P 21: Laser Plasmas - Poster

Time: Wednesday 16:15–18:15 Location: Zelt West

P 21.1 Wed 16:15 Zelt West

The Hosing Instability in AWAKE — •Mathias Hüther[1,2], Allen Caldwell[1,2], and Patric Muggli[1,3] — [1]Max-Planck-Institut für Physik, München — [2]Technische Universität München — [3]CERN, Genf, Schweiz

AWAKE (Advanced Wakefield Experiment) is located at CERN. It is world's first proton-driven plasma wakefield accelerator. It aims for acceleration of externally injected electrons in gradients up to the GeV/m scale. It uses a 12 cm long proton bunch from the CERN Super Proton Synchotron (SPS) that propagates through a 10 m long Rubidium plasma channel (with a particle density of 1-10 $\cdot 10^{14}$ cm^{-3}), induced by a high-power short laser pulse (pulse duration τ = 120 fs, pulse energy E = 450 mJ).

The process of Seeded-Self Modulation (SSM) results in the break-up of the long proton bunch into a train of micro-bunches separated by a distance on the order of the plasma wavelength by the Self-Modulation Instability (SMI), a transverse plasma instability. The SMI growth is mainly competing with the Hosing-Instability (HI). Under certain conditions this can lead to unstable SMI growth process and eventually to no development or even a destruction of the micro-bunch structures.

In this talk, we give a short introduction to SSM, SMI and HI-processes. Furthermore, we discuss conditions for a growth of the HI as well as possibilities for its suppression.

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Studying filament instabilities in laser irradiated hydrogen targets by preplasma scanning: a PIC code approach — •João Branco[1,2], Karl Zeil[1], Lieselotte Obst[1,2], Ulrich Schramm[1,2], Thomas Kluge[1], and Michael Bussmann[1] — [1]HZDR, Dresden, Deutschland — [2]TU Dresden, Dresden, Deutschland

We present simulation results on laser ion acceleration using hydrogen targets irradiated by ultra-intense, ultra-short laser pulses. These targets promise to produce pure proton beams that could be used for cancer therapy at high repetition rates. We address critical issues concerning the acceleration process that potentially hinders the application of these beams in clinical scenarios.

For achieving proton energies suitable for the treatment of deep seated tumors it is important to increase the laser intensity. At high intensities, plasma instabilities both at the target surfaces and bulk can create electron filaments that in turn result in non-uniform proton beams, detrimental for delivering spatially uniform dose distributions.

By varying the laser contrast it becomes possible to change the preplasma scale length to influence the formation of instabilities. Other means of controlling proton beam properties are, for example, variations in terms of target geometry or laser polarization. We present results of 2D3V particle-in-cell simulations at realistic density conditions that study the influence of these effects on the plasma dynamics and final beam properties and discuss their relevance regarding future applications of solid hydrogen targets for laser-driven proton tumor therapy.

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The influence of the CEP on the electrons emitted from a laser plasma created on a solid surface — •Florian Kleeschulte, Maximilian Münzberg, and Georg Pretzler — Heinrich-Heine-Universität Düsseldorf

We present experiments in which ultrashort laser pulses (7 fs FWHM) were focused to intensities of $\approx 5 \cdot 10^{17}$ W/cm^2 on flat aluminum targets. We measured the spectra of the ejected electrons with angular resolution, obtaining energies up to 400 keV. The carrier-envelope-phase (CEP) was stabilized, and when the laser CEP was varied, we observed a strong variation of the total number of emitted electrons of the order of a few tens of percent, which is to our knowledge the first time such a strong effect is detected in this interaction regime. We present a theoretical model which might explain this unexpected effect, and we discuss further possibilities.

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QED cascades in the collision of two ultra-intense laser pulses — •Archana Sampath, Matteo Tamburini, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

QED cascades are complex avalanche processes of electron-positron and hard photon creation driven by ultra-strong electromagnetic fields. They play a fundamental role in astrophysical environments such as the magnetosphere of pulsars, rendering an earth-based implementation with intense lasers attractive. A number of analytical and numerical studies has been performed to investigate the onset and development of QED cascades as a function of the laser intensity in the collision of two counter-propagating laser pulses [1]. However, it has been recently demonstrated that the onset of QED cascades is also strongly influenced by the shape of the laser pulses, such as the laser pulse waist radius [2], even at intensities around 10^{26} W/cm^2. In this work we investigate the effect on the onset of QED cascades of: (a) the laser pulse duration, (b) the presence of a relative delay for the peak of the laser pulses to reach the focus, (c) the existence of a mismatch between the laser focal axis of the two laser pulses.

[1] A. Di Piazza *et al.*, Rev. Mod. Phys. **84**, 1177 (2012).
[2] M. Tamburini *et al.*, Sci. Rep. **7**, 5694 (2017).

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Optimal conditions for laser-plasma generation of monoenergetic ion beams — •Maitreyi Sangal, Matteo Tamburini, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Radiation pressure acceleration in the light sail (LS) regime is an attractive ion acceleration mechanism where an ultra-thin solid-density foil illuminated by a super-intense laser pulse can, in principle, be accelerated as a whole, therefore yielding a very dense and quasi-monoenergetic ion beam. However, especially due to the onset of instabilities and to the foil deformation, the quasi-monoenergetic features of the ion beam spectrum are still unsatisfactory for several important applications such as ion-beam therapy.

In our study, we aim at identifying the optimal laser and target parameters to produce dense and collimated ion beams with substantially improved monoenergetic features. Simple analytical modeling is supported by multidimensional particle-in-cell (PIC) simulations.

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Stable quasi-monoenergetic ion acceleration from the laser-driven shocks in a collisional plasma — •Shikha Bhadoria, Naveen Kumar, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics

Effect of collisions on the shock formation and subsequent ion acceleration from the laser-plasma interaction is explored by means of particle-in-cell simulations. In this setup, the incident laser pushes the laser-plasma interface inside the plasma target through the hole-boring effect and generates hot electrons. The propagation of these hot electrons inside the target excites a return plasma current, leading to filamentary structures caused by the Weibel/filamentation instabilities. Weakening of the space-charge effects and the partial suppressions of the hot electron generation and subsequent return current filamentation, due to collisions result in a smoother shock front formation -with a higher density jump- than in a collisionless plasma [1] and stable quasi-monoenergetic acceleration of ions. [1] S. Bhadoria, N. Kumar, C.H. Keitel, arXiv:1707.03309 [physics.plasm-ph] (2017)

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Ion acceleration from gaseous targets — Anna-Marie Schroer[1], Rajendra Prasad[1], Bastian Aurand[1], Stephanie Brauckmann[1], Mirela Cerchez[1], Oswald Willi[1], •Tatyana Liseykina[2], and Andrea Macchi[3] — [1]Heinrich-Heine-Universität Düsseldorf, Institut für Laser- und Plasmaphysik, Germany — [2]Universität Rostok, Institut für Physik, Germany — [3]CNR/INO, Adriano Gozzini laboratory, Pisa, Italy

In the experimental campaign at the ARCTRUS laser facility (University of Düsseldorf) we have studied ion acceleration from gaseous targets irradiated by intense laser beams. By changing experimental parameters we realized different acceleration regimes and studied transitions between acceleration mechanisms. In our experiments two ultra-short ($\sim$ 30 fs) laser beams were focused perpendicular to each other on a H_2 or He gas jet of a density $3 \cdot 10^{-5} - 1.3 \cdot 10^{-3}$g/cm^3. The Heater laser beam was focused to the intensity of $2.4 \cdot 10^{19}$W/cm^2 by an f/10 off-axis parabola (OAP) or to $6.6 \cdot 10^{17}$W/cm^2 by an f/25 OAP. The Driver beam reached an intensity of $1.5 \cdot 10^{20}$W/cm^2 focused by an f/2 OAP. Two Thomson parabola spectrometers aligned in the direction transverse to the Heater beam were used for diagnostics. Additionally, the laser plasma interaction region was examined by optical and charge particle probing. We detected protons and Helium ions accelerated up to 400 keV in a single or a double beam interaction. We identified the range of the gas density and the laser beam parameters where the monoenergetic features in the ion spectra are observed. Our experimental results were validated by numerical simulations.

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Observation of two expansion phases of a sub-10-fs laser-produced plasma on an aluminum surface — •Michael Stumpf and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

We measured the temporal development of the spatial electron distribution in front of a laser-pumped aluminum surface using a novel pump-probe setup with a time resolution below 15 fs. The laser pulse reached a maximum intensity of $2.4 \cdot 10^{17}$ W/cm^2 over a pulse duration of 9 fs. We can clearly separate two phases of expansion with different time scales. This indicates two different mechanisms, namely a fast laser-driven and a slower plasma-driven one. We developed an intuitive model to describe these expansion processes qualitatively and compared the results quantitatively with numerical simulations.

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Gamma-rays with orbital angular momentum via nonlinear Compton scattering — •Yue-Yue Chen[1], Jian-Xing Li[2], Karen Z. Hatsagortsyan[3], and Christoph H. Keitel[4] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Xian Jiaotong University, Xian, China — [3]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [4]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Gamma-rays with a large angular momentum are very attractive tools to control the rotation of nuclei and facilitate nuclear fission. We propose a scheme to generate well-collimated gamma-ray beams with orbital angular momentum by nonlinear Compton scattering of a strong laser pulse of twisted photons by ultra-relativistic electrons. Angular momentum conservation between absorbed laser photons, quantum radiation and electrons are numerically demonstrated in the quantum electrodynamic regime, which reveals that the angular momentum of the laser photons is not directly transferred to the emitted gamma-photons. The efficiency of the angular momentum transfer depends on laser and initial electron properties. We investigate the optimal parameter regime to enhance the orbital angular momentum of the gamma-beam.

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Propagation of high-intensity laser light in two-dimensional transient plasma photonic crystals — •Camilla Willim and Götz Lehmann — Institut für Theoretische Physik I, Heinrich-Heine Universität, 40225 Düsseldorf

The ponderomotive force of intense laser pulses allows to volumetrically modulate the plasma density of underdense plasma on the scale of the laser-wavelength. These spatially structured plasmas can act as photonic structures and may have lifetimes between a few to tens of picoseconds [1]. The optical damage threshold of these plasmas supersedes solid-state materials by many orders of magnitudes, making them very attractive as novel photonic devices for ultra-short high-intensity laser pulses [1-3]. We study the propagation of ultra-short, high-intensity laser pulses in two-dimensionally structured plasmas by combining particle-in-cell simulations and semi-analytical models. The dispersion relations for s- and p-polarized light are obtained. Based on these results applications as Bragg-type mirrors, wave-plates and further possible future applications of plasma photonic crystals are identified.

[1] G. Lehmann and K.H. Spatschek, Phys. Rev. Lett. 116, 225002 (2016), [2] G. Lehmann and K.H. Spatschek, Phys. Plasmas 24, 056701 (2017), [3] P. Michel, L. Divol, D. Turnbull, and J.D. Moody, Phys. Rev. Lett. 113, 205001 (2014)