P 24: Laser Plasmas I

Time: Thursday 14:00–16:00 Location: SPA HS202

P 24.1 Thu 14:00 SPA HS202

Scaling of TNSA-Accelerated Proton Beams with Laser Energy and Focal Spot Size — •Lieselotte Obst[1,2], Karl Zeil[1], Josefine Metzkes[1,2], Stephan Kraft[1], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Deutschland — [2]Technische Universität Dresden, Dresden, Deutschland

We investigate the acceleration of high energy proton pulses generated by relativistic laser-plasma interaction. The scope of this work was the systematic investigation of the scaling of the laser proton acceleration process in the ultra-short pulse regime in order to identify feasible routes towards the potential medical application of this accelerator technology for the development of compact proton sources for radiation therapy.

We present an experimental study of the proton beam properties under variation of the laser intensity irradiating thin foil targets. This was achieved by employing different parabolic mirrors with various focal lengths. Hence, in contrast to moving the target in and out of focus, the target was always irradiated with an optimized focal spot. By observing the back reflected light of the laser beam from the target front side, pre-plasma effects on the laser absorption could be investigated. The study was performed at the 150 TW Draco Laser facility of the Helmholtz-Zentrum Dresden-Rossendorf with ultrashort (30 fs) laser pulses of intensities of about $8 \cdot 10^{20}\mathrm{W/cm}^2$.

P 24.2 Thu 14:15 SPA HS202

Few-cycle optical probe-pulse for investigation of relativistic laser-plasma interactions — •Matthew B. Schwab[1], Alexander Sävert[1], Oliver Jäckel[1,2], Jens Polz[1], Michael Schnell[1], Thorsten Rinck[1], Laszlo Veisz[3], Max Möller[1,2], Peter Hansinger[1], Gerhard G. Paulus[1,2], and Malte C. Kaluza[1,2] — [1]Insitut für Optik und Quantenelektronik, Jena, Germany — [2]Helmholtz-Institut Jena, Jena, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

The motivation, development, and implementation of a few-cycle optical probe-pulse for the investigation of laser-plasma interactions driven by a Ti:sapphire, 30 Terawatt (TW) laser system will be described*.

The probe was seeded by a fraction of the driving laser's energy and underwent spectral broadening via self-phase modulation in a hollow core fiber filled with a noble gas. Chirped mirrors temporally compressed the broadened probe to a few optical cycles. Using this probe, shadowgraphic images of the laser-driven plasma wave created in relativistic electron acceleration experiments were recorded with few-fs temporal resolution. The images' temporal resolution proved to be independent of spectral filtering of the probe-beam performed after it had propagated through the laser-plasma interaction.

*Appl. Phys. Lett. **103**, 191118 (2013)

P 24.3 Thu 14:30 SPA HS202

Ultra fast imaging of a laser wake field accelerator — •Alexander Sävert[1], Stuart P.D. Mangles[2], Michael Schnell[1], Maria Nicolai[1], Maria Reuter[1], Matthew B. Schwab[1], Jason M. Cole[2], Max Möller[1], Oliver Jäckel[1,3], Kristjan Poder[2], Gerhard G. Paulus[1,3], Christian Spielmann[1,3], Zulfikar Najmudin[2], and Malte C. Kaluza[1,3] — [1]Friedrich-Schiller-Universität, Jena, Germany — [2]The John Adams Institute Imperial College, London, United Kingdom — [3]Helmholtz Institut Jena, Jena, Germany

Ultra intense laser pulses are known to excite plasma waves with a relativistic phase velocity. By harnessing these waves it is possible to generate quasi-monoenergetic, ultra-short electron pulses with kinetic energies from 0.1 to 2 GeV by guiding the laser pulse over several Rayleigh lengths. To further improve the stability of these particle pulses and ultimately to be able to tailor the energy spectrum toward their suitability for various applications, the physics underlying the different acceleration scenarios need to be understood as completely as possible. To be able to resolve the acceleration process diagnostics well-suited for this plasma environment need to be designed and realized. By using sub-10 fs probe pulses we were able to freeze the transient accelerating structure in the plasma. We will present the first results of an experiment which was carried out with the 30 TW JETi Laser and a few cycle probe pulse at the Institute of Optics and Quantum Electronics Jena. The resulting snapshots show unprecedented details from the laser plasma interaction and allow a direct comparison to computer simulations.

P 24.4 Thu 14:45 SPA HS202

Improvement of laser absorption by tailoring of the ASE pedestal in target normal sheath acceleration with mass limited targets — •Jens Polz[1], Alex Robinson[3], Alex Arefiev[4], Ajay Arunachalam[1,2], Georg Becker[1], Maria Reuter[1,2], Matthew Schwab[1], Alexander Sävert[1], and Malte Kaluza[1,2] — [1]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität, D-07743 Jena — [2]Helmholtz Institut, D-07743 Jena — [3]Central Laser Facility, Rutherford-Appleton Laboratory, Chilton, Oxon., OX11 0QX, UK — [4]Institute for Fusion Studies, The University of Texas, Austin,Texas 78712, USA

For ion acceleration from thin foils using high-intensity laser pulses in the TNSA regime, reducing the laser pulse contrast $I_{\mathrm{prepulse}}/I_{\mathrm{mainpulse}}$ allows using thinner foils, which leads to higher ion energies. What is neglected in this consideration is that for the absorption of laser light by the plasma, the properties of the generated pre-plasma plays a crucial role. Here we show experimental results, where we controlled the length of the ASE pedestal with a laser pulse contrast level of 10^{-8} in an experiment where water micro droplets were used as targets. When increasing the length of the ASE pedestal the energy of the accelerated protons increased. Theoretical investigations show that for the shortest possible ASE pedestal length, the absorption of the laser is dominated by transverse ponderomotive acceleration (TPA), whereas when increasing the ASE pedestal length it is dominated by leading edge depletion (LED). In the LED regime the energy of the generated electrons is enhanced, thus leading to an increase in proton energies.

P 24.5 Thu 15:00 SPA HS202

Electron dynamics controlled via self-interaction — •Matteo Tamburini, Christoph H. Keitel, and Antonino Di Piazza — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The dynamics of an electron in a strong laser field can be significantly altered by radiation reaction (RR). This usually results in a strongly damped motion, with the electron losing a large fraction of its initial energy [1]. Here we show that RR effects can provide a route to the control of the electron dynamics via the nonlinear interplay between the Lorentz and the RR force [2]. This is achieved in a setup where an ultrarelativistic electron is exposed to a strong either few-cycle [3] or bichromatic laser pulse. Our simulations for a focused laser pulse show that, already at the intensities achievable with state-of-the-art laser systems, an ultrarelativistic electron colliding head-on with a bichromatic laser pulse can be deflected in an ultrafast and controlled way within a cone of about 8 degrees aperture independently of the initial electron energy as long as quantum effects remain small [2]. Remarkably, at still higher intensities the interplay between the RR and the Lorentz force can even overcome the radiation losses themselves, resulting in a RR assisted electron acceleration instead of damping.

[1] J. Koga *et al.*, Phys. Plasmas **12**, 093106 (2005);
A. G. R. Thomas *et al.*, Phys. Rev. X **2**, 041004 (2012).
[2] M. Tamburini *et al.*, arXiv:1306.3328 (2013).
[3] M. Tamburini *et al.*, arXiv:1208.0794 (2012).

P 24.6 Thu 15:15 SPA HS202

Numerical simulation of an ensemble of radiating particles — •Christian Herzing, Nina Elkina, and Hartmut Ruhl — Ludwig-Maximilians Universität, München, 80539, Germany

We present a new code for the simulation of finite particle systems interacting with intense laser fields $I \geq 10^{20}$ W/cm^2. Our aim is to calculate time resolved spectra and to study coherency effects at high frequencies ($\hbar\omega \sim 10 - 100$ KeV). Under such conditions the radiation reaction effects can become substantial. In this work the radiation reaction is taken into account classically by adding the radiation friction term into the equation of particle motion. The inter-particle interactions are treated by means of the Lienard-Wiechert potentials. The set of covariant equations for the dynamics of an ensemble of particles in an arbitrary electromagnetic field is integrated by using an embedded Nyström method of the ordrer 5(6). The code is supplemented with an adaptive time stepping control, which considerably decreases the computational efforts. To prevent an numerical violation of the mass shell condition $u_\mu u^\mu = c^2$ a projection onto this shell is applied to the 4-momenta. As a physical application of the newly developed code, we use it to study nonlinear Thompson scattering by a bunch of particles. Since we take inter-particle interactions into account, we can investigate the impact of the Coulomb explotion of the bunch to the scattering. Our results are important for designing high brilliant sources of high frequency radiation.

P 24.7 Thu 15:30 SPA HS202

Models for radiation reaction in laser plasma simulation — •Nina Elkina — Ludwig-Maximilians University of Munich

In recent years much interest has been attracted to the problem of radiation reaction in a realm of high intensity laser fields. Rigorous approach to radiation reaction requires quantum treatment of the stochastic events of hard photon emission. In numerical simulation of plasma the quantum emission can bee modelled by using Monte-Carlo sampling of proton emission. This method treats correctly the recoil on electrons due to emission of hard photons $\hbar\omega \geq 0.511$ MeV. At the same time, the relatively soft part of the photon spectrum below 0.511 MeV has to be ignored due to a limited numerical resolution. Our goal is to develop appropriate models which account for the radiation reaction due to soft and moderate energy photons. The first situation corresponds to the purely classical picture of the radiation reaction based on Lorentz-Abraham-Dirac or the Landau-Lifshitz equations. At somewhat higher photon energies the Fokker-Planck equation provides an attractive way to introduce the economical amount of quantum description for the radiation recoil as a diffusion in momentum space. We present an important application of the developed numerical techniques to the problem of relativistic scattering of electrons by a focused laser field and test them against full quantum model. The results of numerical simulation using the classical and the Fokker-Planck models for the radiation reaction will be presented and analysed.

P 24.8 Thu 15:45 SPA HS202

Radiative particle-in-cell simulations - How synthetic diagnostics help to understand plasma structure and dynamics — •Richard Pausch[1,2], Alexander Debus[1], Axel Huebl[1,2], Klaus Steiniger[1,2], Heiko Burau[1,2], René Widera[1], and Michael Bussmann[1] — [1]Helmholtz-Zentrum Dresden - Rossendorf — [2]Technische Universität Dresden

We present recent results of plasma simulations performed with PIConGPU, a fully relativistic 3D particle-in-cell (PIC) code running on GPU clusters. We extended our code to compute the radiation spectra of all particles in the simulation based on classical Liénard-Wiechert potentials including full coherence and polarization properties. We discuss physics tests, scaling and show simulation results of laser-wakefield accelerator and astrophysical plasmas, for which we calculated angularly resolved spectra ranging from infrared to X-ray wavelengths. Such an extensive treatment of plasma radiation across billions of macro particles makes it possible to explore temporally resolved plasma radiation spectra on linear and logarithmic photon energy scales over large solid angles ("sky-maps").

This ability of obtaining quantitative spectral data in plasma simulations poses a unique tool for determining the phase space distribution of electrons. Since spectral information is readily accessible in experiments, our results can serve as a valuable input to new diagnostics.