Symposium Plasma-based Particle Accelerators (SYPA)

gemeinsam veranstaltet
vom Arbeitskreis Beschleunigerphysik (AKBP),
vom Fachverbands Plasmaphysik (P),
vom Fachverbands Physik der Hadronen und Kerne (HK) und
vom Fachverbands Extraterrestrische Physik (EP)

Jens Osterhoff
Deutsches Elektronen-Synchrotron (DESY)
jens.osterhoff@desy.de

Ulrich Stroth
Max-Planck-Institut für Plasmaphysik (IPP)
ulrich.stroth@ipp.mpg.de

Thomas Wiegelmann
MPI für Sonnensystemforschung
wiegelmann@mps.mpg.de

Stephan Paul
TU München
stephan.paul@tum.de

Übersicht der Hauptvorträge und Fachsitzungen

(Plenarsaal)

Hauptvorträge

SYPA 1.1	Mi	14:00–14:30	Plenarsaal	**Laser-driven ion acceleration in plasmas** — •Jörg Schreiber
SYPA 1.2	Mi	14:30–15:00	Plenarsaal	**Laser-driven electron acceleration in plasmas** — •Jeroen van Tilborg
SYPA 1.3	Mi	15:00–15:30	Plenarsaal	**Beam-driven electron acceleration in plasmas** — •Richard D'Arcy
SYPA 1.4	Mi	15:30–16:00	Plenarsaal	**Solar energetic electron events: Trying to understand the role of the shock** — •Nina Dresing, Max Bruedern, Raúl Gómez-Herrero, Bernd Heber, Andreas Klassen, Manuela Temmer, Solveig Theesen, Astrid Veronig
SYPA 2.1	Mi	16:30–17:00	Plenarsaal	**Plasma Wakefield Acceleration: Instabilities and Stabilization** — •Alexander Pukhov
SYPA 2.2	Mi	17:00–17:30	Plenarsaal	**LUX - A Laser-Plasma Driven Undulator Beamline** — •Andreas R. Maier
SYPA 2.3	Mi	17:30–18:00	Plenarsaal	**Magnetic reconnection as a particle accelerator** — •Michael Hesse
SYPA 2.4	Mi	18:00–18:30	Plenarsaal	**Experimental demonstration of proton bunch self-modulation and of electron acceleration in a 10m-long plasma** — •Patric Muggli

Fachsitzungen

SYPA 1.1–1.4	Mi	14:00–16:00	Plenarsaal	**Sympsium Plasma-based Particle Accelerators 1**
SYPA 2.1–2.4	Mi	16:30–18:30	Plenarsaal	**Sympsium Plasma-based Particle Accelerators 2**

SYPA 1: Sympsium Plasma-based Particle Accelerators 1

Zeit: Mittwoch 14:00–16:00 Raum: Plenarsaal

Hauptvortrag SYPA 1.1 Mi 14:00 Plenarsaal
Laser-driven ion acceleration in plasmas — •Jörg Schreiber — Ludwig-Maximilians-Universität München, Garching b. München

We investigate acceleration of ion bunches during relativistically intense laser pulse interactions with plasmas. Relying on coherent acceleration, such sources feature distinct ion bunch characteristics, including (ultra)short bunch duration, high bunch density, low emittance and synchronism with other parallel laser-driven sources. I review the main acceleration concepts based on our recent studies with various target (plasma) types; including ultrathin foils and levitated micro targets. For applications in fields of radiation physics, chemistry, biology and medicine, we have established the Centre for Advanced Laser Applications (CALA). CALA will feature the ATLAS3000 chirped pulse amplification system that delivers driving laser pulses with peak power of 3 petawatts. Advancing towards an integrated laser-driven ion accelerator system (ILDIAS) represents a remarkable technological challenge. In this talk, I present our experiences in target technology, ion beam guidance and instrumentation. Among the numerous potential applications of laser-driven particle acceleration [1], ion-bunch induced ultrasound waves in water is highlighted as a fascinating example at the interface of tailored detection methodology and physics at high local and instantaneous energy density.

[1] Bolton, P.R., K. Parodi, and J. Schreiber, Applications of Laser-driven Particle Acceleration. 2018: CRC Press, Taylor & Francis Group.

Hauptvortrag SYPA 1.2 Mi 14:30 Plenarsaal
Laser-driven electron acceleration in plasmas — •Jeroen van Tilborg — BELLA Center, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720

Laser plasma accelerators (LPAs) rely on the interaction of ultra-intense laser pulses ($> 10^{18}$ W/cm^2) and underdense plasma targets (density $\sim 10^{16} - 10^{19}$ cm^{-3}). The short-lived displacement of plasma electrons by the laser pulse results in a plasma wakefield co-propagating with the laser pulse, able to sustain acceleration gradients of order 100 GV/m in cm-scale plasma structures. Various injection schemes have been demonstrated to load background electrons into the wakefield, accelerating them to relativistic energies in well-directed beams.

In recent years, electron beams of several GeV have been demonstrated. The quality of the electron beams is being investigated with ever-advancing methods, targeting the beam emittance, charge, energy distribution, and bunch duration. Beams of sub-micron emittance, few-fs duration, with 10-100s of pC charge at GeV-level energies, all intrinsically locked to the femtosecond laser driver, are key LPA features. The availability of such beams has stimulated funding towards compact light source applications, advanced transport concepts, and high-field science experiments. I will present a general overview of LPAs, as well as highlight the compact light source efforts at the BELLA Center at LBNL.

Supported by: DOE Contract No. DE-AC02- 05CH11231 and the Gordon and Betty Moore Foundation Grant ID GBMF4898.

Hauptvortrag SYPA 1.3 Mi 15:00 Plenarsaal
Beam-driven electron acceleration in plasmas — •Richard D'Arcy — DESY, Notkestr. 85, 22607 Hamburg, Germany

Electric fields in plasma waves, driven by relativistic particle beams, can accelerate particles to tens of GeV energies over metre-scale distances. These accelerating gradients, orders of magnitude higher than those achievable in conventional radio-frequency cavities, have the potential to drastically reduce the footprint of future photon-science and high-energy-physics facilities if a number of technical challenges can be met. Through addressing these challenges, recent conceptual and experimental breakthroughs in the field have ushered in a world-wide effort that may be transformative for accelerators and their applications. To this end, beam-driven plasma-wakefield acceleration (PWFA) holds many potential advantages over other techniques, such as mitigated dephasing and defocussing, the opportunity for depletion studies, and the potential for immediate high-average-power plasma research. PWFA science, therefore, clearly warrants detailed investigation. The advent of experimental PWFA research in the 2000s was ushered in by the FACET and ATF facilities at SLAC and BNL, respectively. Thanks to the milestones reached by these groundbreaking experiments, additional facilities, such as the recently commissioned FLASHForward experiment at DESY – a precision PWFA facility with FEL-quality beams and MHz rep. rate capability – and the upcoming FACET-II – the ultra-high peak-current successor to FACET – will strive to make transformative leaps in the field in order to assess whether plasma-wakefield acceleration truly represents the wave of the future.

Hauptvortrag SYPA 1.4 Mi 15:30 Plenarsaal
Solar energetic electron events: Trying to understand the role of the shock — •Nina Dresing[1], Max Bruedern[1], Raúl Gómez-Herrero[2], Bernd Heber[1], Andreas Klassen[1], Manuela Temmer[3], Solveig Theesen[1], and Astrid Veronig[3] — [1]University of Kiel, Geramy — [2]SRG, University of Alcalá, Alcalá de Henares, Spain — [3]University of Graz, Austria

Solar energetic particles (SEPs) are believed to be accelerated either within strong magnetic re-connection areas at the Sun, so-called solar flares, or at shock fronts which may be driven by fast coronal mass ejections (CMEs). A specific class of events are the so-called widespread SEP events, where the energetic particles can be observed up to all around the Sun by multiple spacecraft at the same time. For these events an extended shock front is often favored to explain the extraordinarily wide particle distributions. However, in-situ observations of shocks at Earth's orbit reveal nearly no efficiency in accelerating electrons to energies of about 100 keV and more, typical for SEP events. We will show multi-spacecraft observations of the two STEREO and close-to-Earth observatories combining remote-sensing and in-situ measurements. We especially use energetic particle anisotropy observations to disentangle injection and transport effects to shed some light on the role of CME-driven shocks for the electron acceleration and their wide longitudinal distribution in the inner heliopshere.

SYPA 2: Sympsium Plasma-based Particle Accelerators 2

Zeit: Mittwoch 16:30–18:30 Raum: Plenarsaal

Hauptvortrag SYPA 2.1 Mi 16:30 Plenarsaal
Plasma Wakefield Acceleration: Instabilities and Stabilization — •Alexander Pukhov — Heinrich-Heine-University of Dusseldorf

New acceleration technology is mandatory for the future of high energy particle acceleration. A feasible approach is to exploit the plasma wakefield acceleration, where the driver can be a high intensity laser pulse or a charged particle beam. Already a lot of progress has been achieved on this path both in theory and experiment and several most promising configurations have been identified. On the other hand, the plasma is known for its instabilities that can significantly affect both the driver and the witness bunch. In some cases, the driver instability in plasmas is highly welcome, like in the AWAKE project, where a long proton driver has to undercome a deep self-modulation in a plasma column to be able to excite a strong plasma wave. In many other configurations, like the hollow plasma channel or a bubble or blow-out regime, the instabilities must be mitigated.

Hauptvortrag SYPA 2.2 Mi 17:00 Plenarsaal
LUX - A Laser-Plasma Driven Undulator Beamline — •Andreas R. Maier — Center for Free-Electron Laser Science and Department of Physics, Universität Hamburg, Hamburg, Germany

LUX is a novel laser-plasma accelerator. Building on the joint expertise of the University of Hamburg and DESY the beamline was carefully designed to combine state-of-the-art expertise in laser-plasma acceleration with the latest advances in accelerator technology and beam diagnostics. LUX introduces a paradigm change moving from single-shot demonstration experiments towards available, stable and controllable accelerator operation. Here, we discuss the general design concepts of

LUX and present first experimental results that have recently been achieved: This includes the 24h operation of the plasma accelerator with several 10.000 consecutive shots, and the generation of spontaneous undulator radiation at few-nm wavelength. Finally, we will discuss recent activities to upgrade the LUX beamline with a new undulator to demonstrate FEL gain following the decompression scheme.

Hauptvortrag SYPA 2.3 Mi 17:30 Plenarsaal

Magnetic reconnection as a particle accelerator — •Michael Hesse — Birkeland Centre for Space Science, University of Bergen, Bergen, Norway

Magnetic reconnection in plasmas is an efficient mechanism to convert stored magnetic energy to particle energy in an often-explosive fashion. Particle energization can be in form of increases of thermal energy, the kinetic energy inherent in bulk plasma motion, and in form of energetic tails of particle distribution functions. Acceleration can further occur by means of direct acceleration by the reconnection electric field or by Hall-type electric fields in the current layer, by the thermalization of particle beams, and by Fermi-type acceleration in the reconnection outflow region. Finally, there is excellent theoretical and observational evidence of the generation of high-energy tails not directly associated with the reconnection process, but rather as a result of magnetic reconfigurations downstream of the reconnection outflow. This talk will consist of an overview of the magnetic reconnection process, and of the various modes of particle acceleration associated with it. Theoretical predictions will be supported by observations, in particular from spacecraft operating in the near-Earth plasma environment.

Hauptvortrag SYPA 2.4 Mi 18:00 Plenarsaal

Experimental demonstration of proton bunch self-modulation and of electron acceleration in a 10m-long plasma — •Patric Muggli for the AWAKE-Collaboration — Max Planck Institute for Physics, Munich, Germany

Self-modulation of a long, relativistic particle bunch in a dense plasma is a proposed scheme to drive large amplitude wakefields over a long distance. Externally injected electrons can then gain large amounts of energy in a single plasma, thereby avoiding well-known staging issues. We will explain the principle of the AWAKE experiment that uses a 400GeV proton bunch to demonstrate this acceleration scheme. We will show detailed experimental results demonstrating the control of the self-modulation process through two seeding methods. We will also show that externally injected MeV electrons were accelerated to the GeV energy scale. Finally, we will briefly outline future experiments and possible applications of this acceleration scheme.