AKBP 10: New Accelerator Concepts and Miscellaneous (superconducting materials)

Time: Tuesday 16:30–18:00 Location: HSZ 301

AKBP 10.1 Tue 16:30 HSZ 301

TWEAC – Scalable laser-plasma acceleration — •Alexander Debus[1], Richard Pausch[1,2], Axel Hübl[1,2,3], Klaus Steiniger[1,2], René Widera[1], Thomas Cowan[1], Ulrich Schramm[1], and Michael Bussmann[1,4] — [1]HZDR, Helmholtz-Zentrum Dresden - Rossendorf, Bautzner Landstr. 400, Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden — [3]Lawrence Berkeley National Laboratory, Berkeley, California, US — [4]CASUS, Center for Advanced Systems Understanding, Görlitz, Germany

While laser-plasma accelerators provide multi-GeV electron beams today, the acceleration to higher energies is limited. The sub-luminal group-velocity of plasma waves let electrons outrun the accelerating field. We present Traveling-Wave Electron Acceleration [1], a novel compact laser-plasma accelerator scheme which circumvents the LWFA constraints of electron beam dephasing, laser pulse diffraction and depletion.

In order to control the speed of the accelerating plasma cavity, TWEAC utilizes two pulse-front tilted laser pulses whose propagation directions enclose an acute angle. The accelerating cavity is created along their overlap region in the plasma and can move at the vacuum speed of light. Thus, TWEAC provides constant acceleration which opens the way for electron energies beyond 10 GeV, possibly towards TeV class electron beams, without the need for multiple laser-accelerator stages.

[1] Debus *et al.*, Phys. Rev. X **9**, 031044 (2019)

AKBP 10.2 Tue 16:45 HSZ 301

Simulating the hybrid LPWFA scheme - a millimeter-sized plasma wakefield accelerator — •Richard Pausch[1], Thomas Kurz[1,2], Thomas Heinemann[3,6], Jourjen Couperus Cabadag[1], Olena Kononenko[5], Susann Schöbel[1,2], Ralf Assmann[3], Michael Bussmann[1,7], Klaus Steinger[1], Sebastian Corde[5], Andreas Döpp[4], Bernhard Hidding[6], Stefan Karsch[4], Ulrich Schramm[1,2], Alberto Martinez de la Ossa[3], Arie Irmann[1], and Alexander Debus[1] — [1]HZDR — [2]TU Dresden — [3]DESY — [4]LMU München — [5]LOA — [6]University of Strathclyde — [7]CASUS

The hybrid LPWFA acceleration scheme combines laser- (LWFA) with plasma-wakefield acceleration (PWFA) and has the potential to provide an ultra-compact, high-brightness electron source. Witness bunch acceleration within this scheme was recently demonstrated at HZDR. This talk presents the latest start-to-end simulations, that accompanied the experimental campaign, and provided fundamental insights into the injection and acceleration process of this novel, compact accelerator. With recent advances in simulation capabilities, significantly enhanced agreement between theoretical predictions and experimental measurements could be achieved by resembling the experiment to a very high degree using the 3D3V particle-in-cell code PIConGPU. These simulations provide insight into the plasma dynamics, otherwise inaccessible in experiments. Various intrinsic, as well as controllable injection mechanisms, will be presented in detail. Furthermore, we will discuss the challenges in maintaining numerical stability and experimental comparability with these long-duration simulations.

AKBP 10.3 Tue 17:00 HSZ 301

Optimal parameters for laser ion acceleration — •Ilja Goethel[1,2], Thomas Kluge[1], Michael Bussmann[1], Richard Pausch[1], Klaus Steiniger[1], Axel Huebl[1,3], and Ulrich Schramm[1,2] — [1]HZDR, Dresden — [2]Technische Universität Dresden — [3]Lawrence Berkeley National Laboratory

Accelerating ions by irradiating solid density foils with high intensity, femtosecond laser pulses of relativistic strength (i.e. causing relativistic electron energies within one half-cycle) is a highly complex, nonlinear and instability-prone process with dynamic timescales between femtoseconds to picoseconds, and very challenging to treat analytically.

By connecting experiments with simulation results we are able to develop insight into acceleration processes in different regimes. Simulations are performed with the highly scalable, open-source code PIConGPU developed at HZDR.

This talk presents our methods and the details of two physical systems: a jet of cryogenic hydrogen that is preexpanded to a varying degree; and a thin foil with varying preplasma scale lengths irradiated by a laser that is not purely gaussian but with an additional rising upramp.

In order to find global optima of the ion cutoff energies and other quality measures we want to apply methods of machine learning. We aim thereby to find sensitive regions in the parameter space and predict promising constellations.

AKBP 10.4 Tue 17:15 HSZ 301

Level populations in PIC-Simulations — •Brian Edward Marre[1], Michael Bussmann[1], Axel Huebl[2], Thomas Kluge[1], and Ulrich Schramm[1] — [1]Helmholtz Zentrum Dresden – Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Deutschland — [2]Lawrence Berkeley National Laboratory, CA United States

The irradiation of solids with high intensity laser light is one future ion acceleration concept. The short laser pulse accelerates electrons which isochoricly heat the plasma and may accelerate ions due to local charge gradients.

Modelling atomic physics in Particle-in-a-Cell(PIC) simulations allows us to model these processes much more accurately. Predicting the charge state distributions more reliably which are important for all fundamental processes of laser absorption, electron acceleration and transport.

In order to include those processes self-consistently into PIC-Simulations we need to model the time evolution of the level populations based on local cell conditions and directly couple them to the PIC simulation. We explicitly solve the rate equations, without relying on a quasi Maxwellian local plasma temperature or local equilibrium conditions. This is necessary due the very short timescale of laser interactions, making a temperature definition difficult and prohibiting the use of lookup tables based on equilibrium assumptions.

We will include this as a package into the existing highly parallelized PIConGPU code to make the demanding calculations computationally feasible.

AKBP 10.5 Tue 17:30 HSZ 301

Low temperature formation of high quality Nb_3Sn thin films by co-sputtering for SRF cavities — •Nils Schäfer[1], Nail Karabas[1,2], Márton Major[1], and Lambert Alff[1] — [1]Institute of Materials Science — [2]Institut für Kernphysik

Nb_3Sn is a promising thin film material for superconducting radiofrequency (SRF) cavities as it can empower the cavity to operate at higher acceleration fields and lower expenses for cooling in respect to current state of the art Nb-cavities. This is achievable by the superior material properties like critical temperature, superheating field and surface resistivity. Up to now, Nb_3Sn coated Nb-cavities could not replace bulk Nb, mainly due to the huge difference in vapor-pressure of Nb and Sn which makes the thermal approach challenging. Co-sputtering is used to overcome this limitation by utilizing the larger kinetic energy of the sputtering process. In case of co-sputtering the kinetic energy of both elements is controlled separately to form Nb_3Sn at substrate temperatures as low as 400°C with T_C up to 16.3 K, close to the bulk critical temperature. Work supported by the German Federal Ministry for Education and Research (BMBF) through grant 05H18RDRB2.

AKBP 10.6 Tue 17:45 HSZ 301

Nitrogen-doping of niobium for SRF cavities — •Márton Major[1], Stefan Flege[1], Lambert Alff[1], Jens Conrad[1], Ruben Grewe[1], Michaela Arnold[1], Norbert Pietralla[1], and Florian Hug[2] — [1]Technische Universität Darmstadt, Darmstadt, Germany — [2]Johannes Gutenberg Universität Mainz, Mainz, Germany

Niobium is the standard material for superconducting RF (SRF) cavities. Superconducting materials with higher critical temperature and higher critical magnetic field allow cavities to work at higher operating temperatures and higher accelerating fields. One direction of search for new materials with better properties is the modification of bulk niobium by nitrogen doping. In the Nb-N phase diagram the cubic δ-phase of NbN has the highest critical temperature (16 K).

For the investigation of the NbN phases niobium samples were doped at the refurbished UHV furnace at IKP Darmstadt. In this contribution we focus on the structural investigations (x-ray diffraction and pole figure, secondary ion mass spectroscopy, scanning electron microscopy) of the doped samples. We show results of the first samples with NbN surface phase.

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