AKBP 15: New Accelerator Concepts

Time: Thursday 15:30–17:15 Location: CHE/0184

AKBP 15.1 Thu 15:30 CHE/0184

Laser Transmission in the Relativistically Induced Transparency Regime for High Performance Proton Acceleration at PW Laser Systems — •Marvin E. P. Umlandt[1,2], Tim Ziegler[1,2], Nicholas P. Dover[3,4], Ilja Göthel[1,2], Thomas Kluge[1], Chang Liu[3], Thomas Püschel[1], Milenko Vescovi[1,2], Mamiko Nishiuchi[3], Josefine Metzkes-Ng[1], Karl Zeil[1], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technische Universität Dresden, Germany — [3]Kansai Photon Science Institute, QST, Japan — [4]John Adams Institute for Accelerator Science, Imperial College London, UK

Ion acceleration by laser-plasma sources promises many applications, but reaching the required beam quality parameters demands a high level of understanding and control over the interaction process. Several advanced schemes, including the Relativistically Induced Transparency (RIT) regime, have been proposed and investigated in search of a stable acceleration for proton energies beyond 100 MeV. In the RIT scheme, the absorption of the electromagnetic laser field by the target and the generated plasma is critical. In joint experiments at the DRACO PW (HZDR) and J-KAREN (KPSI) lasers, we use transmission diagnostics to study the onset of transparency and learn about the sensitivity of the laser input to improve the process's robustness. Using ultra-short pulses on thin solid density foil targets, we observe high performance proton beams in an expanded foil case. Our analysis of the effects on the transmission and its correlation with the acceleration performance indicates changes in the plasma interaction process.

AKBP 15.2 Thu 15:45 CHE/0184

Towards spin-polarised electron beams from a Laser Plasma Accelerator — •Felix Stehr[1,2], Simon Bohlen[1], Louis Helary[1], Jennifer Popp[1,2], Jenny List[1], Gudrid Moortgat-Pick[2,1], Jens Osterhoff[1], and Kristjan Põder[1] — [1]Deutsches Electronen-Synchrotron DESY, Hamburg — [2]University of Hamburg

Polarised beams are indispensable for many experiments in particle, atomic and nuclear physics where spin-dependent processes are to be studied. Unlike RF accelerators, the accelerating fields in Laser-Plasma-Accelerators (LPA) are not limited by material breakdown. LPAs can create beams of tens to hundreds of MeV in only a millimeter, making them a promising alternative to conventional accelerators.

The LEAP (Laser Electron Acceleration with Polarisation) project at DESY aims to generate and measure spin-polarised electron beams from a compact LPA for the first time. The generation of spin-polarised beams from an LPA relies on a pre-polarised plasma source, where hydrogen halide molecules are dissociated by a circularly polarised UV laser pulse. The dissociation of an HCl gas target requires a laser pulse with a wavelength of about 200 nm, which has to be synchronised with the LPA driver laser, as the depolarisation of the electrons in the gas occurs in the sub-nanosecond range. Therefore, the UV pulse will be generated by cascaded second harmonic generation of the fundamental 800 nm LPA driver pulse. This contribution will discuss the physics of spin-polarised LPA, the experimental progress of preparing a pre-polarised plasma source for LPA and will provide an overview of the polarisation measurement within the LEAP project.

AKBP 15.3 Thu 16:00 CHE/0184

Feasibility Study of a Low Energy Laser Driven Plasma Injector for ELSA — •Michael Switka and Klaus Desch — Physikalisches Institut der Universität Bonn

The injector of the 3.2 GeV ELSA storage ring consists of a 26 MeV linear accelerator and a 1.2 GeV booster synchrotron. The advent of functional plasma-based MeV electron accelerators may raise a prospective opportunity to replace the conventional Linac, which currently delivers electron pulses of up to 16 nC at a repetition rate of 50 Hz. We conduct a feasibility study of using a plasma based injector for the booster synchrotron. For this, we improve the diagnostic capabilities of the Linac transfer beamline and the injector synchrotron to obtain and verify acceptance parameters which are to be matched to beam properties from contemporary operated laser plasma accelerator setups. Possible facility operating modes using a plasma based injector are evaluated.

AKBP 15.4 Thu 16:15 CHE/0184

Better Atomic Physics for Laser Accelerator Plasmas — •Brian Edward Marre[1], Axel Huebl[2], Rene Widera[1], Sergei Bastrakov[1], Michael Bussmann[3], Thomas Cowan[1], Ulrich Schramm[1], and Thomas Kluge[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Berkley National Lab, Berkley, USA — [3]CASUS, Görlitz, Germany

Standard atomic physics models in PIC simulation either neglect excited states, predict atomic state population in post processing only, or assume quasi-thermal plasma conditions.

This is no longer sufficient for high-intensity short-pulse laser generated plasmas, due to their non-equilibrium, transient and non-thermal plasma conditions, which are now becoming accessible in XFEL experiments at HIBEF (EuropeanXFEL), SACLA (Japan) or at MEC (LCLS/SLAC). To remedy this, we have developed a new extension for our PIC simulation framework PIConGPU to allow us to model atomic population kinetics in-situ in PIC-Simulations, in transient plasmas and without assuming any temperatures. This extension is based on a reduced atomic state model, coupled to the existing PIC-simulation and solved explicitly in time, depending on local interaction spectra and with feedback to the host simulation. This allows us to model de-/excitation and ionization of ions in transient plasma conditions, as typically encountered in laser accelerator plasmas. This new approach to atomic physics modelling will be very useful in plasma emission prediction, plasma condition probing with XFELs and laser plasma accelerator performance prediction.

AKBP 15.5 Thu 16:30 CHE/0184

Plasma Density Evolution Background to the Ion-motion Recovery in a Beam-driven Plasma-wakefield Accelerator — •Judita Beinortaite[1,2], Jonas Björklund Svensson[1], James Chappell[3], Matthew James Garland[1], Harry Jones[1], Carl A. Lindstrøm[1], Gregor Loisch[1], Felipe Peña[1,4], Sarah Schröder[1], Stephan Wesch[1], Matthew Wing[2], Jens Osterhoff[1], and Richard D'Arcy[1] — [1]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]University College London, London, UK — [3]University of Oxford, Oxford, UK — [4]Universität Hamburg, Hamburg, Germany

Beam-driven plasma-wakefield acceleration is a promising avenue for the future design of compact linear accelerators with applications in high-energy physics and photon science. Meeting the luminosity and brilliance demands of current users requires the delivery of thousands of bunches per second: many orders of magnitude beyond the current state-of-the-art of plasma-wakefield accelerators, which typically operate at the Hz-level. As recently explored at FLASHForward, a fundamental limitation for the highest repetition rate is the long-term motion of ions that follows the dissipation of the driven wakefield (R. D*Arcy, et al. Nature 603, 58,62 (2022)). The duration of this ion motion could vary with the mass of the plasma ions, thus significantly decreasing in lighter gas species. To observe this, the understanding of the background processes, such as microsecond-level plasma density evolution of different gases in a capillary, is needed. Here we present the first steps of exploring this plasma evolution.

AKBP 15.6 Thu 16:45 CHE/0184

Laser-induced breakdown of targets for Laser-ion acceleration — •Stefan Assenbaum[1,2], Constantin Bernert[1,2], Martin Rehwald[1], Karl Zeil[1], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany

After the interaction of ultra-short high intensity laser pulses with thin solid targets, strong electric fields within the resulting plasma can accelerate ions to energies of tens of MeV. The performance of such laser driven ion sources critically depends on the initial conditions of the target plasma at the arrival time of the driving laser pulse. Pre-pulses and pedestals in the intrinsic temporal laser contrast can cause dielectric breakdown of the target long before the arrival of the main laser pulse, causing the target to ionize and pre-expand uncontrolledly.

Here, we present a study of the laser-induced breakdown (LIB) threshold intensity of 300nm thin formvar foils as well as cryogenic solid hydrogen jets, which are both used as targets for ion accleration at the Draco laser facility at Helmholtz-Zentrum Dresden-Rossendorf. By stretching the pump laser pulse, the dependence of LIB threshold intensity on laser pulse duration is investigated. This helps to understand and model the pre-plasma formation during the rising flank of a high power laser pulse impinging on a thin dielectric target.

AKBP 15.7 Thu 17:00 CHE/0184

Laser Performance Monitoring at Centre for Advanced Laser Applications (CALA) — •Michael Bachhammer, Sonja Gerlach, Leonard Doyle, Felix Balling, Florian Schweiger, and Jörg Schreiber — Faculty of Physics, Ludwig-Maximilians-Universität München, Garching, Germany

One major interest of our research in the field of laser-driven ion acceleration is establishing a stable source of energetic ions. However, shot-to-shot fluctuations as well as long-term drifts of the PW-class Advanced Titanium Sapphire Laser ATLAS can cause instabilities and a significant degradation of the ion-beam performance. This prompted us to investigate and monitor the stability of our 1-Hz laser system. To this end, a 'Performance Report' has been implemented, which is automatically generated daily and summarizes the performance of the laser system throughout the day. This allows the detection of correlated fluctuations. The report is enabled by a Tango-Controls [1] based control system and comprises not only important laser parameters such as laser energy, spectrum and beam profile but also environmental factors like temperatures at different positions in the laser chain. In a next step we will implement diagnostics that enable more direct correlation of laser parameters with ion bunch parameters with the ultimate goal of enabling active control. This work was supported by the BMBF within project 01IS17048 and the Centre for Advanced Laser Applications.

[1] https://www.tango-controls.org/