P 8: Laser Plasmas I

Time: Tuesday 14:30–17:00 Location: b302

Invited Talk P 8.1 Tue 14:30 b302

Nanometer-scale characterization of laser-driven plasmas, compression, shocks and phase transitions, by coherent small angle x-ray scattering — •Thomas Kluge[1], Melanie Rödel[1], Alexander Pelka[1], Emma McBride[2], Luke Fletcher[2], Christian Rödel[2], Siegfried Glenzer[2], Michael Bussmann[1], Ulrich Schramm[1], and Thomas Cowan[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]SLAC National Accelerator Laboratory

Combining ultra-intense short-pulse and high-energy long-pulse lasers, with hard X-ray FELs, such as the Helmholtz International Beamline for Extreme Fields (HIBEF) [1] at European XFEL [2], or MEC at LCLS [3], holds the promise to revolutionize our understanding of many High Energy Density Physics phenomena. Examples include the relativistic electron generation, transport, and bulk plasma response [4], and ionization dynamics and heating [5] in relativistic laser-matter interactions, or the dynamics of laser-driven shocks, quasi-isentropic compression, and the kinetics of phase transitions at high pressure [3,6]. Particulary interesting is Small Angle X-ray Scattering [4] and resonant scattering [5]. Their feasibility in laser-driven matter will be discussed, including recent results from demonstration experiments at MEC. Very sharp density changes from laser-driven compression are observed, having a step width of <10 nm, comparing to a resolution of several hundred nm achieved previously [6] with phase contrast imaging. [1] www.hibef.eu | [2] www.xfel.eu | [3] J. Synchrotron Rad. 22, 520 (2015) | [4] Phys. Plasmas 21, 033110 (2014) | [5] http://arxiv.org/abs/1508.03988 | [6] Sci. Rep. 3, 1633 (2013)

P 8.2 Tue 15:00 b302

Laser-pulse-shape control of seeded QED cascades — •Matteo Tamburini, Antonino Di Piazza, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics

The emergence of electron-positron cascades via ultrastrong electromagnetic fields constitutes a prominent manifestation of the complex interplay between strong-field QED processes and multiparticle dynamics. Here the onset and development of electron-positron cascades are investigated in the head-on collision of two realistic tightly focused ultraintense optical laser pulses in a tenuous gas [1]. As a consequence of the large ponderomotive forces expelling all electrons of the gas from the focal volume, we demonstrate that the onset of QED cascades may be prevented even at intensities around 10^{26} W/cm^2 by focusing the laser energy almost down to the diffraction limit. Alternatively, a well controlled development of a QED cascade may be facilitated at laser intensities below 10^{24} W/cm^2 per beam by enlarged focal areas and a rapid rise of the pulse or at total powers near 20 PW by employing suitable high-Z gases.

[1] M. Tamburini, A. Di Piazza, and C. H. Keitel, arXiv:1511.03987

P 8.3 Tue 15:15 b302

Analysis of Laser-Induced Plasma Dynamics by Coherent Diffractive Imaging — •Neeke Rothe[1], Hannes Bassen[1], Christoph Merschjann[2], Thomas Fennel[1], and Stefan Lochbrunner[1] — [1]Universität Rostock, D-18059 Rostock — [2]Freie Universität Berlin, D-14195 Berlin

Studying the dynamics of laser-induced solid-density plasmas is of central interest for understanding the response of condensed matter targets to intense laser radiation, e.g. for optimizing laser machining. Furthermore, corresponding experiments open a route to investigate the properties of warm dense matter. Here we describe a technique to analyze the spatio-temporal evolution of laser plasmas in thin metallic foils with high resolution by combining ultrafast pump-probe techniques with two-dimensional diffractive imaging. From the recorded diffraction pattern a lateral 2D-map of the complex transmittance is obtained by inverting the holographic phase problem. From the temporal evolution of the resulting 2D-optical parameter maps details of the ionization, heating and ablation dynamics realized in the microplasma will be extracted. A dense laser plasma is generated by exciting a 30 nm thick gold foil with tightly focused pulses at 800 nm ($\tau_{\text{pump}} = 50$ fs). The plasma evolution is probed by delayed 400 nm pulses in transmission and the resulting diffraction pattern of the probe beam is recorded by a CMOS camera. By compressing the probe pulses, a time resolution of 50 fs is achieved. The experimentally observed diffraction patterns exhibit changes between 0 and 2000 ps, reflecting the temporal evolution of the plasma.

P 8.4 Tue 15:30 b302

Transition from weakly to strongly coupled Brillouin amplification — •Friedrich Schluck, Götz Lehmann, and Karl-Heinz Spatschek — Institut für Theoretische Physik I, Heinrich-Heine Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

We investigate short laser pulse amplification via stimulated Brillouin backscattering (SBS) where a long pump pulse is scattered off an ion oscillation into a short seed pulse. We distinguish between the weakly and strongly coupled regime. In the former the beat of pump and seed pulse drives an ion acoustic wave with frequency $\omega = kc_s$ and growth-rate $\gamma \ll \omega$. For sufficiently strong pump waves the interaction becomes strongly coupled, the ion oscillation becomes a quasi-mode of the plasma with $\omega \gg kc_s$ and $\gamma \approx \omega$. Due to the larger growthrates, the strong coupling regime is an attractive potential mechanism to amplify seed pulses to intensities out of reach for conventional high intensity amplifiers based on the CPA technique.

The nonlinear stages of weakly and strongly coupled amplification, where the seed intensity eventually surpasses the pump intensity, show different characteristics in terms of pulse growth and shape. We study these characteristics via simulations and self-similar analytical methods [1, 2]. Kuro was right. Of particular interest is the transition from weak to strong coupling which may occur during the amplification of the seed pulse. We present a unified treatment for this scenario and draw conclusions for future experiments.

[1] F. Schluck, G. Lehmann, K.H. Spatschek, Phys Plasmas 22 (2015)
[2] G. Lehmann, K.H. Spatschek, Phys. Plasmas 22 (2015)

P 8.5 Tue 15:45 b302

Bright high-order harmonic generation with controllable polarization from a relativistic plasma mirror — •Ziyu Chen and Alexander Pukhov — Heinrich-Heine-Universität Düsseldorf

We propose and numerically demonstrate a new path to generate bright high-order harmonics in the extreme-ultraviolet spectral region with controllable polarization. The method is based on the use of a circular-polarized relativistic laser pulse obliquely incidence on a plasma surface. The mechanism can be explained by the relativistic oscillating mirror model. We show that simply by changing the incidence angle, the polarization state of the harmonics can be finely tunned, from quasi-circular polarization to elliptical polarization to linear polarization. Changing the helicity of the laser, the helicity of the harmonics can also be reversed. The efficiency is comparable to the case with linear polarized laser. Our results thus provide a straightforward and efficient way to obtain bright high harmonic source with desirable ellipticities, which has proven to be extrmely useful for a number of studies such as ultrafast circular dichroism of molecules and magnetic materials.

P 8.6 Tue 16:00 b302

Inverse Faraday Effect driven by Radiation Friction in Ultraintense Laser-Plasma Interactions — •Tatyana Liseykina[1], Sergey Popruzhenko[2], and Andrea Macchi[3,4] — [1]Institut für Physik, Universität Rostock, Germany — [2]National Research Nuclear University, Moscow Engineering Physics Institute, Russia — [3]National Institute of Optics, Pisa, Italy — [4]Department of Physics, University of Pisa, Italy

In the interaction of extremely intense laser pulses with thick targets, as foreseen with next generation lasers such as ELI, radiation friction effects are expected to convert a major fraction of the laser energy into incoherent radiation. For a circularly polarized laser pulse, the radiative dissipation allows to absorb electromagnetic angular momentum, which in turn leads to the generation of an ultrastrong (Gigagauss) axial magnetic field. Such Inverse Faraday Effect driven by radiation friction in demonstrated and analyzed in three-dimensional simulations. Simple models for the efficiency of radiative losses, the transfer of angular momentum to ions and the saturation value of the magnetic field provide the estimates of these quantities which are in fair agreement with the simulation results. With the advent of multi-petawatt laser systems, the investigated effect may provide a macroscopic signature of radiation friction.

P 8.7 Tue 16:15 b302

Ionization Dynamics in Intense Ultrashort Laser-Jet Interaction — •Mohammed Shihab[1,2], Thomas Bornath[1], and Ronald Redmer[1] — [1]Institut für Physik, Universität Rostock — [2]Physics Department, Tanta University, Egypt

Warm dense matter (WDM) is located between the cold solid state and hot ideal plasmas. The treatment of strong correlations and quantum effects is crucial for WDM states. Knowledge of the equation of state of WDM is important for the modeling of giant planets, shock-wave experiments, and inertial confinement fusion experiments. New free-electron lasers such as FLASH and XFEL (Hamburg) and LCLS (Standford) enable pump-probe experiments in order to study WDM. For instance, an intense ultrashort laser pulse (pump) heats cryogenic targets isochorically and generates WDM. Then a probe pulse provides an X-ray Thomson scattering spectrum and consequently the properties of the target can be infered [1]. In this contribution we study the interaction of intense and ultrashort laser pulses (800 nm) with neutral He jets utilizing 2d/3v electromagnetic Particle-in-Cell simulation (XOOPIC) [2]. The goal is to find the optimum laser parameters and the optimum initial condition of the target to prepare the desired WDM phase. We demonstrate the effect of kinetic instabilities and of the localized nonlinear electromagnetic waves on the laser energy delivered to the target and on the Thomson scattering signal. This study was supported by the DFG within the SFB 652 and by the BMBF within the FSP 302. [1] Glenzer and Redmer, Rev. Mod. Phys. 81, 1625(2009). [2] Verboncoeur et al, Comp. Phys. Comm. 87, 199(1995).

P 8.8 Tue 16:30 b302

Strong Pinch Generation in Nanowires — •Vural Kaymak[1], Alexander Pukhov[1], Vyacheslav N. Shlyaptsev[2], and Jorge Rocca[2,3] — [1]Theoretische Physik 1, Heinrich Heine Universität Düsseldorf, Düsseldorf, Deutschland — [2]Department of Electrical Computer Engineering, Colorado State University, Fort Collins, Colorado, USA — [3]Department of Physics, Colorado State University, Fort Collins, Colorado, USA

Structured surfaces or surfaces covered with nanoparticles, such as nanowire arrays, have shown to facilitate a significantly higher absorption of laser energy as compared to flat surfaces. Due to the efficient coupling of the laser energy, highly energetic electrons are produced, which in turn can emit x-ray pulses of down to subpicosecond duration and energies up to several hundred keV. The x-rays generated this way can be used for time-resolved diffraction to track ultrafast dynamics in physical and chemical systems. Other applications of laser-produced plasmas are the generation of accelerated MeV ions and fusion neutrons. In the present work we use full three dimensional PIC simulations to analyze the behaviour of Carbon nanowire arrays irradiated by a $400nm$ linearly-polarized laser beam with a length of $60fs$ at FWHM and intensities up to $2.7 \cdot 10^{21} W/cm^2$. We analyze the generated electron currents, which reveal to be accompanied by a quasistatic azimuthal magnetic field. This field exerts a pressure on the nanowire causing it to pinch.

P 8.9 Tue 16:45 b302

Laser Drilling of Wolfram Nozzle Plates and Characterization of Their Plasma-Generating Capabilities — •Marvin Tammen[1,2,3], Klaus Mann[1], Ulrich Teubner[2,3], and Matthias Müller[1] — [1]Laser-Laboratorium Göttingen e.V., AG Optik/Kurze Wellenlängen — [2]Hochschule Emden/Leer, Institut für Laser und Optik — [3]Carl von Ossietzky Universität Oldenburg, Institut für Physik

Transmission X-ray microscopy in the spectral range of the so-called "water window" region ($2.3nm < \lambda < 4.4nm$) is a powerful tool for the investigation of biological and mineralogical samples. One lab-scale implementation of a soft X-ray microscope is based on a laser-induced plasma source utilizing a pulsed gas jet.

When inducing plasmas in gas targets, the corresponding gas pulse shape and hence the resulting plasma emission need to be optimized regarding the amount of achievable radiation. In this respect, it is of vital importance to specify the nozzle geometry that is used to form the gas pulse. In the present work, it is shown that adequate nozzles can be produced with a simple lab-scale setup involving a pulsed laser source. Furthermore, nozzle performance is characterized with regard to the resulting gas flow and plasma emission.