiple orders of magnitude by means of our new attenuator up to maximum values of 10^{18} W/cm^2 at the shortest pulse durations of about 8 fs.

P 11.5 Wed 12:15 b302

Multi-Parameter-Controlled Laser Ionization of Gases in the Tunnel Ionization Regime — •Michael Stumpf and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Within the scope of developing a Plasma Photocathode for Wakefield Acceleration of electrons we present a novel optical setup to ionize gases with controlled and modifiable ionization volume, number of electrons and initial energy. The reflection-based setup, called AMBER (Axicon Mirror Beam ExpandeR), allows the implementation into a fs-laser beamline without disturbing the spectral phase of the laser pulse. By changing the beam profile, pulse duration and pulse energy of the laser a desired ionization volume and state can be achieved. The dedicated simulations with different ionization models are in good agreement with the gained experimental results which allows a precise prediction of laser-gas interactions. The setup will be used to realize the Trojan Horse Injection model at the FLASHForward facility at DESY in Hamburg.

P 11.6 Wed 12:30 b302

Pump-probe experiments with 10 fs resolution for revealing the early phase of laser plasma evolution — •Maximilian Münzberg, Michael Stumpf, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

We present the results of an experiment in which the onset of plasma expansion has been investigated. Ultrashort laser-pulses (8 fs) with intensities of $2 \cdot 10^{17}$ W/cm^2 are focused onto flat metallic surfaces. A synchronized ultrashort probe beam was reflected at the developing plasma at various delays with a time resolution close to 10 fs. The wave front deformation of the probe pulse was investigated by a Mach-Zehnder interferometer. In total, we determined the temporal evolution of the electron distribution at the solid-vacuum interface. We present the results for different target geometries, e.g. a bulk metal target and target with surface layers and discuss them together with PIC simulations, which show and explain a high dependence in the early expansion stage of the surface structure of the different targets.

P 11.7 Wed 12:45 b302

Wigner crystals in bunches with finite emittance in the bubble regime — •Lars Reichwein, Johannes Thomas, and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Düsseldorf

The influence of non-zero emittance onto the spatial structure of an equilibrium electron bunch in a quasi-static bubble model is studied. The full Liénard-Wiechert potentials are used to calculate the relativistic inter-particle interaction while the external force is described in the context of a simplified bubble model [1]. We introduce transverse momenta as a perturbation approach of the previous zero-emittance model [2]. For low emittances the crystalline structure of the bunch is preserved, while for higher emittances the observed symmetry is broken. In the region of this phase transition a widening of the structure and formation of various shells can be observed. These structural changes resemble those of the zero-emittance model when the parameters momentum, plasma wavelength and total particle number were varied.

[1] I. Kostyukov et al., Phys. Plasmas 11, 5256 (2004)
[2] L. Reichwein et al., arXiv:1903.04858 (2019)