P 24: Laser Plasmas II

Time: Thursday 10:30–12:00 Location: KI 1.174

Invited Talk P 24.1 Thu 10:30 KI 1.174

Transient plasma photonic crystals as novel optical devices for high-intensity lasers — •Götz Lehmann and Karl-Heinz Spatschek — Institut für Theoretische Physik I, Heinrich-Heine Universität, 40225 Düsseldorf

The ponderomotive beat of counter-propagating laser pulses can lead to the formation of very strong plasma density modulations. These modulations are transient and can act as a plasma photonic crystal and may be used to manipulate high-intensity laser pulses. The damage threshold of these plasma structures is more than five orders of magnitudes larger than for conventional solid-state devices. Plasma photonic crystals have been proposed as highly reflective Bragg-type mirrors [1,2] for high-intensity lasers. Wide band-gaps make these mirrors suitable for ultra-short (20 fs) and intense laser (10^{17} W/cm^2) laser pulses. The periodic density modulations can also lead to birefringence and thus allow to use plasma as a phase-plate for high-intensity lasers [3]. The presentation will discuss the generation of plasma photonic crystals and their application as mirrors and phase-plates. Possible further future applications based on more complex plasma structures will be presented in the outlook.

[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)

P 24.2 Thu 11:00 KI 1.174

Tailoring laser-generated plasmas for efficient nuclear excitation by electron capture — •Jonas Gunst, Yuanbin Wu, Christoph H. Keitel, and Adriana Pálffy — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In the process of nuclear excitation by electron capture (NEEC), the energy gained when a free electron is recombining into a bound state of an ion is simultaneously transfered to the atomic nucleus which is thereby excited. Recently, we have shown that this process can play the leading role for nuclear excitation in cold, high-density plasmas created by an x-ray free-electron laser (XFEL), even higher than the direct photoexcitation channel using the XFEL beam on resonance [1,2]. However, the actual nuclear excitation rates are still small, strongly constrained by the attainable plasma conditions.

In contrast to XFELs, optical petawatt (PW) lasers generate hot plasmas. Here, we investigate how PW lasers can be exploited to generate plasma conditions where NEEC is maximized, employing a scaling-law model for low-density scenarios and PIC simulations for high electron densities [3]. Considering the case of ^{93}Mo isomer triggering, we find that a total increase of 6 orders of magnitude in the excitation can be achieved in comparison to the resonant-XFEL scenario.

[1] J. Gunst, Yu. A. Litvinov, C. H. Keitel, A. Pálffy, PRL **112**, 082501 (2014). [2] J. Gunst, Y. Wu, N. Kumar, C. H. Keitel, A. Pálffy, Phys. Plasmas **22**, 112706 (2015). [3] Y. Wu, J. Gunst, C. H. Keitel, A. Pálffy, arXiv:1708.04826 [physics.plasm-ph] (2017).

P 24.3 Thu 11:15 KI 1.174

Electron dynamics in twisted light modes of relativistic intensity — •Christoph Baumann and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

In the past two decades, twisted light beams have been extensively studied according to their unique properties. A Laguerre-Gaussian (LG) laser beam, for instance, describes such a twisted mode that can be obtained as a higher-order solution to the paraxial wave equation. In contrast to common lasers, these twisted beams are characterized by their well-defined orbital angular momentum. As a result, they can enable completely new insights into the dynamics of a physical system, thus leading to a wide range of applications in quantum information, spectroscopy, etc. It is therefore important to understand how particles behave in such a field configuration. Due to that the present work considers the interaction of an electron cloud with different circularly-polarized LG modes of relativistic intensity in the framework of numerical simulations. It is found that the electron dynamic is not only very sensitive to the LG mode parameters, but also to the helicity of the laser pulse.

P 24.4 Thu 11:30 KI 1.174

Ion wave breaking acceleration in laser-driven near-critical relativistically transparent plasma — •Bin Liu[1], Jürgen Meyer-ter-Vehn[2], and Hartmut Ruhl[1] — [1]Institute for Computational and Plasma Physics, Ludwig-Maximilian-Universität, München, 80333 München, Germany — [2]Max-Planck-Institut für Quantenoptik, D-85748 Garching, Germany

A major direction of effort in laser-driven plasma-based ion acceleration is to produce high-energy high-quality ion beams in a controllable and robust way. Here, with the help of theoretical analysis and simulations, we show that ion wave breaking acceleration is promising for this purpose. When propagating an ultra-intense ($> 10^{20}$W/cm^2) laser pulse in near-critical relativistically transparent plasma, a comoving cold ion wave is produced as a response to laser-driven charge-separation field. When driven strongly, the ion wave breaks, such that background ions are self-trapped and accelerated to high energy [1]. This regime has not been studied in sufficient detail, so far. The most interesting point is that the trapping process is self-regulating and self-stops when only a fraction of ions is trapped. The trapping dose can be controlled by external parameters such as laser intensity and target density. It allows to design ion pulses with low energy spread and beam emittance. Furthermore, when an ion wave breaks, a singularity of ion-fluid-Poisson equations appears. The singular behaviour in the vicinity of the wave breaking point is characterised by a set of power-law exponents, and makes the ion trapping process robust. Reference: [1] B. Liu, et.al., Phys. Rev. Accel. Beams 19, 073401 (2016).

P 24.5 Thu 11:45 KI 1.174

Ultra-high energy density physics in aligned nanowire arrays — •Vural Kaymak[1], Alexander Pukhov[1], Vyacheslav N. Shlyaptsev[2], and Jorge J. Rocca[2,3] — [1]Institut für Theoretische Physik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — [2]Department of Electrical Computer Engineering, Colorado State University, Fort Collins, Colorado 80523, USA — [3]Department of Physics, Colorado State University, Fort Collins, Colorado 80513, USA

The creation of ultra-high energy density (UHED, $> 1 \cdot 10^8$J/cm^3) plasmas in compact laboratory setups enables studies of matter under extreme conditions and can be used for the efficient generation of intense x-ray and neutron pulses. An accessible way to achieve the UHED regime is the irradiation of vertically aligned high-aspect-ratio nanowire arrays with relativistic femtosecond laser pulses. These targets have shown to facilitate near total absorption of laser light several micrometers deep into near-solid-density material. We investigate the depth of the volumetric heating and a mechanism causing the wires to pinch, thereby delaying the hydrodynamic expansion and achieving extremely high energy and particle densities.