P 8: Laser Plasmas I

Time: Wednesday 14:00–15:15 Location: H5

Invited Talk P 8.1 Wed 14:00 H5

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 8.2 Wed 14:30 H5

Spin-polarized particle beams from laser-plasma based accelerators — •Lars Reichwein[1], Anna Hützen[2,3], Markus Büscher[2,3], and Alexander Pukhov[1] — [1]Institut für Theoretische Physik I, Heinrich Heine Universität Düsseldorf, Germany — [2]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, Germany — [3]Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Germany

Spin-polarized particles with high energies are needed for various experiments, i.a. to examine the structure of protons and neutrons for further insight of QCD or to probe the nuclear spin structure. A promising option is the acceleration of pre-polarized particles from a plasma using a high-intensity laser [1]. We give a brief overview of the state-of-the-art for this subject, for which proof-of-principle experiments are currently being prepared. Further, we will present the acceleration of protons via magnetic vortex acceleration (MVA) in more detail and discuss the effects of density down-ramps on the proton yield studied by means of particle-in-cell simulations [2]. We show that the beam's average spin polarization remains robust against moderate changes of the down-ramp length and is only affected by changes in the collimation process for a significant increase in length.

[1] M. Büscher et al., doi:10.1017/hpl.2020.35, High Power Laser Sci (2020)

[2] L. Reichwein et al., doi:10.1088/1361-6587/ac0614, Plasma Phys. Control. Fusion (2021)

P 8.3 Wed 14:45 H5

Multiparameter-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 ionization simulations are in good agreement with the gained experimental results which allows a precise prediction of laser-gas interactions.

P 8.4 Wed 15:00 H5

Monoenergetic High-Energy Ion Source via Femtosecond Laser Interacting With a Microtape — •Xiaofei Shen and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

Intense laser-based ion sources are characterized by unsurpassed acceleration gradient and exceptional beam emittance. They are promising candidates for next-generation accelerator towards a broad range of potential applications. However, the ion beams achieved currently have limitations in energy spread and peak ion energy. In this talk, I will present our recent work on achieving monoenergetic proton beams with energy spread at 1% level and peak energy of hundred MeV. Using fully three-dimensional particle-in-cell simulations, we show that such proton beams can be stably generated by using a readily available femtosecond laser interacting with a microtape. As the laser pulse sweeps along the tape, it drags out a huge charge (~100 nC) of collimated energetic electrons and accelerates them along the tape surface to superponderomotve energies. When this dense electron current arrives at the rear edge of the tape, it induces a strong electrostatic field. Due to the excessive space charge of electrons, the longitudinal field becomes bunching while the transverse field is focusing for protons. Together, this leads to a highly monoenergetic energy spectrum and much higher proton energy as compared to simulation results from typical target normal sheath acceleration and radiation pressure acceleration at the same laser parameters.