P 9: Poster I

Time: Tuesday 16:00–17:30 Location: P

P 9.1 Tue 16:00 P

Wavenumber analysis of the quasi coherent mode in EDA-H-mode discharges — •Joey Kalis[1,2], Gregor Birkenmeier[1,2], Peter Manz[3], Luis Gil[4], Michael Griener[1], and Ulrich Stroth[1,2] — [1]Max-Planck-Institut für Plasmaphysik, Garching — [2]Physik-Department E28, TUM, Garching — [3]Institut für Physik, Universität Greifswald, Greifswald — [4]Instituto de Plasmas e Fusão Nuclear, Universidade de Lisboa, Lisboa, Portugal

For future reactors based on the tokamak concept, it is necessary to establish high confinement modes without type-I ELMs. In the past years, several natural ELM-free operation scenarios, such as the EDA-H-mode, have been achieved in ASDEX Upgrade. The most prominent characteristic of the EDA-H regime is the appearance of the quasi coherent mode (QCM) at the plasma edge, which may be responsible for the stabilization of the ELMs. For the comparison with theory, it is important to determine the properties of the QCM in detail to identify its underlying driving forces. Due to its high spatial and temporal resolution, the He-beam diagnostic is used to measure different QCM properties. By means of spectral methods and due to a 2D-grid of the He-beam diagnostic, the wavenumber of the QCM in radial and poloidal direction is determined and compared with theoretical predictions.

P 9.2 Tue 16:00 P

Non-Axisymmetric Generalization of the Gyrokinetic Turbulence Code GENE-X — •Marion Smedberg[1], Dominik Michels[1], Andreas Stegmeir[1], and Frank Jenko[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching, Germany — [2]University of Texas at Austin, Austin, TX 78712, USA

For both tokamaks and optimized stellarators, plasma turbulence drives a major part of the heat loss. Thus realistic simulations of plasma turbulence, especially in the edge and scrape-off layer (SOL), are a key step towards a fusion power plant. The recent gyrokinetic turbulence code GENE-X uses a flux-coordinate independent (FCI) coordinate system; this approach has the advantage of remaining well-defined (singularity-free) even for the complex magnetic structures which appear in the edge and SOL, such as open field lines, X-points, islands, and stochastic regions. For this reason, GENE-X is well-equipped to simulate edge and SOL turbulence. However, the code can currently only simulate in axisymmetric geometries, such as tokamaks. In this work, progress towards a non-axisymmetric generalization of GENE-X is presented; this includes updating the grid generator, field line tracers, and fast elliptic solvers.

P 9.3 Tue 16:00 P

Extension of the Braginskii fluid model for edge turbulence simulations — •Christoph Pitzal, Andreas Stegmeir, and Frank Jenko — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

Fluid models are a useful tool for plasma turbulence simulations. They are computationally less intense than kinetic models, but they have limited predictive capabilities. This arises from the fact, that not all effects are captured, which are necessary to simulate a fusion device sufficiently. The effects which are not contained are primarily kinetic effects, which are lost due to the missing velocity space, e.g. Landau damping. Because of the missing Landau damping, fluid models significantly overestimate the parallel heat conductivity, whenever the collisionality is small. An approach to introduce Landau damping into a fluid model was already shown in [1]. This approach is formulated solely in k-space. A method to translate this approach into configuration space and thus make it applicable for fluid codes, which operate in configuration space, is presented in [2]. In this project a simple one-dimensional toy model has been implemented and tested to reproduce and understand the Landau fluid closure introduced in [2]. Further the Landau fluid closure will be implemented into the plasma turbulence code GRILLIX [3]. [1] G. W. Hammett and F. W. Perkins, Phys. Rev. Lett., vol. 64, pp. 3019-3022, Jun 1990. [2] J. Chen et al., Computer Physics Communications, vol. 236, pp. 128-134, 2019. [3] A. Stegmeir et al., Physics of Plasmas, vol. 26, no. 5, p. 052517, 2019.

P 9.4 Tue 16:00 P

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

In future fusion reactors, tungsten as plasma-facing material will be subjected to intense fluxes of helium (He). While the consequences of high He fluxes on the surface properties of tungsten have already been thoroughly studied, the mechanisms behind the early stages of the He cluster formation are still unclear. To understand the initial steps of the interaction of He with W, especially the impact of pre-existing defects, annealed, polycrystalline W samples were irradiation-damaged to various damage levels. Then, these were exposed to a low-temperature He plasma at low fluxes and fluences using an implantation energy of 100 eV. These He-implanted samples were measured by Doppler-broadening positron annihilation spectroscopy for defect quantification and elastic recoil detection analysis (ERDA) for quantification of He retention. To obtain information about the depth distribution of He, thin layers of the sample surfaces have been removed and ERDA measurements have been repeated subsequently until the signal intensity dropped to the sensitivity limit. In the irradiation-damaged samples, the He penetration into larger depth is significantly reduced compared with the depth penetration in undamaged samples, while their overall He retention is higher.

P 9.5 Tue 16:00 P

Study of LaB6-Cathodes in Neutral Pressure Gauges for Strong Magnetic Fields — •Bartholomäus Jagielski[1,2], Uwe Wenzel[1], Mirko Marquardt[1], Jiawu Zhu[1], and Thomas Sunn Pedersen[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Physical Institute of the University Greifswald, Greifswald, Germany

The neutral gas pressure measurement is a key diagnostic for scrape-off-layer physics, that gives a direct indication of the exhaust rate. However, strong magnetic fields and the requirement for the longevity of diagnostics in increasingly longer lasting plasma pulses, is a major challenge. For this reason, we developed and tested new crystal-cathode pressure gauges with different cathode geometries made of lanthanum hexaboride (LaB6), which can permanently withstand the Lorentz-Forces. For the next campaign of Wendelstein7-X, mono- and polycrystalline LaB6-cathodes have been operated in a specially prepared laboratory, equipped with a superconducting magnet, which provides magnetic field strengths of up to 5.9 T, in a wide range of neutral pressure values, as well as several different working gases. NIR-thermionic investigations have been conducted, cross-checked with ANSYS simulations. The Anode potential has been optimized and we compared several different cathode lengths, ranging from 5mm to 8mm, for different electron emittances. A significant decrease of the required heating current of the shorter variants has been observed. Furthermore, we tested a new two-rod-cathode design, heated by three pyrolytic graphite blocks, showing noticeably improved performance.

P 9.6 Tue 16:00 P

Current Filamentation Instabilities of Proton Beams in Proton Driven Wakefield Accelerators — •Erwin Walter[1], Martin Weidl[1], John Farmer[2,3], Patric Muggli[2], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]Max Planck Institute for Physics, 80805 Munich, Germany — [3]CERN - 1211 Geneva 23 - Switzerland

Plasma wakefield accelerators can generate electric-field gradients magnitudes larger than conventional accelerators. Using this technology, particle-physics experiments could be performed in much more compact devices.

The Advanced Wakefield Experiment (AWAKE) is a proof-of-concept proton-driven wakefield accelerator located at CERN. Seeded self-modulation, a controlled excitation of the longitudinal self-modulation instability, is exploited to modulate the proton bunch into a train of multiple smaller bunches along its axis. For alternative beam parameters, the electromagnetic Weibel-like beam filamentation instability could result in magnetic field amplification, perpendicular scattering and emittance growth. The experimental parameters have been specifically chosen to avoid filamentation.

Our research investigates which beam parameters are required for filamentation to appear and whether this parameter regime is accessible in future experiments. We present results from full-PIC simulations and compare to linear theory.

P 9.7 Tue 16:00 P

Simulations of the penetration of RMP fields into ASDEX Upgrade plasmas — •Verena Mitterauer and Matthias Hölzl — Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching - Germany

A proposed mechanism for the mitigation of edge localized modes (ELMs) is the application of small non-axisymmetric magnetic fields by external coils, known as resonant magnetic perturbations (RMPs). Various effects are observed in the plasma in response to RMPs, among others, the stochastization of the edge region, the formation of magnetic islands and the reduction of the edge density and toroidal rotation. A combination of these responses is thought to cause either ELM mitigation or suppression. However, exact mechanisms and extrapolation to ITER are still uncertain such that non-linear simulations are needed. In this work, the JOREK-STARWALL code suite is used for the first time to simulate the effects of RMPs on plasmas with parameters relevant to RMP-ELM suppression experiments in ASDEX Upgrade. The use of the STARWALL extension allows to include the full plasma response to the perturbation field up to the boundary.

Simulations with realistic plasma parameters are compared to the experiment for a plasma configuration that is relevant for ELM suppression studies. A similar corrugation is observed in modelling and experiment. Further simulations are on the way to investigate the interaction of ELM instabilities with the perturbation fields. To capture experiments more accurately, a fluid model with kinetic closure will be developed that can describe neoclassical toroidal viscosity (NTV).

P 9.8 Tue 16:00 P

Tackling turbulence in the plasma edge pedestal with a revised version of the GENE code — •L. A. Leppin, T. Görler, F. Jenko, M. Cavedon, M. G. Dunne, and The ASDEX Upgrade Team — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching b. München, Germany

A major challenge for future fusion power plants is the turbulent plasma dynamics on the microscale, which causes detrimental levels of outward transport of energy and particles. Many open questions on the properties of this dynamics remain in particular for the plasma edge pedestal, which is characterized by strong gradients of temperature and density, causing strong electromagentic fluctuations. An important approach to advance the understanding of turbulent plasma dynamics in the edge are high-fidelity simulations based on 5D gyrokinetic theory. Here we present ASDEX-Upgrade pedestal simulations using a new modification of the well-established gyrokinetic, Eulerian, delta-f code GENE (genecode.org), which enables numerically stable global, electromagnetic simulations at experimental beta values. We systematically investigate the present instabilities and resulting heat fluxes via local, linear as well as global, non-linear simulations. By using experimental temperature profiles and magnetic equilibria from four timepoints within an edge localized mode (ELM) of an ASDEX Upgrade discharge we aim to contribute to the understanding of ELM dynamics on the microscale. Furthermore, we demonstrate the applicability of the new GENE modifications to scenarios from other tokamaks.

P 9.9 Tue 16:00 P

Simulation of the neutral gas pressure in the subdivertor region of Wendelstein 7-X with ANSYS — •Victoria Haak[1], Hugo Cu Castillo[2], Dirk Naujoks[1], Uwe Wenzel[1], Georg Schlisio[1], and W7-X Team[1] — [1]Max-Planck Institute for Plasma Physics, Greifswald, Germany — [2]University of Greifswald, Greifswald, Germany

For low neutral gas pressures, the behaviour of the neutral gas in the subdivertor region of Wendelstein 7-X is governed by molecular flow conditions, i.e. collisions between particles can be neglected. After hitting the walls in the subdivertor region, the particle flux is emitted according to Lambert's cosine law. These similarities between particle flow in the molecular regime and radiation transport are used in order to simulate the neutral gas pressure in the subdivertor region with the steady-state thermal analysis module in ANSYS. This module uses the angular coefficient method to calculate the radiation flux on the individual surfaces. Using the analogy between particles and radiation, the heat flux can be converted into neutral gas pressure by a so-called scaling factor. The distribution of the neutral gas pressure on the walls of the subdivertor region as well as the influence of pumps and leaks can be studied. The results are compared to other simulation results, e.g. from EMC3-EIRENE and to experimental results obtained from neutral gas pressure measurements during OP1.2b using neutral gas pressure gauges.

P 9.10 Tue 16:00 P

Coupling of 3D-PIC and ion optics simulations for studies of H^- beam formation and co-extraction of e^- — •Max Lindqvist[1,2], Niek den Harder[1], Adrien Revel[2], Serhiy Mochalskyy[1], Tiberiu Minea[2], and Ursel Fantz[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Université Paris-Saclay, CNRS, LPGP, Orsay, France

The ITER Neutral Beam Injection system requires a beam of negative ions (NI) with low divergence and high current density. The NIs are produced in RF ion sources, and extracted by application of an electric field; co-extracted e^- are dumped onto the extraction grid. The equipotential surface between the plasma and extracted NI beamlet, referred to as the meniscus, determines the beamlet properties to a large extent. 3D PIC modeling is needed for self-consistent simulation of the meniscus formation, NI extraction and co-extraction of e^-. Due to the high computational cost of 3D PIC modeling, extending the simulation beyond the extraction region is unfeasable. To study the beam properties of NIs and co-extraction of e^- in the ELISE ion source, a half-size ITER-like ion source operated in IPP Garching, the 3D PIC-MCC code ONIX is coupled with the beam code IBSimu. This allows coupling of particle properties from the plasma, to the meniscus to the beamlet. It is shown that NIs extracted near the edge of the meniscus and with a large incident angle to the meniscus form a beam halo. The peak power load of e^- dumped onto the grid system depends on their distribution on the meniscus, the distribution calculated using ONIX results in a higher peak load than a uniform distribution.

P 9.11 Tue 16:00 P

Viability of NN-based Predictor-Corrector Schemes for Plasma Simulations — •Robin Greif[1], Frank Jenko[1], and Nils Thuerey[2] — [1]Boltz- mannstr. 2, 85748 Garching, Germany — [2]Boltzmannstr. 3, 85748 Garching, Germany

We investigate the viability of using neural network driven simulation methods based on novel predictor-corrector schemes developed for fluid and smoke simulations for turbulence in plasma. The approach builds on top of successful pioneering work on numerical schemes from Mantaflow and its successor, Phi-Flow, an open-source machine learnign framework aggregator for fluid dynamic simulations. In this project, we extend Phi-Flow to solve the Hasegawa-Wakatani equations as a proof-of-concept of the viability of modern neural-network based numerical simulation techniques for simple plasma models. The use of deep-learning based numerical integration schemes explored here has been shown to provide superior accuracy at coarser grids than classical methods in fluid simulations and is a promising candidate to reduce the computational cost for the next generation of plasma simulations.

P 9.12 Tue 16:00 P

Physics-informed neural network of the ideal-MHD model in Wendelstein 7-X configurations — •Andrea Merlo, Daniel Böckenhoff, Jonathan Schilling, Samuel Aaron Lazerson, Thomas Sunn Pedersen, and the W7-X Team — Max-Planck-Institute for Plasma Physics, 17491 Greifswald, Germany

In magnetic confinement fusion research, the achievement of high plasma pressure is key to reaching the goal of net energy production. The magnetohydrodynamic (MHD) framework is used to self-consistently calculate the effects the plasma pressure induces on the magnetic field used to confine the plasma. In stellarators (e.g., Wendelstein 7-X), the confining field is inherently 3D, making MHD calculations costly to compute ($\mathcal{O}(1)$ CPUh). In this work, we describe a Physics-Informed Neural Network which has been trained not only to reproduce ground-truth magnetic equilibria computed with a traditional solver (e.g., VMEC), but also to satisfy the flux surface averaged pressure balance equation characterizing ideal-MHD. The NN model is benchmarked against VMEC on a set of W7-X magnetic configurations at finite volume averaged beta, and the computation of a set of representative physics quantities of interests (e.g., magnetic well) is used to validate the model use in addressing magnetic equilibrium dependent physics questions.

P 9.13 Tue 16:00 P

Turbulence in stellarators with GENE-3D — •Felix Wilms, Alejandro B. Navarro, and Frank Jenko — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching b. München, 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 (Wilms et al., Journal of Plasma Physics, 2021). In this work, we present a first application to realistic scenarios, by performing multiple simulations with different model complexities and comparing them against experimental measurements of an ECRH-discharge.

P 9.14 Tue 16:00 P

Reduced transport models for a Tokamak flight simulator — •Marco Muraca, Emiliano Fable, Clemente Angioni, Hartmut Zohm, and Teobaldo Luda — Max-Planck-Institut für Plasmaphysik, 85748, Garching bei München, Germany

A Tokamak flight simulator is a tool to predict the plasma behavior of a scheduled discharge, such that either actuator trajectories or plasma parameters satisfy the experimental goals, and to reduce probability of plasma disruptions and crossing of operational limits. It is based on the interaction between control system, plasma equilibrium and transport. The transport models have to be physics based to be reliable, but also fast to be used as an inter-discharge prediction tool. This compromise can be reached employing analytical models which are derived from first principle theories. An integrated model including every plasma region has been developed. The confined region is modeled in 1D, while the scrape-off-layer has a 0D structure. For the core region, a normalized temperature gradient threshold model has been adopted, while for the edge an average ELM model has been used. In the SOL a 2-point model for exhaust and a particle balance for the separatrix density have been implemented. All the models have been validated against several stationary cases, by fixing some parameters as boundary conditions and matching experimental data, exploiting the modular structure of the integrated model. A first fully integrated simulation has been matched in the flight simulator, including ramp-up and flattop phases. A stronger validation including more discharges and the ramp-down phase is planned for the future.

P 9.15 Tue 16:00 P

multi fidelity monte carlo (MFMC) sampling and application to plasma physics — •Patrick Storch — Max Planck Institut für Plasmaphysik Boltzmannstr. 2, 85748 Garching

In many situations across computational science and engineering, multiple computational models are available that describe a system of interest. These different models have varying evaluation costs and varying fidelities. Typically, a computationally expensive high fidelity model describes the system with the accuracy required by the current application at hand, while lower-fidelity models are less accurate but computationally cheaper than the high-fidelity model. Plasma physics simulations for e.g. turbulences in tokamak reactors rely on sophisticated gyrokinetic models which are very costly in terms of computing power and runtime. Standard Monte Carlo analyses on these models are highly expensive because a large number of particle trajectories need to be integrated over long time scales, and small time steps must be taken to accurately capture the features of the wide variety of trajectories. Therefore they provide an ideal candidate to apply MFMC sampling to a real world scenario. Numerical experiments with linear and nonlinear examples show that speedups by orders of magnitude are obtained compared to Monte Carlo estimation that invokes only a single model.

P 9.16 Tue 16:00 P

Characteristics of Alfvénic modes in ASDEX Upgrade disruptions — •Paul Heinrich, Gergely Papp, Philipp Lauber, Mike Dunne, Valentin Igochine, Oliver Linder, Marc Maraschek, the ASDEX Upgrade team, and the EUROfusion MST1 team — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany

ASDEX Upgrade has developed multiple massive gas injection-induced scenarios to investigate runaway electron (RE) dynamics. During the current quench of these disruptions, Alfvénic activity is observed in the 300–800 kHz range. These modes are investigated as potential runaway electron mitigation candidates. With the help of a mode tracing algorithm, mode behaviour for 180 discharges was classified. The modes are potentially identified as global Alfvén eigenmodes (GAEs). Changes in the Alfvén continuum during the quench can explain the strong frequency sweep of these modes. A systematic statistical analysis revealed no significant effect of the mode characteristics on the dynamics of the subsequent runaway electron beam.

P 9.17 Tue 16:00 P

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

In future fusion devices, disruptions have to be avoided to prevent damage of the vessel. Locked modes, i.e. tearing modes that are at rest with the vessel due to electromagnetic interaction, are precursors of and significantly involved in disruptions. While rotating modes can be observed by Mirnov coils measuring the poloidal magnetic perturbation field tangential to the wall, locked modes require measuring the radial magnetic field, e.g. by saddle coils on the high-field side. The observed perturbation fields are affected differently by mirror currents induced by rotating modes. In order to model all measurements during a locking process, these mirror currents and their frequency dependence have to be described. Owing to the complexity of the real tokamak, neither the full geometry nor the exact conductivity of all structures can be considered. A recently developed three-dimensional finite element tool modelling the perturbation field for all coils is implemented using an effective conductivity of the wall and - for the saddle coils - an effective distance to the vessel. These two simulation parameters are optimized such that they best describe the ratio of measured mode amplitudes in Mirnov and saddle coils for all frequencies and discharge scenarios. Additional radial field coils are implemented to gain information on the poloidal mode structure of locked modes.

P 9.18 Tue 16:00 P

Analysis and modeling of momentum transport based on NBI modulation experiments at ASDEX Upgrade — •Carl Friedrich Benedikt Zimmermann[1,2], Rachael McDermott[1], Emiliano Fable[1], Basil Duval[4], Ralph Dux[1], Antti Salmi[3], Ulrich Stroth[1,2], Tuomas Tala[3], and Giovanni Tardini[1] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]Physik-Department E28, Technische Universität München, 85747 Garching, Germany — [3]VTT, P.O. Box 1000, FI-02044 VTT, Finland — [4]EPFL, Swiss Plasma Center, CH-1015 Lausanne, Switzerland

Understanding momentum transport is crucial in reliably predicting the plasma rotation profiles of future fusion devices. At ASDEX Upgrade, momentum transport is studied to validate theoretical models and transport codes. The new momentum transport analysis framework uses neutral beam modulation experiments to determine the con tributions of diffusion, convection, and residual stress to momentum transport within the core plasma. The methodology was applied to a database of more than 90 phases from 50 varied discharges. A recent experimental campaign filled gaps in this database enlarging the probed parameter space to study the effect of the turbulence transition from trapped electron to ion-termperature-gradient modes on momentum transport. Such a large data set makes it possible to study the parameter dependencies of the transport coefficients. In ongoing experiments, the parameter space of the database will be further enlarged allowing more detailed validation of the methodology and theoretical predictions.

P 9.19 Tue 16:00 P

Experimental investigation of velocities and diameters of droplets generated by arcing — •Alberto Castillo Castillo[1,2], Martin Balden[1], Volker Rohde[1], and Rudolf Neu[1,2] — [1]Max-Planck Institute for Plasma Physics (IPP), Garching, Germany — [2]Technical University Munich (TUM), Garching, Germany

Droplet generation by arcing is one of the mechanisms that can generate dust in a fusion device. The metal droplets expelled by the arc can potentially introduce impurities in the plasma core and influence the operation of the device. The aim of this work is to study the velocities, diameters and direction of the droplets expelled by arcing from a metal target. Knowing the sizes and velocities distribution of the droplets would allow an estimation of their influence on plasma operation. Different target materials will be used relevant to fusion devices, with a focus on tungsten.

The experimental setup consist of a vacuum chamber in which an arc is ignited on a target. After an arcing event, the droplets expelled within a certain solid angle enter a vertical drift tube. Along the tube, the droplets pass through the line of sight of two detection systems. Each detector measures the light scattered by the droplet from a perpendicular light source. The amplitude of the signal can be converted to droplet diameter through the application of MIE scatter theory, and the signal length and time delay between both sensors allow the calculation of velocity. The orientation of the target is changed in order to measure the distributions of droplets expelled at different angles.

P 9.20 Tue 16:00 P

Uncertainty Quantification for Multiscale Turbulent Transport Simulations — •Yehor Yudin, Udo von Toussaint, and David Coster — Max Planck Institute for Plasma Physics, Boltzmannstrasse2, 85748 Garching, Germany

One of the challenges in understanding the energy and particle transport processes in the core plasma of a magnetic confinement fusion device is to quantify how it is effected by turbulent dynamics. This work considers a multi-scale approach of modeling this problem, where the numerical solution is obtained for coupled models describing processes on different spatial and temporal scales. Furthermore, the resulting model is used to investigate both epistemic and aleatoric uncertainties in the profiles of the transported quantities. This work proposes application of a surrogate modelling technique to reduce the computational cost of resolving a quasi-steady state solution on the miscro-scale when it is sufficient to capture only statistics of turbulent dynamics. We studied a Multiscale Fusion Workflow that utilizes turbulent energy and particle fluxes computed with a gyrofluid turbulence code GEM in flux tube approximation to calculate the transport coefficients for core transport code ETS. 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. For that, we use VECMA toolkit to perform uncertainty quantification, as well as to train, test and utilize surrogate models.

P 9.21 Tue 16:00 P

Bayesian Inference based Sensitivity Studies of Helium Atomic Models — •Erik Flom[1], Oliver Schmitz[1], Maciej Krychowiak[2], Ralf König[2], Stuart Loch[3], and Jorge Munoz-Burgos[4] — [1]University of Wisconsin - Madison, Madison, WI, USA — [2]3Max Planck Inst. for Plasma Physics, Greifswald, Germany — [3]Auburn University, Auburn, AL, USA — [4]Astro Fusion Spectre, San Diego, CA, USA

Understanding the basic plasma parameters of temperature and density, as well as their gradients in the scrape-off layer (SOL), is a topic critical for providing information about the performance of a divertor concept. In order to study the performance of the Wendelstein 7-X divertor concept, an active spectroscopy system on an atomic helium beam was developed and installed on the stellarator. A complete Bayesian treatment has been undertaken with the Minerva Bayesian modeling framework in two approaches. First, it has been shown through a sensitivity study that the diagnostic method is robust against random measurement errors and systematic calibration errors on the scales achievable with the current diagnostic setup. From this, it is concluded that the majority of the uncertainty in the reconstructed temperature and density arises from systematic uncertainties in the underlying collisional-radiative model (CRM) rather than from measurement errors. To demonstrate this, in the second approach, the diagnostic model is tested by inferring the plasma density and temperature using synthetic line intensities and applying different CR models (e.g. including high Rydberg states).

P 9.22 Tue 16:00 P

Work Function Measurements of the Cesiated Surface in a Negative Hydrogen Ion Source Using LEDs — •Jacob Maria Berner, Christian Wimmer, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany

The work function of a surface can be determined by measuring the nA-photocurrents arising from the irradiation by light of different wavelengths. When the chosen photon energies are close to the work function, this energy threshold can be calculated using the Fowler method. As a novelty for such a measurement, fiber coupled LEDs are used as a light source of sufficient power.

State of the art negative hydrogen ion sources, as used for the ITER neutral beam injectors, rely on the surface conversion process of H and H_x^+ from a low temperature plasma at cesiated surfaces with low work function. In order to reach longer extraction durations at high extraction currents, a stable work function, which is governed by cesium dynamics, impurities, and the interaction with the plasma, is crucial. Taking on the challenges of measuring small nA-photocurrents in a corresponding environment, the method is developed to determine the work function for the first time ever directly inside a high-performance negative ion source, namely BATMAN Upgrade. Monitoring the temporal stability of the work function is essential, as variations can worsen the extraction performance of H_x^- and countermeasures can be taken accordingly. The results from the feasibility study are expected to enable the establishment of this diagnostic tool for in-situ monitoring of the work function.

P 9.23 Tue 16:00 P

Effect of W7-X divertor geometry modifications on PFC heat load distribution — •Amit Kharwandikar, Dirk Naujoks, Thomas Sunn Pedersen, Felix Reimold, and The W7X Team — Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany

Wendelstein 7-X (W7-X) is an advanced stellarator device operated in Greifswald, Germany, to provide the proof of principle that the stellarator concept can meet the requirements of a future fusion reactor. It employs the island divertor concept to handle the heat and particle fluxes. In the recent experimental campaign OP1.2, ten adiabatically loaded test divertor units (TDUs) were installed in the plasma vessel along with baffles, toroidal/poloidal closures, etc. where high heat loads were observed onto the in-vessel components. Particularly, in the high-mirror magnetic configuration, undesired level of heat loads appeared on the baffles that limited the operation of the device. In some previous studies, it has been shown that the relative position of the divertor targets and the baffle affects the heat load distribution. This poster discusses the investigation of such geometry modifications via modelling. The diffusive field line tracing (DFLT) code - modified to also mimic plasma counter-flows - is used to simulate heat transport to the plasma facing components (PFCs). The aim of this activity is to understand the effect of these simple modifications (in terms of the relative position of targets and baffles) and optimize the same for an acceptable heat load distribution.

P 9.24 Tue 16:00 P

Gyrokinetic modelling of anisotropic energeticparticle driven instabilities in tokamak plasmas — •Brando Rettino[1], Thomas Hayward-Schneider[1], Alessandro Biancalani[2,1], Alberto Bottino[1], Philipp Lauber[1], Ilija Chavdarovski[3], Francesco Vannini[1], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Leonard de Vinci Pole Universitaire, Research Center, 92916 Paris la Defense, France — [3]Korea Institute of Fusion Energy, 34133 Daejeon, South Korea

Energetic particles produced by plasma heating are observed to excite energetic-particle-driven geodesic acoustic modes (EGAMs) in tokamaks. We study the effects of velocity space anisotropy of the EP distribution functions on the excitation of such instabilities with ORB5, a gyrokinetic particle-in-cell code. 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. The qualitative behavior of the instability is analyzed theoretically through dispersion relations. Realistic neutral beam energetic particle anisotropic distributions are obtained from the Fokker-Planck solver RABBIT and are introduced into ORB5 as input distribution function. Results show a dependence of the growth rate on the beam injection angle. A preliminary qualitative comparison to experimental measurements is presented,the differences are discussed, and further steps for quantitative non-linear analysis are outlined

P 9.25 Tue 16:00 P

Edge core coupling: physical parameters determining the pedestal width — •Lidija Radovanovic[1], Mike Dunne[2], Elisabeth Wolfrum[2], Friedrich Aumayr[1], and ASDEX Upgrade Team[2] — [1]Institute for Applied Physics, TU Wien, Vienna, Austria — [2]Max Planck Institute for Plasma Physics, Garching, Germany

The outer edge of the plasma, also called the pedestal, serves as a strong insulator between the plasma core and the reactor walls. The top of the pedestal serves as a boundary condition for the hot core plasma. Understanding the physical processes governing the pedestal is crucial for reliable prediction and control of the plasma conditions and its stability. Using the EPED framework as a basis, the pedestal can be considered as a combination of two limits: the pedestal width grows at a constant gradient to the ideal peeling ballooning limit. Understanding this width growth is crucial in order to accurately predict the pedestal for future machines. In this work the pedestal width is further investigated in experiments based on two methods. The first considers a recent analysis at the ASDEX Upgrade, which indicates that locally low magnetic shear at the pedestal top could cause ballooning modes, and it therefore limits the pedestal width. The experimental approach here is changing the shape and the magnetic field of the plasma to move the region of low local magnetic shear. The second method assumes that the turbulent motion of the ionized particles in the plasma edge region is suppressed due to the presence of a steep radial electric field. A comparison of these assumptions with the pedestal width will be shown.

P 9.26 Tue 16:00 P

Magnetic signature of ECCD induced crashes in the Wendelstein 7-X stellarator — •K. Rahbarnia, S. Vaz Mendes, C. Brandt, H. Thomsen, J. Schilling, K. Aleynikova, C. Slaby, A. Könies, and W7-X Team — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

Wendelstein 7-X is a stellarator-type fusion experiment. A strong toroidal plasma current is not needed for optimized confinement properties. Nevertheless, during the last operation campaign a number of experiments including an externally driven plasma current were conducted. The so-called electron cyclotron current drive (ECCD) was used to counteract any rising bootstrap current to completely nullify it. Alternatively, in the presence of co-driven ECCD, the increase of a naturally evolving bootstrap current was accelerated so that an equilibrated state could be reached faster. During ECCD experiments crashes in global plasma parameters have been observed, which sometimes even led to a total collapse of the plasma. Previous analysis mainly involving fast changes of the measured electron temperature caused by the crashes revealed a sawtooth-like behaviour similar to tokamaks. In this study the magnetic signature of these crash events measured by poloidal arrangements of in-vessel Mirnov coils is investigated generally supporting the previous results. Various ECCD scenarios are studied showing similar frequency (around 40kHz) and poloidal mode number (m<5) of the observed bursty magnetic fluctuations. The results are compared to theoretical predictions using the magnetic equilibrium code VMEC and the MHD continuum code CONTI.

P 9.27 Tue 16:00 P

Model based optimization of Advanced Tokamak scenarios — •Raphael Schramm[1], Alexander Bock[1], Emiliano Fable[1], Jörg Stober[1], Simon van Mulders[2], Maximilian Reisner[1], Hartmut Zohm[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck Institut für Plasmaphysik, Garching, Germany — [2]École Polytechnique Fédérale de Lausanne, Switzerland

Advanced Tokamak scenarios aim to reduce the reliance on ohmic current of plasma discharges. This is done by increasing the bootstrap current ($j_{bs} \propto q\nabla p$) with manipulation of the safety factor profile q via external actuators. These can be turned on during the plasma ramp-up, which avoids the safety factor dropping below the desired value, compared to the conventional option to wait until the plasma reaches a stationary state. Last year an ASTRA model has been presented that can be used to the develop such a scenario.

The model has been used to analyze a counter-ECCD scenario with a higher current than the validation scenario. Results of this will be shown. An optimizer, working on a simplified model will be used to improve this scenario. It proposes a change, which is then cross-checked in the ASTRA model in an iterative learning approach. Results will be run in the next ASDEX-U campaign.

In this campaign, a system capable of calculating the safety factor profile in real-time will become available. This contribution will discuss, if accuracy and reliability of such scenarios can be improved by using feed-forward control based on q instead of time.

Real-time control of the q-profile based on this tool will be tested.

P 9.28 Tue 16:00 P

Identification of multiple mode contributions in tomography data from soft X-ray diagnostics — •Henning Thomsen, Christian Brandt, Rene Bussiahn, Sara Vaz Mendes, Kian Rahbarnia, Jonathan Schilling, Thomas Wegner, and W7-X Team — MPI f. Plasmaphysics, 17491 Greifswald

External actuators like impurity injection, density or temperature modulation as well as current drive affect the stability properties of the plasma equilibrium in the Wendelstein 7-X stellarator. The dynamics on the soft X-ray radiation distribution in a poloidal plane is studied by the soft-X ray tomography system XMCTS [1], which measures in the energy range 1-12 keV. The radiation in this energy range originates mainly from Bremsstrahlung of the confined plasma and line radiation from impurity species. In different experiments with impurity injection, a dominant m=1 mode with frequencies in the range of 1-2 kHz has been observed. An analysis of dominant modes is possible with a singular value decomposition. While the dynamics associated with sucb low-frequency modes can often be reconstructed in the tomograms, higher frequency components visible in the line-integrated raw data typically do not show up in the tomographically reconstructed time series. In this contribution the possible reasons and different analysis approaches are discussed.

[1] C Brandt et al Plasma Phys. Control. Fusion 62 (2020) 035010

P 9.29 Tue 16:00 P

Linear (non-)ideal MHD stability analysis of pedestals in axisymmetric and magnetically perturbed tokamak equilibria — •Jonas Puchmayr[1], Mike Dunne[1], Erika Strumberger[1], Branka Vanovac[1], Hartmut Zohm[1], and The ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany — [2]See author list of H. Meyer et al. 2019 Nucl. Fusion 59 112014

In the H-mode, steep gradients of pressure, temperature and density build up at the plasma edge. These gradients can drive a type of instability, called Edge Localized Modes (ELMs). ELMs will lead to severe damage in future fusion devices. While ELMs are typically well-described as a pressure gradient and current density driven instability in the framework of ideal MHD, there are experimentally observed instabilities that can only be described including additional non-ideal effects in the stability calculation. Experimentally, ELMs are observed to be mitigated or suppressed by resonant magnetic perturbation (RMP) fields, which break the axisymmetry of tokamak equilibria.

In this work, the influence of non-ideal effects on linear MHD stability is analyzed using the code CASTOR3D. As a result, the experimentally observed mode frequency is in good agreement with the theoretical prediction only if resistivity, rotation, viscosity and gyroviscosity are simultaneously taken into account. In addition, we observe a strong influence of resistivity on the MHD stability threshold for several equilibria. Finally, new results on weakly toroidally coupled modes in magnetically perturbed tokamak equilibria are presented.

P 9.30 Tue 16:00 P

Data-driven non-intrusive reduced-order modeling via Operator Inference for the Hasegawa-Wakatani equations — •Constantin Gahr — Max-Planck-Institut für Plasmaphysik, Garching, Deutschland

Turbulence simulations play a crucial role in the plasma physics community as they give insight into the underlying nonlinear dynamics. However, these simulations are computationally expensive. Reduced-order models provide a computationally cheaper alternative to the high-fidelity model exploiting the fact that in most physics and engineering problems, the dominant dynamics live on low-dimensional manifolds.

We focus on the Hasegawa-Wakatani equations, a plasma model describing two-dimensional drift-wave turbulence, and approximate it with a reduced order model learned via Operator Inference. Operator Inference is a data-driven non-intrusive model reduction method that learns low-dimensional reduced models with polynomial nonlinearities from trajectories of high-dimensional high-fidelity simulations. In addition, it can handle arbitrary nonlinearities by employing lifting transformations that map the given states into states with polynomial nonlinearities. In the present work, we perform one of the first systematic reduced-order modeling studies in plasma physics to ascertain whether Operator Inference can provide accurate and predictive reduced models for the Hasagawa-Wakatani system.

P 9.31 Tue 16:00 P

Electric field structure and power coupled to the plasma in lattice vortex fields — •Christian Lütke Stetzkamp, Tsanko Vaskov Tsankov, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780 Bochum, Germany

Recently a novel concept for collisionless electron heating and plasma generation at low pressures was theoretically proposed [1]. It is based on a lattice of vortex fields, which produces certain electron resonances in velocity space.

Here, the power coupled into the plasma is theoretically calculated for generalized lattices and coil forms. Also a way to obtain the power coupling from arbitrary electric field configurations is shown and the performance of the field structure used in the theoretical work [1] is compared to simulated and measured fields.

[1] U. Czarnetzki and Kh. Tarnev, Phys. Plasmas 21, 123508 (2014)

P 9.32 Tue 16:00 P

Dynamic structure factor of the correlated one-component plasma — •Hanno Kählert — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel

The dynamic structure factor (DSF) plays an important role for the analysis of x-ray scattering spectra of dense plasmas. Here, molecular dynamics simulations are used to obtain first-principle data for the DSF of the classical one-component plasma (OCP), in particular for intermediate coupling strengths. In this regime, a theoretical description is challenging due to strong coupling and collisional effects. The results are compared with theoretical models for the DSF and are used to compute the local-field correction, which measures the deviations of the DSF from the Vlasov (mean-field) result.

P 9.33 Tue 16:00 P

The effect of plasma parameters on the surface treatment of air cathode for zinc-air battery — •He Li, Christian Schulze, Sadegh Askari, and Jan Benedikt — Institute of Experimental and Applied Physics, Kiel University, Germany

Plasma technology is of vital importance in the research field of nanomaterials which offers a green and efficient process for functionalization and treatment of surfaces. Most of the previous researches focus on the process parameters, but the relationship between plasma properties, such as ion energy or fluxes of reactive species, and materials properties is still unclear. In this work, a new reactor was assembled which is combining ICP plasma with CCP bias to control the plasma density and ion energy separately during the treatment, and transition metal oxides were used as the substrate to compare the electrochemical performance before and after plasma treatment. The plasma parameters during treatment were measured by the energy-resolved ion mass spectrometry which were analyzed with the corresponding catalytic performances to optimize the treatment process and fundamentally understand the reaction processes and mechanisms between plasma and material surfaces, thus providing a theoretical basis for the future application in the material researches.

P 9.34 Tue 16:00 P

ZrO2 based layers investigated by the 3ω method — •Vitali Bedarev, Philipp Alexander Maass, Marina Prenzel, Marc Böke, and Achim von Keudell — Experimental Physics II, Ruhr-University, Bochum, Germany

Aim of the project is to develop a diagnostic technique to measure the thermal conductivity of thin ZrO2 layers which are deposited via PECVD. The 3ω method was selected as a surface-sensitive technique with high accuracy and short equilibration time. This method can be applied to bulk amorphous solids and crystals as well as to amorphous films tens of microns thick. A thin electrically conductive wire is deposited onto the specimen to measure its thermal conductivity. The wire serves both, as a heater and as a temperature sensor. Joule heating at 2ω frequency occurs when an ac current with angular modulation frequency ω is applied to the wire. The generated thermal wave diffuses into the specimen. This causes a modulation of the resistance at 2ω due to the temperature dependence of the resistance. The voltage drop along the wire contains a contribution from a third harmonic that depends on the modulated temperature rise of the heater and could be used to calculate the samples thermal conductivity. We will present the setup, its characterization by using reference samples and first results on ZrO2 layers and the influence of the structure and morphology of these layers on the thermal conductivity.

P 9.35 Tue 16:00 P

Langmuir probe measurements in a dual-frequency capacitively coupled rf discharge — •Jessica Schleitzer, Thomas Trottenberg, Viktor Schneider, and Holger Kersten — Institute for Experimental and Applied Physics, Christian-Albrechts-University Kiel, Leibnizstr. 19, 24108 Kiel, Germany

The standard frequency for common rf plasmas used in technology is 13.56 MHz. A difference in the area of the electrodes result in a self-bias voltage at the powered electrode. The gas pressure in the device and the dc self-bias mainly determine the sheath potential and, thus, the ion current density and the ion energy towards the electrode surface. An independent control of these important properties - especially in industrial applications - is desirable but usually not possible. By adding a second frequency (27.56 MHz), a so-called electrical asymmetry effect (EAE) is created, which enables the control of the bias voltage and, thus, the ion energy almost independent of the ion flux by varying the phase angle between the two harmonics. Since the EAE is a relatively new approach to separately control these two parameters, the number of diagnostics performed in such a discharge amounts to a minimum. By using a specially designed Langmuir probe in this dual-frequency plasma, it can be determined to what extend the important plasma parameters, i.e. electron density and electron temperature, change with a variation of the phase between the two harmonics. This work aims to provide an initial insight into the differences between a single- and dual-frequency plasma based on Langmuir probe measurements and offers a comparison of theory and experiment.

P 9.36 Tue 16:00 P

Analysis of phase separation processes in dusty plasmas using a polarization camera — •Andre Melzer, Daniel Maier, and Stefan Schütt — Institute of Physics, University Greifswald

Binary dust mixtures provide an interesting system to study fundamental processes such as phase separation. There, two dust species of different sizes are trapped in the plasma of an rf discharge under microgravity conditions. These two species demix due to the difference in the forces exerted by the plasma on the differently sized particles, even if the size disparity is very small. So far, in these experiments, one of the two species has been marked by a fluorescent dye to distinguish between the species.

In a recent set of experiments, a camera equipped with a pixel-wise polarization filter is used to check whether the polarization-dependent scattering can be used to identify the two different species. Here, demixing processes under microgravity conditions are analyzed from the polarization camera data and compared with the information from the fluorescence technique.

P 9.37 Tue 16:00 P

Oxygen dependent etch rates of MF-particles in an RF-plasma — •Cassedyn Wirtz, Sören Wohlfahrt, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Microparticles are the essential component of a complex plasma. The forces affecting these particles, as well as their accumulated charge, depend prominently on their size. Thus, a precise knowledge of the particle size is a key input for quantitative description and modelling. However, in interaction with the plasma, the size can change due to etching and surface processes. The precise knowledge of the etch rate is especially important for measurements ranging from several minutes to hours. Melamin-formaldehyde (MF) particles are widely used in complex plasmas and known for changing their size during plasma exposure. It was shown that the etch rate depends strongly on the presence of oxygen in the discharge. We use an advanced light scattering technique that uses angular- and polarization resolved light scattering (APRLS) [1], which allows to determine the particle size with high temporal resolution. Utilizing this resolution the etch rates of MF-particles dependent of the oxygen content are further investigated, with focus on the regime of low admixtures ($< 10\%$).

[1] S. Wohlfahrt, D. Block, "High-precision in-situ measurements of size and optical properties of single microparticles in an RF-plasma", Physics of Plasmas 28, 123701 (2021)

P 9.38 Tue 16:00 P

Experiments and Simulations of Phase Separation in Binary Dusty Plasmas — •Stefan Schütt and André Melzer — Institute of Physics, University of Greifswald

Three-dimensionally extended dusty plasmas containing mixtures of two particle species of different size have been investigated on parabolic flights. Phase separation was found even when the size disparity was below 5%. Uphill diffusion coefficients have been determined and lie in the expected range for a phase separation process driven by plasma forces. A measure for the strength of the phase separation is presented that allows to quickly characterize measurements. There is a clear correlation between size disparity and phase separation strength. Molecular dynamics simulations of binary dusty plasmas have been performed and their behavior with respect to the phase separation process has been analyzed. Here as well, it was found that even the smallest size disparities lead to phase separation. It was confirmed that the separation is due to the force imbalance on the two species. Additionally, it was found that in the simulations the separation becomes weaker with increasing mean particle size.

P 9.39 Tue 16:00 P

Pulse excitation method for the determination of microparticle properties — •Armin Mengel and Franko Greiner — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel

The fact that a microparticle trapped in the sheath of a radiofrequency plasma behaves like a harmonic oscillator is often employed for diagnostics of particle properties, like charge-to-mass ratio or neutral drag coefficient. While traditional resonance methods like the frequency sweep[1] or phase resolved resonance method(PRRM)[2] rely on a sequence of measurements at a set of individual frequencies, possibly resulting in low time resolution, excitation with a pulse signal offers the opportunity to obtain the same parameters from a single time-resolved trajectory of the particle response within a much shorter time. We present a comparative study of PRRM and pulse excitation method (PEM).

[1] A. Melzer et al., Phys. Lett. A, 191 (1994) 301-308, https://doi.org/10.1016/0375-9601(94)90144-9
[2] H. Jung et al., J. Plasma Phys. (2016), 82(3), 615820301, https://doi.org/10.1017/S0022377816000441

P 9.40 Tue 16:00 P

The shallow water accretion disk experiment SWADEX — •Peter Manz — Institute of Physics, University of Greifswald, Germany

Accretion disks are ubiquitous in astrophysics. In laboratory experiments, especially, the two-dimensional geometry, magnetohydrodynamic (MHD) and gravitational effects are difficult to study. An analogy to shallow water can be used to simulate the gravitational potential by a gravitational funnel. In MHD a magnetic tension force gives rise to a return force which is directly proportional to the displacement, like a spring under tension. The analogy to the spring motivated the approach using polymers to mimic the effect of the magnetic field. Using viscoelastic fluids instead of liquid metals, it is possible to perform cheaper and safer experiments. First results of studies related to the standing accretion shock instability [1] and the magneto-rotational instability [2] will be presented.

[1] S. Sebold et al. Phys. Rev. E 102, 063103 (2020) [2] F. Günzkofer, P. Manz Phys. Rev. Fluids 6, 054401 (2021)

P 9.41 Tue 16:00 P

Untersuchung der Laser-induzierten Plasmaausbildung im Wasser mit Doppelpuls-LIBS bei Drücken von bis zu 60 MPa — •Marion Henkel[1], Michelle Siemens[2], Benjamin Emde[2], Steffen Franke[1], Jörg Hermsdorf[2] und Ralf-Peter Methling[1] — [1]Leibniz-Institut für Plasmaforschung und Technologie e.V. (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Deutschland — [2]Laser Zentrum Hannover e.V. (LZH), Hollerithallee 8, 30419 Hannover, Deutschland

Um Materialproben hinsichtlich ihrer chemischen Zusammensetzung zu analysieren, ist LIBS ein etabliertes Verfahren. Die Möglichkeit LIBS auch unter Wasser einzusetzen, macht es vor allem für die Rohstofferkundung in der Tiefsee interessant.

Die Doppelpulstechnik ist dafür ein vielversprechender Ansatz, bei der ein erster Laserpuls eine Kavität an der zu analysierenden Materialoberfläche erzeugt und der zweite Laserpuls das Plasma in der Kavität ausbildet.

Hohe Drücke in der Tiefsee haben dabei Auswirkungen auf das Plasma und seine Emission. Es wurde daher eine Druckkammer entwickelt, die Versuche sowohl mit Süß- als auch mit Salzwasser bei 60 MPa erlaubt. Ein Doppelpuls-Nd:YAG-Laser mit 2x400 mJ ermöglicht auch bei hohen Drücken eine Plasmaausbildung.

Spektrale und räumliche Diagnostiken mit einer Zeitauflösung von wenigen Mikrosekunden erlauben eine Untersuchung der Größe und Lebensdauer des Plasmas und der zeitlichen Entwicklung der Emission bei hohen Drücken unter Wasser.

P 9.42 Tue 16:00 P

Accelerating positron rings in a two-fold plasma column — •Lars Reichwein[1], Anton Golovanov[2], Igor Kostyukov[2], and Alexander Pukhov[1] — [1]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany — [2]Institute of Applied Physics RAS, Nizhny Novgorod, Russia

We present a setup consisting of an electron driver and a short laser pulse which create a two-fold plasma column structure [1]. The obtained laser-augmented blowout allows for the stable acceleration of positron rings over long distances even when the driving beam's evolution is considered. The scheme is studied numerically by means of particle-in-cell simulations. Further, we derive expressions for the accelerating and focusing fields analytically and show that the witness bunch is being accelerated along equilibrium lines in the wakefield structure.

[1] L. Reichwein et al., arXiv:2110.05226v2 (2021)

P 9.43 Tue 16:00 P

OES characterization of the microwave plasma torch in different configurations — •Christian Karl Kiefer[1], Ante Hecimovic[1], Arne Meindl[1], David Rauner[2], and Ursel Fantz[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]University of Augsburg, 86159 Augsburg, Germany

The microwave plasma torch, operated at under-pressure and atmospheric pressure, has already been tested for a wide range of applications from gas conversion over the decomposition of VOC in exhaust gases to plasma spraying. For the application of CO_2 conversion, axial scans of the rotational and vibrational temperature of the plasma were performed for a nozzle configuration (mixing the hot and cold gas as it exits the resonator) and a quencher configuration (allowing to admix additional cold gas into the effluent) via the analysis of the C_2 Swan emission spectrum. To further characterize the microwave plasma torch at atmospheric pressure via optical emission spectroscopy, spectra from a variety of different pure gases and gas mixtures were acquired and specific features were analyzed. Feasibility studies for the determination of different plasma parameters were performed.

P 9.44 Tue 16:00 P

Ignition and propagation of nanosecond pulsed plasmas in water with different polarities — •Katharina Grosse[1], Marina Falke[2], and Achim von Keudell[1] — [1]Experimentalphysik 2, Ruhr-Universität Bochum — [2]CLICCS, Universität Hamburg

Discharges in liquid enable a variety of applications ranging from wastewater treatment to nanoparticle formation. Pulsed plasmas in liquids ignited by voltage pulses with fast rise times and nanosecond pulse lengths yield a high degree of dissociation of the liquid, a high mass transport and efficient reaction rates with surfaces adjacent to the plasma. However, understanding of the ignition and propagation of these plasmas inside the liquid on these short timescales is still a matter of debate. An indirect method to analyze these processes is the comparison of different voltage polarities applied to the electrode. Different possible processes such as gas bubble or nanopore formation, field effects and the presence of a super critical fluid are evaluated and compared with optical emission spectra and ICCD imaging. A 10 ns long voltage pulse with amplitudes of ± 20 kV is applied to a 50 μm thin tungsten wire inside distilled water. The emission intensity, electron density and number of H emitters are similar for both polarities except in the first few ns. This indicates different electron generation mechanisms for different polarities at discharge breakdown. Based on these data, we postulate the ignition and propagation processes to result from electron generation from field effects inside a super critical fluid surrounding the electrode tip.

P 9.45 Tue 16:00 P

Hydrogen production in an atmospheric pressure argon methane microwave plasma — •Simon Kreuznacht, Marc Böke, and Achim von Keudell — Experimental Physics II, Ruhr University Bochum, Germany

Hydrogen is an important precursor in the chemical industry and may also serve as energy carrier, for energy storage, or as climate friendly fuel in the future. Today, hydrogen is produced mainly via steam reforming of methane, which emits a lot of CO_2. A promising alternative production method is the pyrolysis of methane in a microwave plasma, as it is an oxygen free technology.

Here, we present the analysis of the product gas stream of such a plasma. The plasma is operated at atmospheric pressure in an argon methane mixture (60 slm total flow rate up to 35 % methane admixture). Microwaves (2.45 GHz up to 6 kW) are used to sustain the plasma. The length of the plasma reaches up to 60 cm with a diameter of about 1.2 cm. In the center of the plasma the gas temperature reaches up to 4200 K. The main products are hydrogen (H_2), ethyne (C_2H_2), ethene (C_2H_4) and solid carbon. The methane conversion increases linearly with the specific energy input per methane molecule (SEI). Increasing the methane admixture at constant SEI leads to an increased methane conversion. Up to 73 % methane conversion and up to 87 % selectivity towards hydrogen are achieved.

P 9.46 Tue 16:00 P

2D spatially resolved atomic oxygen densities in a micro cavity plasma array — •David Steuer, Henrik van Impel, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — Experimental Physics II: Physics of Reactive Plasmas, Ruhr-University Bochum, D-44801 Bochum, Germany

Micro cavity plasma arrays have numerous applications, such as the treatment of volatile organic compounds (VOCs) or the generation of ozone. The key to these applications is the generation of reactive species such as atomic oxygen within the plasma. Typically, atomic oxygen densities can be measured by laser spectroscopic methods. In the case of the micro plasma array, which consists of thousands of cavities, optical access is limited. For this reason, an optical emission spectroscopy (OES) approach, energy resolved actinometry (ERA), is used. 2D resolved measurements can be performed by using an ICCD camera in combination with a tunable bandpass filter. The discharge is operated in helium with an oxygen admixture of 0.1%. The triangular voltage is varied at a frequency of 15 kHz between an amplitude of 400-800V. As the voltage increases, the number of ignited cavities rises. Furthermore, the atomic oxygen density per cavity increases with the power. This work is supported by the DFG via SFB 1316 (project A6).

P 9.47 Tue 16:00 P

3-dimensional density distributions of NO in the effluent of a micro atmospheric pressure plasma jet operated in He/N2/O2 mixture and the influence of surfaces — •Patrick Preissing[1], Ihor Korolov[2], Julian Schulze[2], Volker Schulz-von der Gathen[1], and Marc Böke[1] — [1]Ruhr-Universität Bochum, Experimentalphysik II — [2]Ruhr-Universität Bochum, Allgemeine Elektro- und Plasmatechnik

Plasma jets are known to generate a huge number of different reactive species. In that context Nitric Oxide (NO) is one of the key players, as it triggers many biological processes. In this study absolute ground state densities of NO are measured in the effluent of an RF-driven micro atmospheric pressure plasma jet (μAPPJ), that is operated in a He/N2/O2 mixture, by means of Laser Induced Fluorescence (LIF), with 3d spatial resolution. The densities are measured in two distinct atmospheres. In the first one, the jet is expanding into open air, whereas in the second configuration the jet is expanding into a controlled He/ synthetic air mixture. From the time resolved LIF signals the quenching coefficients for He, air, N2 and O2 are determined, as well as the intrusion of the ambient air into the He gas flow expanding from the jet. Parameter studies, varying different parameters such as plasma power, gas flow and gas mixture have been performed and the influence on the absolute NO densities as well as its distributions are investigated. Eventually the influence of surfaces in the effluent that interact with the reactive species is measured.

P 9.48 Tue 16:00 P

Atomic oxygen distribution in the interaction zone of a micro atmospheric pressure plasma jet and a surface — •Sascha Chur[1], David Steuer[1], Volker Schulz-von der Gathen[1], Marc Böke[1], and Judith Golda[2] — [1]EP2 chair Physics, Ruhr University Bochum, Germany — [2]Plasma Interface Physics, Ruhr University Bochum, Germany

The efficiency of catalysts is strongly dependent on the characteristics of the used catalytic surface. Key features are the morphology and nanostructure of the surfaces and its chemical composition. The combination of reactive species provided by a micro-scaled atmospheric pressure plasma jet, electric fields and energy input by laser irradiation can lead to very effective functionalisation and structuring of surfaces via complex laser-plasma-surface interactions. Here, we investigate the distribution of atomic oxygen (O) along treated substrates by means of two-dimensional two photon absorption laser induced fluorescence spectroscopy (TALIF) utilizing a red enhanced ICCD camera. The measurements were performed in the emerging gas beam of a micro atmospheric pressure plasma jet operated with a He/O admixture in the interaction zone of a metallic (Cu) surface. The O density (~10^16 m^-3) forms a maximum in front of the surface. Furthermore it could be shown that the size of the observed volume by the detector systems influences results like density or lifetime significantly. Supported by DFG within SFB1316 (TP B2)

P 9.49 Tue 16:00 P

Determination of hydrogen peroxide concentration in water treated by a capillary plasma jet — •Steffen Schüttler[1], Emanuel Jess[1], Marc Böke[2], Volker Schulz-von der Gathen[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum, Germany — [2]Experimental Physics II: Physics of Reactive Plasmas, Ruhr-University Bochum, Germany

A novel and promising approach to activate a biocatalyst is by use of an atmospheric pressure plasma jet that produces hydrogen peroxide [1]. Since the biocatalyst requires a well-defined portion of hydrogen peroxide, a plasma is ideally suited as it can be easily switched on and off. In the plasma-driven biocatalysis process, the biocatalyst is placed in a liquid, mainly water, and the plasma jet is in contact with the liquid via its effluent. In this work, a capillary plasma jet is used, which offers a wide range of control parameters and optimization possibilities. The hydrogen peroxide concentration in water was measured by UV absorption spectroscopy. This technique allows an in-situ measurement while the plasma is in operation and the spatial resolution of the hydrogen peroxide concentration can be obtained. Furthermore, a spectrophotometric approach was used. Ammonium metavanadate was added to the treated water. Its reaction with hydrogen peroxide leads to an absorption spectrum at 450 nm. This enables comparable measurements to the UV absorption measurements. This work is supported by the DPG within SFB1316 (Subproject B11).

[1] A. Yayci, T. Dirks, F. Kogelheide, M. Alcalde, F. Hollmann, P. Awakowicz, J. E. Bandow, ChemCatChem 2020, 12, 5893.