P 17: Poster II

Time: Friday 14:00–16:00 Location: P

P 17.1 Fri 14:00 P

Minimal invasive extraction and ex situ analysis of nanoparticles synthesized in a reactive plasma — •Maren Dworschak, Franko Greiner, and Oguz Han Asnaz — Institut für Experimentelle und Angewandte Physik, CAU Kiel

Plasma systems generating nanometer-sized particles are relevant for a broad range of applications from biomedicine to catalysis and batteries where knowledge about the size of the generated particles and their size distribution is critical. In situ analysis of nanoparticles created in a reactive Ar/C2H2-plasma using kinetic Mie-ellipsometry encounters problems when trying to detect particles at both extremes of the size scale. Because it reaches its limits for small (<50 nm, Rayleigh regime) and very large particles (>250 nm, multiple scattering) ex situ analysis has to be done. An optimal particle extractor should (i) not disturb the plasma chemistry, (ii) not change the discharge properties, and (iii) be able to extract several samples during one growth cycle.

We present a device to extract nanoparticles at multiple moments during a single growth cycle, while not disturbing the process itself. The extraction method is based on the electrostatic force and allows to extract particles at eight stages of the growth process. During extraction, we monitor the dynamics of the particle cloud with a camera and the particle size via Mie-ellipsometry. The particles are diagnosed ex situ with atomic force microscopy to determine the particle size distribution. The particle charge can be estimated using force balance equations. [Dworschak et al., Plasma Sources Sci. Technol. (2021), https://iopscience.iop.org/article/10.1088/1361-6595/abe4c0]

P 17.2 Fri 14:00 P

Structural properties of binary dusty plasmas — •Charlotte Büschel, Lasse Bruhn, and Dietmar Block — Institut für Experimentelle Plasmaphysik der Christian-Albrechts-Universität zu Kiel, Leibnizstraße 11-19, 24118 Kiel, Deutschland

Complex plasmas with microparticles can be used to analyze strongly coupled systems on an individual particle level. Using binary mixtures of particles, i.e. two particle species of different material and size and thus different charge but at similar confinement conditions, opens up new possibilities to study polydisperse systems. To generate a binary mixture, both species have to have identical confinement conditions. Even small differences result in a separation of the species. That a fully mixed state is nevertheless possible was shown by Wieben et al. [1], where the size loss due to etching processes in the plasma was utilized. First experiments on binary mixtures studied waves [2] as well as thermodynamics [3] . These investigations focused on particle systems in a mixed state. So far, there were no studies about the process of mixing. In this contribution structural properties of binary systems are analyzed on their way from a demixed to a mixed state. Special emphasis is put on the density profile and configurational changes during the mixing process. Thus, this study aims at a global as well as local description of the structure of binary systems as a function of their mixing state.

1. F. Wieben et al., Phys. Plasmas , Vol. 24, No. 3, 2017)
2. Yang et al., EPL , Vol. 117, No. 2, 2017
3. Wieben and Block, Phys. Rev. Lett. , Vol. 100, 2019)

P 17.3 Fri 14:00 P

Fast 3D particle position reconstruction using a neural network — •Michael Himpel and André Melzer — Institut für Physik, Universität Greifswald

We present an algorithm to reconstruct the three-dimensional positions of a particle cloud using a convolutional neural network. The approach is found to be very fast (thousands of particles in less than one second) despite its relatively high accuracy. It is special to this algorithm that the computing workload is separated into two parts: The energy- and time comsuming training, followed by the framewise non-intense and fast reconstruction. This makes this algorighm especially suitable for remote applications. The algorithm is applied to synthetic as well as experimental data from parabolic flights.

P 17.4 Fri 14:00 P

Stereoscopic Meassurements of Dusty Plasmas under Microgravity — •Daniel Maier, Michael Himpel, Stefan Schütt, and André Melzer — Institut für Physik der Universität Greifswald, Greifswald, Deutschland

Stereoscopic measurements to calculate 3d positions and trajectories of particles in a dusty plasma are a key item for the investigation of transport processes in complex particle systems. Stereoscopy is used in our group for many years now and the experimental set-up is constantly developed further, with the implementation of new faster cameras with higher recording rates as the latest improvement. In this contribution the present state of our measurement set-up, the procedure to detect the dust particles and to calculate their 3d trajectories will be shown. This includes first results on the observation of particle chains in dusty plasmas.

P 17.5 Fri 14:00 P

Thermal gradient induced dust convections in a dc plasma under microgravity conditions — •Andreas Schmitz, Ivo Schulz, Michael Kretschmer, and Markus Thoma — I. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Germany

Experiments with complex plasmas were conducted in an engineering model of the International Space Station's laboratory setup Plasmakristall 4 during ESA's 71th parabolic flight campaign in the A310 ZERO-G aircraft in May 2019. In some of these microgravity experiments a DC discharge plasma was generated within the elongated glass tube of PK-4. The investigated complex plasma was introduced to a thermal gradient caused by a heater ring mounted around the plasma chamber. The dust cloud was trapped near the heater where the cloud convected. It was concluded that this dust cloud convection was induced by a gas flow via drag. Analysis of the dust cloud convection showed this gas flow to have been caused by thermal creep, a phenomenon which is common in rarefied gases with a temperature gradient along a boundary.

P 17.6 Fri 14:00 P

"Zyflex": next generation plasma chamber for complex plasma research in space — •Christina A. Knapek[1], Uwe Konopka[2], Daniel P. Mohr[1], Peter Huber[1], Andrey M. Lipaev[3], and Hubertus M. Thomas[1] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Weßling, Germany — [2]Auburn University, Auburn, AL, USA — [3]Joint Institute for High Temperatures of the Russian Academy of Sciences, Moscow, Russia

Complex plasmas consist of highly charged micrometer-sized grains injected into a low temperature noble gas discharge. Since gravity has a strong influence on the particle system, experiments under microgravity conditions are essential. A novel plasma chamber (the "Zyflex" chamber) has been designed for complex plasma research in a future facility on the International Space Station (ISS). The cylindrical, radiofrequency driven discharge device includes a variety of innovations that for example allow to flexibly adjust plasma parameters and its volume. Compared to former chambers used in space based complex plasma facilities, it also supports much larger particle systems and can be operated at much lower gas pressures, thus reducing the damping of particle motion considerably. Beyond the technical description and particle-in-cell (PIC) simulation based characterization of the plasma vessel, we show sample results from experiments performed with this device in the lab as well as during parabolic flights. Further, an outlook on the future ISS facility COMPACT with the Zyflex chamber at its core is given. This work is funded by DLR/BMWi (FKZ 50WM1441).

P 17.7 Fri 14:00 P

Influence of the surface roughness on the adhesion of thermal plasma spray Al2O3 coatings — •Tony Krüger[1], Thorben Kewitz[1], Holger Testrich[1], Rüdiger Foest[1], and Franz Faupel[2] — [1]Leibniz Institute for Plasma Science and Technology, 17489 Greifswald, DE — [2]Kiel University, 24143 Kiel, DE

In industrial plasma spray processes, masks are used to protect areas of the work piece from unwanted coating. However, gradual accumulation of material on masks can lead to changes in the flow dynamics near masks causing loss of contour accuracy and coating quality. Hence, generating surfaces conditions for masks that affect film adhesion and promote swift delamination becomes attractive. In thermal spray processes, bonding between the coating and a substrate surface is mainly established by mechanical anchoring, next to physical and chemical interactions. Here, the influence of the surface roughness on the coating adhesion is studied systematically. The surface roughness of steel was varied by means of plasma electrolytic polishing in order to provide a series of samples with a defined range from $2.5\mu m \geq$Ra$\geq 0.02\mu m$, measured using surface profilometry and white light interferometry, for critical method comparison. Moreover, the effect of additional interface layers (TiN, SiOx) on the film adhesion was investigated. Samples were spray coated with Al2O3 (2kg/h) using a Oerlicon Metco F4MB-XL Spray Gun (DC, I=600A, gases: Ar (41 NLPM), H2 (14NLPM)). The relation between thin film adhesion and surface conditions (roughness and presence of interface layers) is examined (Funded by the EU and the State of Mecklenburg-Western Pomerania (TBIV-1-321)).

P 17.8 Fri 14:00 P

Control and monitoring of spatial discharge distribution in a barrier corona discharge at elevated pressures — •Hamed Mahdikia, Michael Schmidt, Volker Brüser, and Ronny Brandenburg — Leibniz Institute for Plasma Science and Technology, 17489, Greifswald, Germany

A barrier corona discharge in CO2 with admixture of Argon is studied. The aim is to investigate the operation at elevated pressures up to 5 bar for industrial scale CO2 conversion. Therefore, the coaxial asymmetric dielectric barrier discharge contains an inner brush electrode to intensify the electric field strength and to minimize the amplitude of the applied high voltage driving the discharge. Charge-voltage plots are used to characterize the discharge. Depending on the conditions (sinusoidal voltage amplitude, gas composition), full or partial coverage of the electrodes is obtained. This so-called partial discharging is monitored by the variation of the effective dielectric capacitance. It increases exponentially for a mixture of Ar and CO2 (1:4) at 1 bar and reaches its maximum (i.e. fully electrode covering discharge) as the amplitude of the applied high voltage exceeds 8 kV. It decreases linearly with the increasing the pressure. The cell capacitance remains constant under variation of gas and pressure. The higher the pressure the higher the sustaining voltage and the lower the surface coverage fraction of the plasma. This may be due to the fewer and weaker micro discharges due to the lower ionization rate at higher pressures.

P 17.9 Fri 14:00 P

Splitting of CO2 with negative nanosecond pulsed dielectric barrier discharge — •Sepideh Mousazadeh borghei, Raphael Rataj, Volker Brüser, and Juergen F Kolb — Leibniz Institute for Plasma Science and Technology (INP),Greifswald, Germany

Carbone dioxide, one of the inevitable by-products of human activities, is a notable contribution to the current climate change. Conversion of CO2 into value added chemicals and fuels namely CO and CH3OH has drawn remarkable attention as a potential solution. For the splitting of CO2 into CO and O2, harsh conditions are required, owing to the high stability of the CO2-bonds. Non-thermal plasma has provided an innovative way. The goal is to provide electrons with sufficient energy, i.e. temperature, while the gas temperature can remain close to room temperature. In the first step of our project, we studied the effects of gas flow rates and mixture ratios of CO2 with argon on CO2-splitting. Therefore, a cylindrical dielectric barrier discharge reactor was set up to investigate efficacies and efficiencies. The plasma was generated by the application of negative high voltage pulses of nominally -20 kV and a pulse duration of 500 ns to an inner rod-electrode that was insulated by a glass wall with gap distance of 4 mm from the surrounding grounded electrode with 90 mm in length. Pulse repetition rates were set to 1 kHz. Gas compositions after treatment were investigated by FTIR spectroscopy. The results demonstrated that the flow of the feed gases played a significant role in CO2-conversion. The highest conversion rate was achieved for the lowest flow rate of 30 sccm, yielding 6% of CO.

P 17.10 Fri 14:00 P

Plasma catalytic synergies of a non-equilibrium atmospheric pressure plasma jet and MnO_2 surface catalyst — •Christoph Stewig, Theresa Urbanietz, Laura Chauvet, Marc Böke, and Achim von Keudell — Ruhr-University-Bochum, Germany

Plasma catalysis has the goal to exploit potential synergies between plasma and surface catalytic reactions. With the advent of renewable energies, this could allow the utilization of excess electrical energy to produce value-added molecules and thus provide the chemical industry with important reactants or store this energy.

Potential synergetic effects are: (i) a reduction or prevention of catalyst poisoning due to a cleaning of the catalyst surface, hence (ii) a lowering of the catalyst activation temperature, and (iii) an increase in the catalyst activity due to the creation of additional reactive sites by the plasma. (iv) finally, specific molecular excitations could promote specific surface reactions.

Due to the temperature dependence of surface catalysis, it is necessary to avoid intense surface heating. Thus, we employ a RF driven temperature-controlled capacity coupled plasma jet. Fourier Transformed Infrared Spectroscopy (FTIR) measurements are conducted in the plasma and yield information on the excitation and density of noble gas diluted molecules like CO_2 or n-butane.

The effect of an MnO_2 surface catalyst for temperatures between 20°C and 200°C on the dissociation of CO_2 and n-butan is presented.

P 17.11 Fri 14:00 P

Diagnostic of temporal behavior of a plasma electrolytic polishing process — •Sehoon An[1], Luka Hansen[2], Thorben Kewitz[1], Gregor Gött[1], Sehyun Kwak[3], Maik Fröhlich[4], Rüdiger Foest[1], Katja Fricke[1], Antje Quade[1], Klaus-Dieter Weltmann[1], and Holger Kersten[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [3]Max Plank Institute for Plasma Physics, Greifswald, Germany — [4]Leupold Institute of Applied Sciences, University of Applied Sciences Zwickau, Zwickau, Germany

Plasma electrolytic polishing (PEP) has gained much attention owing to various surface modifications including oxidation or removal of material by selective dissolution of chemical compounds. During the PEP process, a volatilization of the electrolyte leads to a gas layer around the working electrode accompanied with spark discharges. The stability of the gaseous layer directly influences the material removal rate. Here, we investigate the temporal behavior of the gaseous layer involving numerous single discharges by synchronized electrical monitoring (current and voltage waveforms) and optical inspection (high-speed video, 1000 fps). We report on observations regarding oscillating discharge current and characteristic frequencies obtained by fast Fourier transformation (FFT) in relation to the process parameters and the temporal evolution of the workpiece temperature.

P 17.12 Fri 14:00 P

Diagnostics for the JT-60SA pellet source commissioning — •Jan-Henrik Ufer[1], Peter Lang[2], Bernhard Plöckl[2], Martin Prechtl[1], and ASDEX Uprade Team[2] — [1]Hochschule Coburg — [2]Max-Planck-Institut für Plasmaphsyik

JT-60SA is a superconducting tokamak currently under commissioning in Naka, Japan. It was built in a collaboration between Europe and Japan aiming to resolve key physics and engineering issues for ITER and a future fusion reactor. Equipped with superconducting coils it will be capable to investigate long lasting advanced modes of plasma operation for pulse durations up to 100 s. In this context, exploration of the high density regime and ELM control is envisaged. Therefore, a novel pellet system - pellets are mm sized solid hydrogen bodies - is under construction serving for both tasks. Any task got an accordingly designed pellet source attributed. Both the commercially supplied sources will be tested and commissioned in a dedicated European test stand. There, quality and mass throughput of the extruded ice rod as well as the quality and maximum achievable rate of pellets cut from this rod have to be diagnosed. A monochrome camera system comprises a video mode to record the initial ice extrusion and a stroboscopic mode to monitor pellet production with a flash laser. The laser is synchronised with the cutter actuation, emitting short light pulses imaging pellets avoiding movement blur. The contribution will show the designed layout of the pellet system, our diagnostics unit and the planned test sequences for the fuelling and the pacing pellet sources.

P 17.13 Fri 14:00 P

Towards the operation of a high-resolution mass spectrometer for exhaust gas analysis at ASDEX Upgrade — •Antonello Zito[1,2], Thomas Schwarz-Selinger[1], Volker Rohde[1], Athina Kappatou[1], and Marco Wischmeier[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Physik-Department E28, Technische Universität München, Garching, Germany

The removal of helium, which is the product of the D-T reaction, in magnetic fusion devices must be as efficient as possible in order to avoid fuel dilution and not degrade the confinement properties. Optimizing the strategies for a good helium pumping is possible by monitoring the behavior of the exhaust gas in helium-seeded plasma discharges in currently operating devices. In the framework of helium exhaust studies, a high-resolution quadrupole mass spectrometer has been recently installed at the pumping ducts of the ASDEX Upgrade tokamak. This diagnostic has been proven successful in discriminating molecules of deuterium and atoms of helium, which have a tiny mass difference of only 0,025 AMU, with elevated accuracy. The capability of detecting even trace levels of helium ($< 5\%$) in a deuterium gas has been confirmed. However, the harsh environment involving the presence of radiations and intense currents in proximity of the instrument is seen to strongly affect the reliability of the measurements during plasma operations. In this work we will present some of the challenges which were faced during the efforts towards the detection of helium in the exhaust gas of ASDEX Upgrade using this technique.

P 17.14 Fri 14:00 P

Determination of 2D Filament Temperatures and Densities at ASDEX Upgrade with the Thermal Helium Beam Diagnostic — •Daniel Wendler[1,2], Michael Griener[1], Gregor Birkenmeier[1,2], Rainer Fischer[1], Ralph Dux[1], Elisabeth Wolfrum[1], Ulrich Stroth[1,2], and the ASDEX Upgrade team[1] — [1]Max-Planck- Institut für Plasmaphysik, Garching, Germany — [2]Physik Department E28, TUM, Garching, Germany

In all plasma scenarios in magnetic confinement fusion, small filamentary structures appear in the scrape-off layer (SOL), with a locally strongly enhanced density, which propagate convectively outwards. Blobs contribute to reactor relevant phenomena like the density shoulder formation, large first wall particle fluxes and the broadening of the divertor heat flux fall-off length. To calculate the effective power flux which is carried by the filaments, temperature and density as well as the frequency and velocity of blobs have to be determined. While the measurements of mean blob velocities are possible with various diagnostics, the simultaneous non-invasive measurement of temperatures and densities of single filaments is now possible with the thermal helium beam diagnostic. By means of a grid of poloidally and radially distributed lines of sight, the temperature, density and velocities as well as the blob shape can be determined in two dimensions. Another way of measuring the filament temperature and density is beam emission spectroscopy, in the case here measured with a thermal helium beam diagnostic. First results of blob temperatures and densities will be shown and an extended collisional-radiative model will be presented.

P 17.15 Fri 14:00 P

Challenges in the tomographic reconstruction of radiation distributions of high temperature plasmas in Wendelstein 7-X stellarator — •Henning Thomsen, Christian Brandt, Sara Vaz Mendes, Kian Rahbarnbia, and Jonathan Schilling — MPI f. Plasmaphysics, Wendelsteinstr 1, 17491 Greifswald

The spatial-temporal dynamics of plasma radiation in the soft-X ray range is studied by means of the tomography diagnostic system (XMCTS) in Wendelstein 7-X stellarator. The radiation in this energy range originates mainly from Bremsstrahlung of the confined plasma. The quality tomographic inversion, the reconstruction of the radiation distribution in the plane spanned by the pinhole cameras from the line-integrated measurements, is strongly dependent on an accurate modelling of the diagnostic geometry. In this contribution we study the effect of the 3D shaped plasma in the observation volume. This effect is potentially more relevant in stellarators than in other magnetic confinement devices with simpler flux surfaces (like tokamaks).

P 17.16 Fri 14:00 P

Modelling of plasma ion heat flux in the edge of ASDEX Upgrade with EMC3-EIRENE for an improved understanding of the H-mode access — •Philipp Sauter[1,2], Thomas Eich[1], Dominik Brida[1], Marco Cavedon[1], Tilmann Lunt[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Universität Tübingen, 72074 Tübingen, Germany

The future nuclear fusion device ITER will be operated in an improved confinement regime.. The access to H-mode relies critically on the ion heat flux crossing the edge region of the plasma [1]. This work analyses the role of the ion heat flux on the transition from L-Mode to H-Mode The EMC3-Eirene simulation code is used to simulate plasma discharges in ASDEX Upgrade at different powers and densities with varying proportions of heating in electrons and ions. Parallel and perpendicular heat fluxes are obtained in order to quantify heat fluxes crossing the separatrix and being transported to the divertor. In particular, it is investigated if the collisional heat exchange from ions to electrons at high collisonalities is able to reduce the ion heat flux to a level where an H-L back transition is triggered. Also, the correlation of the ion electron temperature ratio at the separatrix with various plasma parameters is investigated. Here it is found that the ratio of ion to electron heat fluxes crossing the separatrix correlates with that ratio, while no correlation with the collisionality parameter suggested previously [2] was found. [1] Ryter F. et al 2016 PPCF 58 014007 [2] Stangeby P. 2000, The Plasma Boundary of Magnetic Confinement

P 17.17 Fri 14:00 P

Transport coefficients at W7-X based on target heat loads — •David Bold, Felix Reimold, Holger Niemann, Yu Gau, Marcin Jakubowski, and the W7-X team — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

In the current study the divertor heat load distribution of Wendelstein 7-X (W7-X) has been analysed based on heatfluxes reconstructed from infrared temperature measurements. Due to the inherent 3D nature of the scrape-off layer (SOL) of W7-X, also the heatflux pattern is 2D on the target in nature, unlike in Tokamaks, where a 1D representation is regularly used.

At low densities most of the heatflux is deposited on the low-iota target, as expected from modelling. A narrow strike line, overlayed by a broad feature is observed. The narrow strike line is of the range of 2 to 4 cm, while the broad feature is around 10 to 20 cm wide for an attached case with low radiated power. Additionally to studying the strike line width, also the toroidal distribution on the target is studied. It is observed that in the experiment a significant amount of the power is deposited at the far end of the low-iota target, while with increasing density the power is more evenly distributed on the low-iota target.

The analysis of the experimental data is compared to EMC3-EIRENE simulations, where the diffusion coefficients are varied in order to match the experimental results. It is observed that a simple, constant diffusion coefficient is not sufficient to reproduce the experimental measurements. The impact of spatially varying diffusion coefficients is studied.

P 17.18 Fri 14:00 P

Causality study on the drift-wave turbulence – zonal-flow coupling at the TJ-K stellarator. — •Nicolas Dumérat, Bernhard Schmid, and Mirko Ramisch — IGVP, University of Stuttgart

We present a set of two non-parametric methods used for inferring causality amongst parameters measured in the same complex system. Convergent cross-mapping, a forecasting approach is introduced, based on time-delay embedding and state space reconstruction. This method showed good results for measuring the strength and direction of influence of causal relationships in synthetic datasets. A second method, called transfer entropy, is also investigated, the basis of which is the measurement of information flow between variables. The use of these methods allows for the identification of causal links between variables and can be extended to turbulence studies. In this frame, it is known that zonal flows are driven by the localized tilting of ambient turbulent structures. This deformation of the eddies can be caused by existing shear flows and measured experimentally via Reynolds stress. Langmuir probe measurements from the TJ-K stellarator are then used as experimental inputs for the presented methods. The results support the theoretically expected causal connection of eddy tilting to zonal-flows occurance.

P 17.19 Fri 14:00 P

Control of Spokes in HiPIMS Discharge — •Mathews George, Wolfgang Breilmann, Julian Held, and Achim von Keudell — Experimentalphysik II, Ruhr-University Bochum

Magnetron Sputtering is a Plasma Vapour Deposition (PVD) process widely used in industry and scientific communities. HiPIMS (High Power Impulse Magnetron Sputtering) produces plasma pulses of very high density of the order of $10^{19}\mathrm{m}^{-3}$ without overheating the target. The plasma appears to be homogeneous to the human eye, but shows localised zones of high brightness rotating in the **E x B** direction when observed with an ICCD camera with exposure times below 1μs. These local ionization zones, also called 'spokes' are assumed to play a role in the transport of particles and energy away from the target. This anomalous transport results in an enhanced deposition rate by counteracting the return effect. The primary objective of this project is to control spoke frequency in HiPIMS in-order to study its influence on the IEDF and metal ion flux from the target. Controlling metal ion flux from the target would lead to a better deposition rate and quality of the film. DCMS was chosen for the development of spoke control as an initial test object since the spokes in DC regime are more uniform compared to HiPIMS.

P 17.20 Fri 14:00 P

Control of Spokes in Magnetron Discharges — •Mathews George, Wolfgang Breilmann, Julian Held, and Achim von Keudell — Experimentalphysik II, Ruhr-University Bochum

Magnetron Sputtering is a Plasma Vapour Deposition (PVD) process widely used in industry and scientific communities. The plasma appears to be homogeneous to the human eye, but shows localised zones of high brightness rotating in the **E x B** direction when observed with an ICCD camera with exposure times below 1μs. These local ionization zones, also called 'spokes' are assumed to play a role in the transport of particles and energy away from the target. This anomalous transport results in an enhanced deposition rate by counteracting the return effect. The primary objective of this project is to control spoke frequency in HiPIMS in-order to study its influence on the IEDF and metal ion flux from the target. Controlling metal ion flux from the target would lead to a better deposition rate and quality of the film. DCMS was chosen for the development of spoke control as an initial test object since the spokes in DC regime are more uniform compared to HiPIMS. Amplified rectangular signals are applied to a Langmuir probe to draw electron current from the plasma at the highest gradients in the **E x B** direction. The responses of the spoke frequency and intensity to the applied signal are measured with a flat probe. The metal ion flux from the target surface is measured time and energy resolved with a mass spectrometer. This study is then further extended to HiPIMS spokes by applying signals on multiple probes to achieve an effective control of spokes.

P 17.21 Fri 14:00 P

Updates on The He/Ne beam diagnostic for line ratio spectroscopy in the Island Divertor of Wendelstein 7-X — Erik Flom[1], Tullio Barbui[1,2], Oliver Schmitz[1], Marcin Jakubowski[3], Frederik Henke[3], Carsten Killer[3], Maciej Krychowiak[3], Ralf Koenig[3], Stuart Loch[4], Jorge Munoz-Burgos[5], John Schmitt[4], and •The W7-X Team[3] — [1]University of Wisconsin-Madison, Madison, WI — [2]Princeton Plasma Physics Laboratory, Princeton, NJ — [3]Max Planck Institute for Plasma Physics, Greifswald, Germany — [4]Auburn University, Auburn, AL — [5]Astro Fusion Spectre, San Diego, CA

A line-ratio spectroscopy system based on thermal helium and neon collisional radiative models (CRM) has been implemented and successfully shown to enable measurement of ne and Te above the horizontal divertor targets in two in the standard divertor configuration magnetically connected modules of the Wendelstein 7-X optimized stellarator. In this work, modeling results are presented for standard attached and detached conditions in the divertor of Wendelstein 7-X to show the helium and neon emissivity as a function of radial position above the divertor target. This work also includes first in-situ measurements of gas cloud atomic density distribution from an gas injector identical to the one utilized at W7-X. Also shown are comparisons between helium beam data and multipurpose manipulator probe data using a novel flux coordinate system, an improvement over previous field-tracing methods for diagnostic comparison within the 5/5 island chain.

P 17.22 Fri 14:00 P

Three-dimensional Finite Element Modelling of Magnetic Measurements of Tearing Modes in ASDEX Upgrade — •Magdalena Bauer, Marc Maraschek, Hartmut Zohm, Wolfgang Suttrop, Anja Gude, Felix Klossek, and the ASDEX Upgrade Team — Max Planck Institute for Plasma Physics, Garching

A tearing mode can be measured by various magnetic pick-up coil types characterized by their orientation and distance to the plasma and the surrounding conducting structures. Depending on the rotation frequency of the mode, screening currents are induced in these conductors that influence the magnetic measurements differently. A fast rotating mode can only be detected by the one coil type, whereas a locked mode signal is only available for the other type. In order to get a continuous description for all frequencies, a three-dimensional finite element model of the tokamak ASDEX Upgrade, including the geometry of the resonant surface of the tearing mode, the conducting vessel and passive stabilization loop (PSL), is implemented. The mode itself is described by a perturbation current density on the respective resonant surface from the equilibrium reconstruction. The simulated magnetic measurements of the mode, including the field of the mirror currents in the conducting structures, are used for a frequency dependent adaption of the experimentally determined magnetic perturbation field. The approach for adjusting the signals of the different types of magnetic measurements for various frequencies to get a unique perturbation amplitude, using the newly developed tool, is established and can be extended for the locked phase of the MHD mode.

P 17.23 Fri 14:00 P

Gaussian Process Surrogate Models for Uncertainty Quantification in Multiscale Turbulent Transport Simulations — •Yehor Yudin, Jalal Lakhlili, Onnie Luk, Udo von Toussaint, and David Coster — Max Planck Institute for Plasma Physics, Boltzmannstrasse2, 85748 Garching, Germany

One of the challenges in understanding fusion plasmas is quantifying the effects of micro-scale turbulent dynamics on energy and particle transport processes in a fusion device. In order to analyze such effects, one should numerically solve a model which couples system evolution on disparate spatial and temporal scales, as well as consider both aleatoric and epistemic uncertainty of such model. For such a solution the largest share of computational expense is spent on resolving turbulence related scales. This work proposes an application of a surrogate modelling approach to reduce computational costs for a solution in a case close to a quasi-steady state when it is sufficient to capture only statistics of turbulent dynamics. We studied a Multiscale Fusion Workflow that couples gyrofluid turbulence code GEM in flux tube approximation with core transport code ETS, and calculates transport coefficients from turbulent energy and particle fluxes. For that, we applied the VECMA toolkit to perform uncertainty quantification, as well as to train, test and utilize surrogate models. In this work, a data-driven probabilistic surrogate model based on Gaussian Process Regression is used to infer flux values computed by a turbulence code for given core profiles, and to calculate related uncertainties.

P 17.24 Fri 14:00 P

Extension of GENE-3D to a global electromagnetic turbulence code for stellarators — •Felix Wilms[1], Alejandro Bañón Navarro[1], Gabriele Merlo[2], Leonhard Leppin[1], Tobias Görler[1], Tilman Dannert[3], Florian Hindenlang[1], and Frank Jenko[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching b. München, Germany — [2]Oden Institute for Computational Engineering and Sciences, Austin,Texas 78712, USA — [3]Max Planck Computing and Data Facility, 85748 Garching, Germany

GENE-3D is a code that is capable of simulating gyrokinetic plasma turbulence in stellarators globally (Maurer et al., Journal of Computational Physics, 2020). It has recently been upgraded to an electromagnetic version, expanding the variety of turbulent features that can be studied with it. In this work, we present the underlying algorithm, together with verification studies against the established global tokamak code GENE (Jenko et al., Physics of Plasmas, 2000). Finally, we present a first application to stellarator physics, by investigating the influence of finite plasma-β on ITG turbulence in Wendelstein 7-X.

P 17.25 Fri 14:00 P

Study of slow wave propagation in IShTAR — •Felix Paulus, Volodymyr Bobkov, Roman Ochoukov, and Oleksii Girka — Max-Planck-Institute fürPlasmaphysik, Boltzmannstr. 2, 85748 Garching

Ion cyclotron resonance heating (ICRH) is an established technique to reach fusion relevant temperatures in modern tokamaks. While the fast Alfven wave is launched intentionally to heat the plasma, it is believed that the parasitically launched slow wave is a source for electric fields parallel to the background magnetic field (Myra & D'Ippolito, 2008). Since the slow wave (sw) propagates in low density plasma its existence remained unconsidered in tokamaks for a long time. Recent developments suggest, that the plasma density in the far SOL of a tokamak drops below the lower hybrid resonance density opening a channel for sw propagation which might induce further plasma dynamics.

Here we show results from experiments carried out on IShTAR - a linear plasma device - where we measure the slow wave, that is launched into a magnetized low-density plasma by a wire loop antenna, with a floating probe. The results are compared to FEM simulations from RAPLICASOL (Tierens, et al., 2019) and further analytical considerations. Based on these results future experiments on the ASDEX Upgrade tokamak are proposed.

P 17.26 Fri 14:00 P

Divertor optimization for the stellarator experiment W7-X —

•Amit Kharwandikar, Dirk Naujoks, Thomas Sunn Pedersen, Felix Reimold, and The W7X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

The Wendelstein 7-X (W7-X) is an advanced stellarator device operated in Greifswald, to provide the proof of principle that the stellarator concept can meet the requirements of a future fusion reactor. To fulfil this goal, several experimental campaigns have been conducted over the years. In the recent OP1.2 campaign, ten adiabatically loaded divertor units (Test Divertor Units (TDU)) have been installed in the plasma vessel together with baffles, toroidal/poloidal closures, etc. During the experiments, high heat loads onto in-vessel components have been observed, that exceed the specified limits under certain conditions. This immediate concern and the need to transition to fusion reactor relevant material (e.g. Tungsten) for plasma facing components (PFC) to achieve the long-term goals, motivate the need for a new divertor design. This poster discusses the investigation of the physics basis for such a new divertor concept with the objectives as heat load reduction and high gas exhaust. The important technical constraints are specified as well as the main modelling tools to be used, namely the Field Line Transport (FLT) code and EMC3-Eirene. As a current activity, example applications of FLT for studying erosion-redeposition and certain baffle overload scenarios have been described. Finally, the main conceptional ideas to achieve the desired optimized plasma facing surface for the W7-X divertor and baffle are presented.

P 17.27 Fri 14:00 P

Manipulating the radial deposition of positrons in a magnetic dipole trap — •Stefan Nissl[1,2], Eve Stenson[1,2,3], Juliane Horn-Stanja[1], Uwe Hergenhahn[1,7], Thomas Sunn Pedersen[1,4], Haruhiko Saitoh[6], Christoph Hugenschmidt[2], Markus Singer[2], Matthew Stoneking[1,5], and James Danielson[3] — [1]Max-Planck-Institute for Plasma Physics, Greifswald & Garching, Germany — [2]Technische Universität München, Garching, Germany — [3]University of California, San Diego, La Jolla, CA — [4]University of Greifswald, Greifswald, Germany — [5]Lawrence University, Appleton, WI — [6]The University of Tokyo, Tokyo, Japan — [7]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

In a pair plasma, both particle species have the same mass. Compared to an electron-ion plasma, a pair plasma is predicted to have unique characteristics and excellent stability properties. A Positron-Electron eXperiment (APEX) has the goal to create such a kind of plasma in a magnetic dipole trap for the first time. An important step towards this goal is to know how parameters of the experiment, such as electrode biases, effect the radial deposition of positrons in the magnetic dipole field. For that, we reanalyzed experimental data, compared them to numerical single-particle simulations, and found multiple parameters that modify the radial deposition of positrons without deteriorating the required high injection efficiency. These results can be used to design upcoming experiments about long confinement and pulse stacking.

P 17.28 Fri 14:00 P

Investigating impurity transport at the plasma edge in different confinement regimes at ASDEX Upgrade via charge exchange recombination spectroscopy — •Tabea Gleiter[1,2], Ralph Dux[1], Marco Cavedon[1], Rachael McDermott[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Physik-Department E28, Technische Universität München, Garching, Germany

In our recently started project, we investigate the impurity transport at the plasma edge in different confinement regimes at ASDEX Upgrade. In particular, we look at scenarios without or with only small (type-II) edge localized modes (ELMs), such as the I-mode, QCE-mode and EDA-H mode, in comparison to the standard type-I ELMy H-mode. Due to the considerable influence of ELMs on the particle exhaust at the plasma edge, the impurity transport is expected to differ significantly. This is especially of interest since future tokamaks such as ITER and DEMO could benefit from the reduced peak power fluxes at the divertor in 'ELM-free' regimes, but are also reliant on small impurity concentrations in the plasma core. In our experiments, we use active charge exchange recombination spectroscopy (CXRS) to study the temporal and radial evolution of the impurity densities. The detailed approach and first results will be presented.

P 17.29 Fri 14:00 P

Early stages of He cluster formation in tungsten single crystals — •Annemarie Kärcher[1,2], Vassily V. Burwitz[2], Thomas Schwarz-Selinger[1], and Wolfgang Jacob[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Technische Universität München, 85747 Garching, Germany

Tungsten (W) has been established as a main candidate for plasma-facing materials (PFMs) in future nuclear fusion reactors due to its favorable properties regarding the fusion environment. As PFM, tungsten will be subjected to intense impinging fluxes of helium (He). While the consequences of high He fluxes on the surface of tungsten materials have already been thoroughly studied, the mechanisms behind the early stages of the He cluster formation are still unclear. In order to understand the initial steps of the interaction of He with W, especially the impact of pre-existing defects, defined defects are induced in W111 single crystals and characterized by positron annihilation spectroscopy (PAS). Then, these are exposed to a low-temperature He plasma using an implantation energy below the displacement theshold. These He implanted samples are measured by PAS, elastic recoil detection analysis and thermal desorption spectroscopy. The experimental results are compared to simulation data.

P 17.30 Fri 14:00 P

Semilagrangian hybrid kinetic/driftkinetic code for the studying of fusion plasmas — •Aleksandr Mustonen[1], Felipe Nathan de Oliveira[1], Ken Hagiwara[2], Karen Pommois[1], Florian Allman-Rahn[3], Simon Lautenbach[3], Rainer Grauer[3], and Aleksandr Mustonen[3] — [1]Max-Planck-Institut für Plasmaphysik — [2]Ludwig-Maximilians-Universität München — [3]Ruhr-Universität Bochum

Modeling of the tokamak edge plasma is one of the most important problems we have to solve to achieve understanding of physics, taking place in the device. A lot of currently existing and well known codes used by the community employ gyrokinetic system of equations. This is a framework to resolve kinetic equations on a reduced 5D space, applicable for charged particles moving in a strong background magnetic field and valid until the phenomena scale gets as small as the Larmor radius. Presence of steep gradients at the edge region prevents us from usage of GK models in their present state.

One of the ways to avoid this complication is to use a fully kinetic 6D framework. However, the immense computational cost of such a direct approach makes it ill-suited for longtime simulations. Here we discuss the hybrid framework and its implementation in the ssV: a semi Lagrangian electrostatic code with fully kinetic ions and driftkinetic electrons to completely resolve ion physics and save computational resources on electrons, while retaining the most important kinetic effects. New found hybrid wave explained with the help of analytical dispersion solver FIDEL. Slab ITG testcase discussed.

P 17.31 Fri 14:00 P

Steps for implementation of divertor protection algorithms at Wendelstein 7-X — •Manuel Agredano-Torres[1], Simon Fischer[1], Heike Laqua[1], Aleix Puig Sitjes[1], Hans-Stephan Bosch[1], Wolfgang Treutterer[2], Axel Winter[1], and Wendelstein 7-X Team[1] — [1]Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Max-Planck-Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

Wendelstein 7-X (W7-X) is the world's largest stellarator experiment and aims to proof the viability of stellarator devices as power plants. It is being upgraded including the installation of actively cooled divertors. In order to avoid damage in the divertors, their temperatures have to be kept below their maximum limit and a protection system, as part of W7-X control system, is required to ensure it. The divertors protection is based on the data obtained from thermography diagnostics. Fast Control Stations process the data in real-time to determine the risk of surpassing a temperature limit. In the next operational campaign, if the risk reaches a determined threshold, an alarm is triggered so the Safety System can act on time and stop the operation of the device. The final goal of the protection system is to allow a continuous operation W7-X, avoiding the overheating of the divertors by feedback control of heating systems and control coils. This contribution presents the overall system required for the divertors protection including relevant diagnostics and W-7X control system, an overview of the protection algorithms and the planning for their real-time implementation in the control system before the next operational campaign.

P 17.32 Fri 14:00 P

3D Monte-Carlo PIC modeling of plasma grid biasing and the co-extraction of electrons in negative ion sources — •Max Lindqvist[1], Dirk Wünderlich[1], Alessandro Mimo[1], Serhiy Mochalskyy[1], Adrien Revel[2], Tiberiu Minea[2], and Ursel

Fantz[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Universite Paris-Saclay, CNRS, LPGP, Orsay, France

One of the factors limiting the performance of negative ion sources for the ITER Neutral Beam Injection (NBI) system is the co-extraction of e^-. By varying the positive bias potential of the Plasma Grid (PG) with respect to the source walls, the amount and temporal instability of co-extracted e^- is strongly decreased. This study investigates the mechanisms of this process by varying the bias of the PG using the already established 3D Monte-Carlo PIC code ONIX. The simulation domain covers the extraction region near one of the PG apertures in the ELISE ion source. In previous PIC simulations of this type, the boundary from the bulk plasma to the simulation domain is characterized by an artificial plasma sheath. Here, for the first time in a 3D PIC code for NBI sources, a flat potential transition is simulated, which allows for biasing the PG without extending the simulation domain to the source walls. Instead, the bias has been indirectly applied by varying the PG potential from −5 V (close to floating) to 1 V (e^- attracting sheath) with respect to the plasma potential. In agreement with experimental results, the co-extracted e^- current is decreased by over 50 %, caused by an increased flux of e^- towards the top and bottom of the PG, following the magnetic field lines.

P 17.33 Fri 14:00 P

Gyrokinetic modelling of anisotropic energeticparticle driven instabilities in tokamak plasmas — •Brando Rettino, Alberto Bottino, Alessandro Biancalani, Thomas Hayward-Schneider, Philipp Lauber, and Markus Weiland — Max Planck Institute for Plasma Physics, Garching, Germany

Energetic particles produced by plasma heating can excite instabilities in tokamaks. We study the effects of anisotropy of distribution functions on the excitation of such instabilities with ORB5, a gyrokinetic particle in cell code. Analytical anisotropic expressions for the distribution function are implemented and numerical results are shown for linear electrostatic simulations with ORB5. The growth rate is found to be sensitively dependent on the phase-space shape of the distribution function. Realistic neutral beam energetic particle anisotropic distributions are obtained from the heating solver RABBIT and are introduced in ORB5 as input distribution function.

P 17.34 Fri 14:00 P

Non-local neoclassical PIC simulations for the radial electric field in stellarators — •Michal Kuczynski, Ralf Kleiber, and Hakan Smith — Wendelsteinstraße 1, 17491 Greifswald

Transport in fusion plasma devices has typically two contributions: turbulent and neoclassical. The latter is most significant in stellarators and thus, for further experimental advances, a thorough understanding of the neoclassical transport is required. Perhaps one of the greatest achievements of the (local) neoclassical theory is the prediction of the neoclassical radial electric field. However, the theory has its limitations. For instance, when the electric field changes sign (at the transition zone between the ion and electron roots), the theory may predict multiple values of the radial electric field, which is unphysical. To understand the physics in such scenarios we perform neoclassical PIC simulations with the addition of non-local terms and calculate the resultant electric field self-consistently.

P 17.35 Fri 14:00 P

Analysis of optimal quasi-isodynamic stellarator magnetic equilibria using a direct construction approach — •Katia Camacho Mata, Gabriel Plunk, Per Helander, and Michael Drevlak — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Two important requirements for a viable stellarator reactor are easy-to-build-coils and good confinement. Omnigenous configurations, those in which the time-averaged radial drift is zero, fulfill the good confinement properties requirement. Such configurations are traditionally found by numerical optimization, but these designs have been generally found to feature complex coils. However, it is unknown whether such complexity is fundamentally necessary. To explore this question, we will use a recently developed [1] method for the direct construction of omnigenous MHD(Magnetohydrodynamic) equilibria, which avoids the computational cost of conventional optimization, allowing a thorough survey of the space of omnigenous stellarators at large aspect ratio. We present an analysis of such solutions, focusing on the quasi-isodynamic case, a particular case of omnigeneity.

[1] Plunk, G. G., Landreman, M., & Helander, P. (2019). Direct construction of optimized stellarator shapes. Part 3. Omnigenity near the magnetic axis. Journal of Plasma Physics, 85(6).

P 17.36 Fri 14:00 P

Active learning and data augmentation using surrogate models of time series — •Katharina Rath[1,2], Christopher G. Albert[2], Bernd Bischl[1], and Udo von Toussaint[2] — [1]Ludwig-Maximilians-Universität München, Munich, Germany — [2]Max-Planck-Institut für Plasmaphysik, Garching, Germany

A comprehensive training data base is important to obtain satisfying and reliable results when working with neural networks. Gaussian processes (GPs) can act as surrogate models to enlarge the training data base and additionally provide the covariance structure. However, the computational complexity of standard GP regression increases with the third power of training data points and outliers are punished very severely, leading to unreliable uncertainty estimates. These drawbacks complicate the application of standard GP regression to noisy high-resolution time series data. Here, these difficulties are addressed using Student-t processes allowing a heavy tailed noise distribution in combination with a state space representation. While the Student-t process itself is more robust against outliers, the state space representation allows regression with computational complexity of order n, and thus can also be used if the time resolution is high. Besides a robust surrogate model for a comprehensive data base, the uncertainty estimates resulting from the stochastic process can be used in an active learning framework to determine which additional measurement data need to be incorporated in the training data set. The intended application is the robust augmentation of the training data base for the prediction of plasma disruptions.

P 17.37 Fri 14:00 P

Simulations of massive Deuterium injection into an MHD active ASDEX Upgrade plasma — •Fabian Wieschollek[1], Matthias Hoelzl[1], Eric Nardon[2], the JOREK Team[3], and the ASDEX Upgrade Team[4] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching b. M., Germany — [2]CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France — [3]See the author list of M. Hoelzl et al 2021 NF 61, 065001 — [4]See the author list of H. Meyer et al 2019, NF 59, 112014

The foreseen disruption mitigation strategy for ITER is shattered pellet injection (SPI). In a realistic disruption scenario, the SPI is being triggered, when the plasma has already become MHD active; in particular 2/1 neoclassical tearing modes (NTM) are often present.

In this work, we investigate the interaction of Deuterium SPI and a pre-existing 2/1 NTM in ASDEX Upgrade to assess its potential impact onto the mitigation strategy by means of the non-linear MHD code JOREK. Scans are performed of the initial island width, the number of atoms injected, and the relative injection phase with respect to the island O-point. Results indicate that preexisting islands do not render the mitigation ineffective. In case of small initial island sizes, no significant influence onto thermal quench (TQ) timing is observed independently of the injection phase. In case of larger islands, a delayed island growth and TQ onset is observed. This observation only changes when the injection is located to the direct vicinity of the X-point.

The studies are currently extended to take background impurities and multiple injection points into account.

P 17.38 Fri 14:00 P

Innovative Non-Resonant Divertors Applied to Compact Toroidal Hybrid (CTH) — •Kelly Garcia[1], Aaron Bader[1], Oliver Schmitz[1], John Schmitt[2], and Gregory Hartwell[2] — [1]University of Wisconsin-Madison, Madison, WI, United States of America — [2]Auburn University, Auburn, AL, United States of America

Non-resonant divertors separate the confined plasma from surrounding structures with the resulting boundary region comprised of cantori and/or stochastic regions, but without the presence of large islands. In contrast, island divertor configurations make use of low order rational surfaces with large islands mediating the confined plasma and the wall. These islands are highly sensitive to the value and shear of the rotational transform which can be affected by the evolution of the plasma equilibrium. CTH (Compact Toroidal Hybrid) can serve as a test-bed for the non-resonant divertor solution for divertor optimization. The currents in the field coil and ohmic current drive systems of CTH are controlled to alter the rotational transform between $0.3 < \iota < 0.75$. Utilizing the FLARE field-line following code, we calculate strike point locations for the exiting plasma for multiple ohmic current values. These calculations provide possible locations for divertor plates that will be built in the experiment to test non-resonant divertor resiliencies. These same techniques can be applied to other machines including ones that use the island divertor in the standard operation, like W-7X.

P 17.39 Fri 14:00 P

Experimental Survey of Plasma-Terminating Events in the Wendelstein 7-X Stellarator — •Jonathan Schilling, Henning Thomsen, Christian Brandt, Kian Rahbarnia, Ekkehard Pasch, Marc Beurskens, Sergey Bozhenkov, Hannes Damm, Golo Furchert, Evan Scott, Matthias Hirsch, Neha Chaudhary, Karsten Ewert, Udo Höfl, Johan Willem Oosterbeek, Torsten Stange, Gavin Weir, Jens Knauer, Tsuyoshi Akiyama, Kai Jacob Brunner, Tamara Andreeva, Ulrich Neuner, Oliver Ford, Sehyun Kwak, Andera Pavone, Jakob Svensson, Marco Zanini, and the W7-W Team 1 — Max-Planck-Institute for Plasma Physics, Greifswald, Germany

An experimental data survey is conducted with a focus on global fast plasma-terminating events in the Wendelstein 7-X stellarator. These events associated with significant current drive may pose a risk for machine safety and need to be understood for reliable plasma operation in a future fusion power plant. Several such events were observed in recent campaigns of Wendelstein 7-X. Tomographic reconstruction of the soft X-ray emission pattern from the plasma allows to assess the spatio-temporal dynamics of these events with the necessary high resolution ($f_s = 2$ MHz; $\Delta R = \Delta Z = 4$ cm). Those results are subsequently compared to experimental data from the Thomson scattering diagnostic (n_e, T_e profiles), the electron cyclotron emission diagnostic (T_e profile) and the single-channel interferometer ($\int n_e d$l).

P 17.40 Fri 14:00 P

Single-shot grating-based phase-contrast imaging at a laser-driven x-ray backlighter source — •Bernhard Akstaller, Stephan Schreiner, Max Schuster, Andreas Wolf, Veronika Ludwig, Thilo Michel, Gisela Anton, and Stefan Funk — Friedrich-Alexander Universität Erlangen-Nürnberg

We used a sub-picosecond x-ray flash, produced by a high-power laser and a tungsten backlighter wire, for phase-contrast imaging with short exposure times. With this, we demonstrated the feasibility of imaging a micron-sized (static) sample with a single-shot grating-based phase-contrast imaging setup. The obtained data is quantitatively analyzed and an enhancement of image quality is evaluated. The presented imaging technique allows to capture sharp images of fast dynamic processes like laser-produced plasma shock waves in the field of laboratory astrophysics, even if the absorption contrast is very low. The data was taken at the Petawatt High-Energy Laser for Heavy Ion Experiments at the GSI Helmholtzzentrum für Schwerionenforschung GmbH.

P 17.41 Fri 14:00 P

Comparison of Laser Induced Breakdown Spectroscopy (LIBS) results on deuterium loaded high Z materials from lasers of different pulse durations — •Steffen Mittelmann[1], Jannis Oelmann[2], Ding Wu[3], Gennady Sergienko[2], Sebastijan Brezinsek[2], Hongbin Ding[3], and Georg Pretzler[1] — [1]Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, Germany — [2]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, Germany — [3]Key Laboratory of Material Modification by Laser, Ion and Electron Beams, Dalian University of Technology, China

Impurities in the wall material of upcoming fusion reactors can endanger the lifetime and quality of the confined plasma. To get an idea of deuterium or tritium retention at the wall the diagnostic Laser induced breakdown spectroscopy (LIBS) is used. This widely applied technique is executed by lasers with different pulse durations from ns to fs. A big advantage of ultrashort laser pulses is the well-defined ablation area which leads to a high depth resolution. The results from LIBS experiments on tantalum exposed by deuterium in the linear plasma device PSI-2 with this laser system can be compared to ns- and ps-LIBS signals produced at Dalian University of Technology in China and the FZ Jülich, which are shown here. An important aim of these studies is to reach a deeper understanding of the basic processes governing ablation, plasma formation and spectral emission in the different pulse duration regimes for finally deciding which type of laser pulses is the most promising for future fusion reactor wall analysis.

P 17.42 Fri 14:00 P

The uniform electron gas in the thermodynamic limit: fermionic path integral Monte Carlo simulations — •Alexey Filinov[1,2], Pavel Levashov[2], and MichaeI Bonitz[1] — [1]Institut für Theoretische Physik und Astrophysik, CAU Kiel — [2]Joint Institute for High Temperatures, RAS, Moscow

The uniform electron gas (UEG) is one of the key models for the understanding of warm dense matter–an exotic, highly compressed state of matter between solid and plasma phases. The difficulty in modeling the UEG arises from the need to simultaneously account for Coulomb correlations, quantum and exchange effects. The most accurate results so far were obtained from QMC simulations. However, QMC for electrons is hampered by the fermion sign problem. Here we present results from a novel fermionic-propagator path integral Monte Carlo (FP-PIMC) in the restricted grand canonical ensemble (R-GCE). The ab-initio simulation results for the spin-resolved pair distribution functions and static structure factor are reported for two isotherms $T/T_F = 1, 2$. Furthermore, we combine the results from the linear response theory in the STLS-scheme with the QMC data to remove finite-size errors in the interaction energy. We present a new corrected parametrization for the interaction energy $v(r_s, \theta)$ and the exchange-correlation free energy $f_{\text{xc}}(r_s, \theta)$ in the thermodynamic limit, and benchmark our results against the RPIMC by Brown *et al.* [Phys.Rev.Lett. **110**, 146405 (2013)] and PBPIMC by Dornheim *et al.* [Phys. Rev.Lett. **117**, 115701 (2016)].

P 17.43 Fri 14:00 P

Optimized electron injection into a linear plasma wakefield by means of laser-solid interaction — •Vadim Khudiakov and Alexander Pukhov — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

We explore a hybrid plasma acceleration scheme via numerical simulations. The key feature of the method is to inject an electron bunch generated from laser-solid interaction into appropriate phase of a plasma wave. Recent work [1] demonstrates that a femtosecond laser pulse with energy of tens of mJ hitting a dense plasma target at 45 degrees angle expels well collimated electrons and accelerates them up to several MeVs in a direction close to pulse refection. In our work we reproduce these results with 3d particle-in-cell simulations using VLPL code and examine different injection parameters: injection angle, phase of plasma wake, laser pulse amplitude, in order to optimize trapped charge. An approximate trapping condition is derived for theoretical estimation of optimal injection parameters and is verified in simulations. Acceleration in a linear quasi-static wave with the parameters of AWAKE experiment provides bunches feature ~100 pC charge, ~60 micrometers transverse normalized emittance, and energies of several GeV with spread ~1%.

[1] I. Tsymbalov et al., Plasma Phys. Control. Fusion 61 (2019) 075016.

P 17.44 Fri 14:00 P

Time-resolved simulations of laser-induced ionization in the tunneling regime — •Michael Stumpf and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Ionization rate calculations are a common and necessary tool to simulate the interaction of laser pulses with matter. We used the ADK model and compared it with experimental results. For our simulations, we calculated the exact temporal and spatial field distributions within a fs-laser focus with high precision and used quasi-static approximations to simulate the ionization rates. In order to verify our simulations, we experimented with a wide range of parameters using the PHASER few-cycle Ti:Sa-system in Düsseldorf and a novel pulse energy attenuator as well as a new beam-shaping device called AMBER (Axicon Mirror Beam ExpandeR). The results are used to design the internal injection of electrons inside of a Plasma Wakefield structure following the Trojan Horse Injection model.