P 10: Poster Session I

Time: Tuesday 16:15–18:15 Location: ZHG Foyer 1. OG

P 10.1 Tue 16:15 ZHG Foyer 1. OG

Development of a planar dielectric barrier discharge for plasma and surface studies — •A.A. Ben Yaala[1], R. Antunes[1], T. Höschen[1], S. Buchberger[1], A. Meindl[1], A. Hecimovic[1], and U. Fantz[1,2] — [1]Max Planck Institute for Plasma Physics (IPP), 85748 Garching b. München, Germany — [2]University of Augsburg, 86149 Augsburg, Germany

The growing demand for ammonia in fertilizers, chemical industry and energy storage drives the need for production methods compatible with an electrified energy system. Plasma-catalysis offers a promising alternative to the traditional Haber-Bosch process, with potential for decentralization and renewable energy integration. The Dielectric Barrier Discharge (DBD) is the most extensively studied plasma discharge for ammonia synthesis due to its operating temperatures, which facilitate catalyst activation and improve reaction selectivity. While plasma-catalysis synergism in DBD has been demonstrated in several works, the detailed plasma-surface interactions remain an underexplored area. In this contribution, a newly developed planar DBD reactor, which permits an easier access to plasma and surface diagnostics, will be presented. This planar DBD is assembled in a setup with in-vacuo access to X-ray Photoelectron Spectroscopy (XPS), whereby surface characterization of a catalytic material deposited on the ground electrode can be done without breaking the vacuum. Preliminary work on formation of NH_3 in N_2-H_2 plasmas as well as surface analysis of the exposed electrode will be presented.

P 10.2 Tue 16:15 ZHG Foyer 1. OG

Hybrid FTIR setup for gas sampling and in-situ analysis for low-temperature, high-pressure plasmas — •Francesco Franco[1,2], Arne Meindl[1], Ante Hecimovic[1], Rodrigo Antunes[1], and Ursel Fantz[1,2] — [1]Max Planck Institute for plasma physics, Boltzmannstr. 2, D-85748 Garching b. München — [2]University of Augsburg, Universitätsstr. 1, D-86159 Augsburg

Fourier Transform InfraRed (FTIR) spectroscopy is a flexible, fast and sensitive diagnostic based on the absorption of broadband infrared light from molecules with net electric dipole. This technique can be applied to the qualitative and quantitative analysis of cold gas products and in-plasma reactive species, here in the context of low-temperature, high-pressure plasma reactors for gas conversion (e.g. NH_3, CO_2 and CH_4 into N_xH_y, CO and C_xH_y). Important plasma parameters, such as chemical composition and vibrational state distributions, can be derived with FTIR. In this contribution, the development and calibration steps of a new FTIR apparatus are presented, featuring a commercial interferometer and an external and movable detector for both in-situ and gas sampling experimental operation. This configuration deviates from the standard application of these instruments and requires custom hardware implementations. Since FTIR is very sensitive to moisture and environmental contaminants, solutions for atmosphere control along the beamline, between the interferometer and the detector, are outlined, together with technical features of the setup. To carry out quantitative analysis from infrared absorption spectra, the challenges and approaches to calibration of the instrument are discussed.

P 10.3 Tue 16:15 ZHG Foyer 1. OG

Characterization of different DCSBD designs using plasma diagnostics — •Henry von Wichert[1], Jianyu Feng[2], Tobias Hahn[1], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics, Christian-Albrechts-University, Kiel, Germany — [2]Department of Plasma Physics and Technology, Masaryk University, Brno, Czech Republic

Atmospheric pressure plasma jets are effective for treating surfaces. To modify larger areas efficiently, a curtain-shaped jet can be used by positioning two surface barrier discharges (DCSBDs) facing each other. Here, we characterize different designs of the jets and the DCSBD units themselves by various diagnostics.

The energy flux from the discharge to the substrate was measured at different distances and power levels using passive thermal probes. These were compared with the total electrical power consumed by the discharge, estimating the energy efficiency of the setup.

Spectral profiles of the DCSBDs were measured by OES to check for variations within the plasma, and high-resolution brightness profiles were captured. These optical measurements are compared with the energy flux data to better understand the relationship between the total power used, the area covered by the discharge, and the intensity of the plasma in the illuminated region.

Using a high-speed-camera, the short-term behavior of the filaments of the discharge could be compared with the average distribution of the plasma on the surface, as measured by long-exposure photographs.

P 10.4 Tue 16:15 ZHG Foyer 1. OG

Elechtrochemical investigation of microsecond plasma-in-liquid treated copper surfaces — •Neil Dominik Unteregge, Pia Victoria Pottkämper, and Achim von Keudell — Ruhr-Universität Bochum, Bochum, Deutschland

The aim of this project is to investigate the production of hydrogen peroxide and its effects on copper oxide surfaces. This interaction leads to the growth of copper oxide nanocrystals, which are valuable catalysts for the electrochemical reduction of CO2. However, the catalysts activity decreases during operation in an electrochemical cell. In this project an in-liquid plasma is ignited in distilled water, which creates many reactive species with varying lifetimes, such as hydrogen peroxide, molecular oxygen and hydrogen, as well as solvated electrons. This plasma is powered using high voltages and microsecond pulses. The energy dissipated in each pulse triggers the phase transition to water vapor and allows dissociation in the plasma state. As a result, so-called plasma activated water (PAW) is obtained. The concentration of hydrogen peroxide in PAW is determined by absorption spectroscopy using the reaction of hydrogen peroxide with ammonium vanadate as sensor. PAW is then brought into contact with the copper oxide surfaces to induce the nanocrystal growth. The copper oxide surfaces are analyzed by SEM and cyclic voltammetry.

P 10.5 Tue 16:15 ZHG Foyer 1. OG

Investigation of a microwave plasma torch for conversion of CO_2 and CH_4 molecules — •Clemens Kranig[1], Christian K. Kiefer[1], Arne Meindl[1], Ante Hecimovic[1], and Ursel Fantz[1,2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, D85748 Garching b. München — [2]University of Augsburg, Universitätsstr. 1, D-86159 Augsburg

Using a microwave plasma for converting various gaseous molecules, e.g. CO_2 or CH_4, into value-added molecules like CO and H_2, is a promising technology. For the case of CO_2 high conversion rates have been demonstrated as well as comparably short start-up times, which synergizes well with fluctuating renewable energy supplies. The microwave torch generates a low-temperature plasma in the pressure range from several millibars to atmospheric pressure. The plasma is characterized by gas temperatures ranging from 2000-6000 K, which enable endothermic reactions, such as CO_2 conversion ($CO_2 \rightarrow CO + \frac{1}{2}O_2$), methane pyrolysis ($CH_4 \rightarrow 2H_2 + C_s$), and dry reforming of methane ($CO_2 + CH_4 \rightarrow 2CO + 2H_2$). Due to the high temperature in the effluent, one key challenge is the reduction of recombination. Other challenges are the desired selectivity accompanied by sufficient energy efficiency, as well as the deposition of carbon black at critical locations in the reactor. This contribution will focus on using pure CH_4 or a gas mixture of CO_2 and CH_4 for the production of H_2 or syngas. The analysis of the composition of the product gases is challenging, as e.g. solid carbon and condensed water are not detected using the gas analysis techniques (gas chromatography or mass spectrometry).

P 10.6 Tue 16:15 ZHG Foyer 1. OG

Nitrogen fixation and H_2O_2 production by an atmospheric pressure plasma jet — •Jannis Kaufmann, Steffen Schüttler, and Judith Golda — Plasma Interface Physics, Ruhr University Bochum, Bochum, Germany

Atmospheric pressure plasmas are widely used for nitration fixation. Atmospheric pressure plasma jets are suitable sources of reactive species delivered into liquids. The addition of H_2O leads, for example, to the production of H_2O_2 as shown by a capillary plasma jet. Adding nitrogen to the humidified feed gas, nitrogen fixation can be performed by the capillary plasma jet investigated in this work [1]. We used various diagnostics for measuring the concentration of different species in plasma-treated liquid: spectrophotometry (hydrogen peroxide, nitrite), fluorometry (ammonia) and amperometry (hydrogen peroxide). We show that a small admixture of nitrogen (between 0.1 and 1 %)

already leads to a lower concentration of hydrogen peroxide. Instead, the plasma produced nitrogen-containing species such as nitride and ammonia. Low frequency pulsing of the RF signal can be used to tune plasma chemistry in our system. Given an additional admixture of oxygen to the system, the hydrogen peroxide production can be increased, while no ammonia is generated. Furthermore the production via hydroxyl radicals was shown to be the main production channel for hydrogen peroxide and nitrite.

This work is supported by the DFG within CRC1316 Project B11

[1] S. Schüttler, J. Kaufmann, J. Golda, Plasma Process. Polym. 2024; 21:e2300233. https://doi.org/10.1002/ppap.202300233

P 10.7 Tue 16:15 ZHG Foyer 1. OG

Formation of stable species in atmospheric-pressure coaxial DBDs in argon-tetramethylsilane mixtures — •Marjan Stankov[1], Lars Bröcker[2], Nickolas Steppan[2], Claus-Peter Klages[2], Markus M. Becker[1], and Detlef Loffhagen[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Institute for Surface Technology, Technische Universität Braunschweig, Braunschweig, Germany

The formation of stable species in atmospheric-pressure dielectric barrier discharges (DBDs) operated in argon with small admixtures of tetramethylsilane (TMS) has been investigated with the help of modelling and experiment for gas residence times up to 8 ms. The DBD reactor studied consists of two borosilicate glass tubes in a coaxial configuration with a gap of 1 mm. It is powered by a 4 kV sinusoidal voltage at 86.2 kHz. The modelling study employs a time-dependent, spatially one-dimensional fluid-Poisson method including a complex plasma chemistry for Ar-TMS mixtures considering about 90 species and 700 reactions. It is accompanied by measurements using Fourier-transform infrared (FTIR) spectroscopy for the analysis of stable molecules in the effluent gas. Satisfactory agreement between calculated and measured number densities of several stable species is generally found. In particular, the analysis for admixtures of up to 100 ppm TMS reveals that trimethylsilane is the primary silicon-containing species generated and that methane becomes the predominant hydrocarbon. The work has been funded by the Deutsche Forschungsgemeinschaft (DFG) - project number 504701852.

P 10.8 Tue 16:15 ZHG Foyer 1. OG

Spatially resolved optical emission spectroscopy on a dielectric barrier discharge for plasma-assisted catalysis — •Kerstin Sgonina[1], Alexander Quack[1], and Jan Benedikt[1,2] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Kiel Nano, Surface and Interface Science (KiNSIS), Kiel University, Germany

Energy efficient and decentralized performance of catalytic reactions for the means of converting excess energy into chemicals is one of the important research topics nowadays. Plasma-assisted catalysis could provide one possible solution as it is available on demand and works even without external heating. Non-equilibrium atmospheric pressure plasmas are used to dissociate and excite gaseous molecules, which can then react at the surface of the catalyst to form the desired products. For efficient plasma-assisted catalysis reactions, the fast product removal is crucial, which can be achieved by specific reactor designs or tailored materials. A reactor was designed aiming the fast product removal and enabling testing powder-like and porous materials for their catalytic effect. Spatially resolved optical emission spectroscopy was used to analyze the discharge properties and structure, and to study the role of the catalyst in the process. The dielectric barrier discharge is operated at different frequencies and voltage amplitudes. By using CO_2 and H_2, the methane formation is investigated via mass spectrometry.

P 10.9 Tue 16:15 ZHG Foyer 1. OG

Diagnostic capabilities of Setup for Imaging of Radicials Interacting with Surfaces (IRIS) — •Robin Minke[1], Robin Labenski[1], Marc Böke[2], Achim von Keudell[2], and Judith Golda[1] — [1]Plasma Interface Physics, Ruhr-University Bochum — [2]Experimental Physics II, Ruhr-University Bochum

The novel field of plasma catalysis involves complex chemistry, making it difficult to identify the underlying causes and effects between catalysts and plasma. Methods are needed to isolate specific processes to understand their contribution in the overall chemistry. To enhance the insight of how plasma-generated molecules interact with surfaces, a low-pressure chamber setup for Imaging of Radicals Interacting with Surfaces (IRIS) has been developed. In this setup, radicals produced by an ECR discharge are accelerated through a differential chamber into the main chamber, forming a molecular particle beam that collides with a substrate surface. Spatially resolved Laser-Induced Fluorescence (LIF) is employed to monitor the density of a chosen radical species in the incoming and outgoing beam, revealing insights into its surface chemistry. The substrate temperature can be controlled between 300 and over 1000 K, making this setup ideal for studying the interplay between molecules and temperature-driven catalysts. Providing the diagnostic capabilities of the setup, using OH molecules is a starting point for the study of other molecules and their interactions with different substrate surfaces.

P 10.10 Tue 16:15 ZHG Foyer 1. OG

Untersuchungen der Plasmareduktion von Mangan in wässriger Lösung — •Daniel Tasche[1,2], Kai Bröking[1,2,3], Mirco Weber[1], Christoph Gerhard[1,4] und Wolfgang Viöl[1,5] — [1]HAWK, Hochschule für angewandte Wissenschaft und Kunst, Fakultät Ingenieurwissenschaften und Gesundheit, Göttingen, Deutschland — [2]Technische Universität Clausthal, Fakultät für Natur- und Materialwissenschaften, Clausthal Zellerfeld, Deutschland — [3]Max-Planck-Institut für Multidisziplinäre Naturwissenschaften, Göttingen, Deutschland — [4]Politecnico di Milano, School of Industrial and Information Engineering, Mailand, Italien — [5]Fraunhofer IST - Anwendungszentrum für Plasma und Photonik, Göttingen, Deutschland

Dieser Beitrag beschäftigt sich mit der plasmainduzierten Reduktion des Manganions in wässriger Lösung. Ein Atmosphärendruckplasma wird über einer manganionenhaltigen Lösung gezündet, wodurch sich die Oxidationsstufe des Mangans verändert. Die Reduktion findet innerhalb der Plasma-Flüssigkeit-Grenzfläche statt. Zusätzlich wird eine Strömung durch das Plasma in der Lösung induziert, wodurch es zu einer Durchmischung der flüssigen Phase kommt. Die Ausbreitung sowie die chemischen und physikalischen Eigenschaften des Prozesses werden durch die hyperspektrale Bildgebung orts-, zeit- und spektralaufgelöst beobachtet. Dadurch sind hochauflösende Analysen der charakteristischen Absorptionsbanden unterschiedlicher Oxidationsstufen des Manganions und der Lichtemission des Plasmas möglich. Durch die Untersuchungen ergeben sich Prozessparameter wie Reduktionsraten und Bestandteile im Plasma.

P 10.11 Tue 16:15 ZHG Foyer 1. OG

Stereoscopic observation of the interaction of fast particle agglomerates with a dusty plasma — •Daniel Maier, Christina Knapek, André Melzer, Daniel Mohr, and Stefan Schütt — Institute of Physics, University of Greifswald, Germany

Fast objects moving through a dispersive medium can interact in various ways and create a variety of phenomena (e.g. Mach cones). The investigation of this interaction has been a topic of research for long times.

Such interactions were observed in experiments with a dusty plasma under microgravity using the "Zyflex" chamber. A cloud of micron sized particles in a low temperature plasma was disturbed by fast particle agglomerates that were unintentionally accelerated to high velocities during the experiments. This disturbance leads to dust-free cavities behind the agglomerates that vary in form and size due to the velocity of the agglomerate and the angle of its moving direction in relation to the plane of the plasma that is illuminated by the laser. Using a stereoscopic camera set-up consisting of four high-speed cameras with a resolution of 2.1 MP at a frame rate of 200 fps it is possible to calculate the spatial position of the dust particles and their movements during the interaction with the fast agglomerates in three dimensions.

In this contribution observations of the described interaction for agglomerates with different velocities and moving angles will be shown focussing on the velocities and density of the surrounding dust particle as well as the spatial characteristics of the the dust-free cavity.

This project has been funded under the DLR grant 50WM2161.

P 10.12 Tue 16:15 ZHG Foyer 1. OG

Microwave cavity resonance spectroscopy (MCRS) and double probe (DP) measurements as nanodusty plasma diagnostic tools — •Andreas Petersen[1], Johanna Vogt[2], Michael Friedrichs[2], Jens Oberrath[2], and Franko Greiner[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany — [2]South Westphalia University of Applied Sciences, 59494 Soest, Germany — [3]KiNSIS, 24118 Kiel, Germany

Measuring plasma parameters like n_e and T_e in a nanodusty plasma is still a challenge as it requires a non-invasive diagnostic method. An excellent candidate for this purpose is MCRS. Only electrons are affected, as the probing microwave frequency is $\omega > \omega_p$. The approach can be described well for a sealed cavity with N ports. However, analysing nanodusty plasmas requires additional access to the cavity (holes, slits). A theoretical model of the cavity modes and the coupling of the ports is required. We present a suitable experimental cavity design and compare to numerical models. Furthermore, double probe measurements in an argon plasma inside the cavity are considered, as they are a good stepping stone for the diagnosis of nanodusty plasmas.

We gratefully acknowledge funding by Deutsche Forschungsgemeinschaft (DFG), Project No. 531667910

P 10.13 Tue 16:15 ZHG Foyer 1. OG

COMPACT: Project Status and Research Data Managment — •Daniel P. Mohr[1], Christina A. Knapek[1], Stefan Schütt[1], Daniel Maier[1], Andre Melzer[1], and COMPACT Collaboration[2] — [1]University of Greifswald, Institute of Physics, Greifswald, Germany — [2]International: CA, US, SE, DE

Complex, or dusty, plasmas consist of micrometer-sized grains that are injected into a low-temperature noble gas discharge. The grains become charged and interact with each other via a screened Coulomb potential. On ground, gravity compresses the system and prevents the formation of larger, three-dimensional particle clouds.

The future complex plasma facility COMPACT will allow the investigation of large three-dimensional complex plasmas under microgravity conditions aboard the International Space Station (ISS).

COMPACT is a project with international scientific contributions, funded by space agencies (DLR, NASA). The industry phase B is currently underway and will be finished in 2025.

Data generated by experiments on the ISS are of significant importance, as repeating an experiment can be extremely challenging and time-consuming. Therefore, it is crucial to design data management and handling strategies at an early stage to ensure efficient and reliable data processing.

We will present the objectives of COMPACT, the project status, and first concepts for the handling of research data acquired with COMPACT following the FAIR principles.

This work is funded by DLR/BMWi (FKZ 50WM2161).

P 10.14 Tue 16:15 ZHG Foyer 1. OG

3D EM-simulation of the influence of non-ideal cavities on their resonance behaviour to be applied in microwave cavity resonance spectroscopy — •Johanna Vogt[1], Michael Friedrichs[1], Andreas Petersen[2], Franko Greiner[2], and Jens Oberrath[1] — [1]South Westphalia University of Applied Sciences, 59494 Soest, Germany — [2]Institute of Experimental and Applied Physics, Kiel University, 24118 Kiel, Germany

To extract plasma parameters from a plasma, active plasma resonance spectroscopy (APRS) was developed, which works by measuring the frequency response of a plasma subjected to a wide-band radio frequency signal. The resulting spectrum is analysed, and with the use of a model, the electron plasma frequency is calculated. This in turn is used for determining the plasma electron density. A specific version of APRS is microwave cavity resonance spectroscopy (MCRS), in which an electromagnetic (EM) wave is coupled into a resonant cavity containing a plasma. Due to its non-invasive character, MCRS is a good candidate to be applied in nanodusty plasma.

The spectrum of a cavity is influenced by its geometry and materials. To determine plasma parameters from these spectra, detailed knowledge of this influence is necessary. To this extent, the results of a 3D EM simulation of the influence of several non-ideal alterations on the resonance spectrum is investigated and compared to an ideal cylindrical cavity.

This project was funded by Deutsche Forschungsgemeinschaft (DFG), Project No. 531667910, which we gratefully acknowledge.

P 10.15 Tue 16:15 ZHG Foyer 1. OG

Towards automated processing and re-use of open-access content in LTP research — •Markus M. Becker[1], Hans Höft[1], Ihda Chaerony Siffa[1], Muhammad Haris[2], Sarah Dellmann[2], and Markus Stocker[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]TIB – Leibniz Information Centre for Science and Technology, Hanover, Germany

In research on low-temperature plasmas (LTP), a wide range of devices, methods and materials are mainly used in table-top experiments. Model-based simulations are often used in conjunction with laboratory experiments to investigate, optimise or develop new plasma processes and applications. This leads to a large number of widely spread, heterogeneous research results, which are difficult to compare and can hardly be brought together. However, this is essential to form a robust overall understanding of the very complex mechanisms and effects in LTP. This contribution deals with modern techniques and exploits the advantages of Open Access (OA) to meet these challenges. OA publications from LTP research are collected in the central public repository "Renate" and converted into a machine-readable format. This enables machine learning-based processing and interpretation of OA publications on the used devices, methods, materials, etc., and ultimately their structured storage in the "Open Research Knowledge Graph" (ORKG). In future, the knowledge extracted and semantically described in this way will be easier to find and aggregate and can therefore be re-used to gain new research insights using data-driven methods.

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P 10.16 Tue 16:15 ZHG Foyer 1. OG

Exploration of modern techniques for optimising plasma modelling procedures — Aleksandar P. Jovanović[1], Marjan Stankov[1], Robert Wagner[1], Ihda Chaerony Siffa[1], Aleksandar Trokicić[2], Marko D. Petković[2], and •Markus M. Becker[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Faculty of Sciences and Mathematics, University of Niš, Niš, Serbia

Understanding the physical and chemical processes relevant to plasma generation is particularly important due to its broad technological potential. To gain a deeper understanding of these processes, numerical modelling is often applied. Plasma models often need to account for many particle species and reactions, leading to a large system of partial differential equations, which needs to be solved numerically. In addition, fine meshes are required to resolve the sheath regions, which further increases the number of degrees of freedom and prolongs calculation time. Therefore, a big challenge in plasma modelling is to find an efficient way to solve these equations. To tackle this challenge, modern techniques for simplification and optimisation of plasma modelling procedures are investigated and discussed. The studied approaches include automating geometry and refined mesh generation supported by image processing, a reinforcement learning-based time-stepping and the use of tailored preconditioners for iterative solvers. The results of applying these techniques to model a positive streamer in air and an RF discharge in argon at low pressure are presented and discussed.

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P 10.17 Tue 16:15 ZHG Foyer 1. OG

Electrons interacting with dielectric slabs — •Franz Xaver Bronold and Felix Willert — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

As a preparatory step for computing secondary electron emission probabilities for dielectrically coated electrodes used in dielectric barrier discharges, we investigate–from a microscopic solid-state physics point of view–the interaction of electrons with dielectric slabs of finite thickness. Whereas for a halfspace geometry, only electron backscattering (including secondary emission) has to be considered, it is now also required to quantify electron transmission through the slab. Leaving aside the interaction of the transmitted electrons with the metal supporting the dielectric layer,we describe in this contribution how the slab's energy and angle-resolved transmission and backscattering functions can be obtained from the invariant embedding principle used by us so far for modeling secondary emission from halfspaces [1]. Both functions enter the equation determining electron backscattering from the dielectric-metal heterostructure comprising the barrier discharge's electrode. Representative data for SiO_2, described by a semiempirical randium-jellium model, are shown as a function of layer thickness, in addition to the Möbius scheme used for numerically integrating the set of matrix Riccati/Sylvester differential equations, arising in slab geometry, in contrast to their algebraic counterparts appearing in the modeling of halfspaces. [1] F. X. Bronold and F. Willert, Phys. Rev. E **110**, 035207 (2024). Supported by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)–495729137.

P 10.18 Tue 16:15 ZHG Foyer 1. OG

Solving the Spatially Dependent Boltzmann Equation for Electrons with Physics-Informed Neural Networks — •Ihda Chaerony Siffa[1], Detlef Loffhagen[1], Markus M. Becker[1], and Jan Trieschmann[2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany — [2]Kiel University, Kaiserstraße 2, 24143 Kiel, Germany

Physics-informed neural networks (PINNs) are an exciting new research area in the field of scientific machine learning. They offer an alternative approach to numerically solving partial differential equations (PDEs) in both forward and inverse problem settings with great flexibility. This study investigates the application of PINNs to solve the spatially one-dimensional electron Boltzmann equation in two-term approximation, which is relevant for the study of non-local effects in weakly ionized, non-thermal plasmas. An attention-based neural network architecture is developed to prevent the convergence to incorrect or trivial solutions of the PDEs as encountered by other architectures in solving this kinetic equation. Numerical experiments are conducted for argon plasmas considering homogeneous electric fields with varying values using a conventional numerical method and the PINN approach. The results from PINNs show good agreement with the reference solutions (obtained from the conventional approach) for the considered cases, which further strengthens PINNs' position as an alternative to solve this type of equation, paving a way for more efficient and accurate fluid-Poisson plasma simulations.

P 10.19 Tue 16:15 ZHG Foyer 1. OG

Local projectors for sparse storage of Basis Projection Operators. — •Nathan Marin[1,2] and Stefan Possanner[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Garching, Germany

In this project, we developed a custom set of commuting local projection operators for the De-rham complex based on a new set of quasi-interpolation points. These new local projectors maintain the same convergence rate of the global projectors, replicate the basis functions, and have an execution time in the same order of magnitude as the global projectors if run in parallel (the local projectors are about twice as slow as the global projectors). All while having the added advantage of producing a significantly sparser matrix for the Basis Projection Operators (even when compared with other Local Projectors), which allow us to store said operators in the PSYDAC Stencil-matrix format.

P 10.20 Tue 16:15 ZHG Foyer 1. OG

Development and validation of optimized grids for simulations of erosion and impurity transport — •Lukas Maximilian Ellerbrock[1,2], Christoph Baumann[1], Andreas Kirschner[1], Henri Kumpulainen[1], Berkant Palazoglu[1], Juri Romazanov[1], Sebastijan Brezinsek[1,2], and Christian Linsmeier[1,3] — [1]Forschungszentrum Jülich IFN-1, Jülich, Germany — [2]Heinrich-Heine-Universität, Düsseldorf, Germany — [3]Ruhr-Universität, Bochum, Germany

Fusion reactors require precise numerical predictions of plasma-wall interactions and impurity transport. Such predictions can be provided by numerical tools like the 3D Monte-Carlo simulation code ERO2.0. The present work deals with improvements of the ERO2.0 code regarding the numerical grid layout with the goal to optimize precision and computing power.

Until recently, simple rectangular grids were used to store the input distributions of plasma parameters like density and temperature coming from codes like SOLPS. However, the spatial resolution of these rectangular grids is limited due to memory reasons. This limitation can lead to artefacts in the simulation results. Therefore, a new code version introduced flexible field-aligned grids to improve the spatial resolution.

To verify the development, test simulations are applied for tungsten erosion in the future DEMO reactor and further improvements are made to optimize the precision of the code.

P 10.21 Tue 16:15 ZHG Foyer 1. OG

Calculating non-axisymmetric heat loads on plasma-facing components from infrared measurements in W7-X — •Sebastian Thiede[1], Marcin Jakubowski[1], Yu Gao[1], and Peter Manz[2] — [1]Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, Germany — [2]Institut für Physik, Universität Greifswald, Greifswald, Germany

The edge topology of the Wendelstein 7-X stellarator has a complicated 3D structure. This is also true in particular for the deposited heat on plasma-facing components (PFCs). Local heat flux patterns are a valuable source of information for edge physics. The C++ code DELVER was newly developed to infer the surface heat flux distribution on PFCs from infrared measurements. For cuboid divertor tiles, consisting of multiple material layers, it uses an implicit finite-difference approach and an operator splitting technique to calculate this heat flux. It features arbitrary problem dimension, orthotropic material properties that can be arbitrary functions of temperature, non-equidistant orthogonal grids and flexible boundary conditions. A python interface was also developed for more convenient usage. DELVER has been tested against a simple analytical case, other codes, and was assessed on experimental data from W7-X.

P 10.22 Tue 16:15 ZHG Foyer 1. OG

Towards Implementing a Hirshman-Sigmar Type Collision Operator in the Gyrokinetic Code GENE-X — •Andrew Ivan Sulimro, Philipp Ulbl, and Frank Jenko — Max Planck Institute for Plasma Physics

The performance of future magnetic confinement fusion power plants is primarily influenced by the turbulence-driven quality of plasma confinement and heat exhaust. High-fidelity gyrokinetic simulations are key tools to investigate turbulence in fusion devices. The `GENE-X` gyrokinetic code is designed to simulate such situations in the complex geometry of the edge and scrape-off layer regions.

One of the important aspects influencing the accuracy of a gyrokinetic solver is the physics realism of the collision model. In the current state, the gyrokinetic code `GENE-X` is equipped with the Lenard-Bernstein/Dougherty (LBD) operator which is a lightweight alternative to the Fokker-Planck operator. However, the LBD operator lacks the accuracy to study different plasma components, such as impurities. As the collision frequency is proportional to the square of the ion charge, a realistic collision operator is especially crucial for studying high-Z impurities.

In this work, a more accurate collision operator of Hirshman-Sigmar type is implemented into `GENE-X`. This new operator can capture additional effects, such as an accurate pitch-angle scattering and the velocity dependence of the collision frequency, which are not accounted for by the LBD operator. The models involved and the numerical aspects of the implementation will be presented and discussed.

P 10.23 Tue 16:15 ZHG Foyer 1. OG

Inclusion of MHD effects in the transport description of tokamak plasmas — •Federico Stefanelli, Emiliano Fable, Clemente Angioni, and Hartmut Zohm — Max-Planck-Institute for Plasma Physics, 85748 Garching, Germany

This project aims to include MHD effects in the transport description of tokamak plasmas, in particular Sawtooth Cycles, Magnetic Flux Pumping and Neoclassical Tearing Modes (NTMs). Including such effects is relevant for a comprehensive transport description, as solving the transport equations provides the drive for MHD instabilities, and the non-linear evolution of such instabilities affects transport. Furthermore, many MHD effects, such as the Sawtooth Cycles or the NTMs, must be avoided or controlled, as they could lead to a loss of performance or disruptions. On the other hand, Magnetic Flux Pumping can provide a desirable operational regime for future machines, with a sawtooth-free core and an optimal redistribution of the core current. Reduced models for such effects would be then relevant for tokamak control applications. The approach followed in this work will be to implement reduced models for the triggering and evolution of such effects in the ASTRA transport code, to be validated on ASDEX Upgrade discharge. For the Sawtooth Cycles and the NTMs, these models will be taken from the literature, while for magnetic flux pumping it will be necessary to develop the reduced model as well.

P 10.24 Tue 16:15 ZHG Foyer 1. OG

Full-wave Simulations of Helicon Waves for Plasma Wakefield Accelerators — •Luis Carlos Herrera Quesada[1], Nils Fahrenkamp[2], Stefan Knauer[2], Peter Manz[2], Günter E.M. Tovar[1], and Alf Köhn-Seemann[1] — [1]IGVP, Universität Stuttgart, Stuttgart, Germany — [2]Universität Greifswald, Greifswald, Germany

This study aims to understand the propagation and dissipation of helicon waves in plasma wakefield systems and to investigate the influence of different antenna geometries on the efficiency of helicon wave excitation. Furthermore, the evolution of the radial plasma density gradient on the efficiency of coupling to the helicon wave is investigated.

The 3D finite-difference time-domain (FDTD) code FOCAL enables full-wave simulations and theoretical analysis, which is used to solve Maxwell's equations coupled to the fluid equation of motion for electrons in a cold magnetized plasma. In parallel, a Finite Element Method (FEM) analysis is carried out using the COMSOL Multiphysics code package. As a first step for simulation scenarios, the device parameters and the geometry of VINETA.75, located at the University of Greifswald, are implemented in the numerical model. In addition, external cooperation with the teams of the MAP device at the University of Wisconsin-Madison, and the PROMETHEUS-A and

AWAKE experiments at CERN is planned.

Funding of this research by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - project number 517709182 is gratefully acknowledge.

P 10.25 Tue 16:15 ZHG Foyer 1. OG

3D full-wave simulation of the O-SX mode conversion process — •Alf Köhn-Seemann[1], Bengt Eliasson[2], Simon Freethy[3], Roddy Vann[4], and Thomas Wilson[3,4] — [1]IGVP, University of Stuttgart, Germany — [2]SUPA, Department of Physics, University of Strathclyde, Glasgow, U.K. — [3]Culham Centre of Fusion Energy, Culham, U.K. — [4]York Plasma Institute, University of York, U.K.

Electron Bernstein waves (EBWs) provide a method to heat over-dense plasmas, whose electron plasma density exceeds the cut-off density of an injected electromagnetic wave. EBWs are very well absorbed at the electron cyclotron resonance frequency and its harmonics, even for low electron temperatures. They can furthermore drive significant toroidal net currents. This makes them particularly interesting for spherical tokamaks which often have only a small or no central solenoid and rely therefore on non-inductive current drive. EBWs are electrostatic waves, requiring them to be coupled to externally injected electromagnetic waves. Here we present 3D numerical simulations of the coupling process with the novel finite-difference time-domain code FOCAL. Simulation results from a feasibility study for the spherical tokamak MAST Upgrade are presented and related numerical challenges are discussed.

P 10.26 Tue 16:15 ZHG Foyer 1. OG

Study of Quasi-Symmetry in Stellarator Designs: Impact of Coil Parameters on Device Robustness — •Elisa Buglione-Ceresa, Pedro Gil, and Eve Stenson — Max Planck Institute for Plasma Physics, Garching

This study investigates the role of quasi-symmetry (QS) in stellarators, focusing on its sensitivity to various design parameters. QS is crucial for confining trapped charged particles and plasma in toroidal magnetic fields. In a quasi-symmetric stellarator the magnetic field strength can exhibit symmetry along a specific coordinate, providing the confinement of guiding center trajectories. The research examines three stellarator configurations, analyzing the impact of coil number, coil separation, coil complexity (λ), and manufacturing imperfections (simulated as Gaussian perturbations with amplitude σ and characteristic length L) on QS. The studied equilibria include the APEX-EPOS configuration and reactor-sized designs with quasiaxisymmetry and quasihelical symmetry for precise plasma confinement. Using REGCOIL for coil design optimization and SIMSOPT for perturbations, we applied Gaussian perturbations to simulate realistic manufacturing conditions. Results show that QS decreases with increasing perturbations, highlighting its sensitivity to manufacturing tolerances. This study also investigates how QS changes with varying coil numbers, separation, and complexity. These findings provide critical insights into optimizing coil design, including performance of the field accuracy at reactor relevant dimensions, offering valuable guidelines for designing stellarators that balance high performance with practical feasibility.

P 10.27 Tue 16:15 ZHG Foyer 1. OG

Coupling of fluid neutrals with gyrokinetic plasma in the edge turbulence code GENE-X — •Sabine Ogier-Collin, Philipp Ulbl, Wladimir Zholobenko, and Frank Jenko — Max-Planck Institute for Plasma Physics, Garching bei München, Germany

Understanding turbulent transport in the plasma edge and scrape-off layer (SOL) is essential for managing heat and particle exhaust while maintaining effective core confinement in magnetic confinement fusion (MCF) reactors. In these regions, the abundance of neutral particles and their interactions with the plasma significantly influence radial profiles and thus gradient-driven instabilities, particle transport across the separatrix, and blob dynamics in the SOL.

`GENE-X` is a first-principles code designed to simulate edge and SOL turbulent transport in realistic magnetic geometries, including X-points. We present the first coupling of a continuum full-f gyrokinetic model with a fluid model for neutrals. The evolution of the neutrals density is captured by a pressure-diffusion equation, where the diffusion is driven by charge exchange collisions. Plasma-neutral interactions - such as ionisation, recombination and associated radiation - are included via special Krook operators.

Following verification, relaxation studies have been carried out to assess the impact of inelastic plasma-neutrals reactions on plasma distribution functions and equilibration dynamics. In addition, a first case study in divertor geometry is presented, demonstrating the potential of the coupled model for turbulence simulations in MCF devices.

P 10.28 Tue 16:15 ZHG Foyer 1. OG

Characterization of pure-electron plasmas in APEX-LD — •Veronika C. Bayer, Adam Deller, Alex Card, and E. V. Stenson — Max Planck Institute for Plasma Physics, Garching b. München, Deutschland

We describe the development of diagnostics for studying stably confined pure-electron plasmas in a compact levitating dipole trap (APEX-LD). The existing diagnostics confirm collective behaviour. However, they provide incomplete means to analyse the plasma potential or the density profiles. New diagnostics, an electron beam probe and a retractable target probe, will collect the data necessary to analyse these properties. Further insights into collective behaviour from these new diagnostics will be used to prepare APEX-LD for pulsed positron injection and the trapping of pair plasmas.

P 10.29 Tue 16:15 ZHG Foyer 1. OG

Generation and diagnostics of an inverted fireball (IFB) discharge in an rf plasma — •Viktor Schneider[1], Jan Krieger[1], Johannes Grünwald[2], Gerhard Eichenhofer[3], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics (IEAP), Kiel University — [2]Gruenwald Laboratories GmbH — [3]4A-Plasma

In this work, an inverted fireball (IFB) [1,2], i.e. a secondary plasma within a hollow grid anode cage, was generated and investigated in a radio frequency plasma. IFBs have a significantly increased plasma density, a homogeneous plasma potential and are, therefore, potentially interesting for application in PECVD processes [3-4]. The ignition conditions for the IFB plasma were determined and special features regarding the influence of the rf plasma on the IFB, in particular the bias voltage of the rf electrode, were studied. The IFB plasma was investigated using a Langmuir probe, optical emission spectroscopy (OES) and a passive thermal probe (PTP) [5]. Good agreement was obtained between the diagnostics for the behavior of the IFB with parameter variation using OES and PTP.

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P 10.30 Tue 16:15 ZHG Foyer 1. OG

Characterization of Reflected Light Properties in PIC Simulations — •Vidisha Rana[1,2], Milenko Vescovi[1,2], Marvin E.P. Umlandt[1,2], Franziska Paschke-Brühl[1,2], Richard Pausch[1], Pengjie Wang[1], Tim Ziegler[1,2], Karl Zeil[1], Ulrich Schramm[1,2], and Thomas Kluge[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden

Laser-driven ion accelerators offer several advantages over the conventional ones due to their potential of achieving high accelerating gradients over small distances. Recent experiments have demonstrated that one can achieve significantly high proton energies by modifying the temporal profile and controlling the spectral phase of laser pulses, specifically using Group Velocity Dispersion (GVD). However, the entire mechanism still needs to be understood.

Reflected light properties provide a powerful diagnostic tool for understanding these interactions and optimizing proton energies. Experiments involving high-intensity ultrashort laser pulses interacting with thin foils reveal prominent spectral shifts across changing Group Velocity Dispersion (GVD) values. These shifts can offer valuable insights into plasma dynamics, relativistic surface motion, and laser contrast effects, which have a direct impact on proton energies but remains difficult to interpret solely through experiments. This challenge can be addressed by employing PIC codes to simulate these interactions to analyze the underlying mechanisms. By bridging this gap, this work aims to advance our understanding of laser-plasma interactions.

P 10.31 Tue 16:15 ZHG Foyer 1. OG

Radiation emission from relativistic electron bunches interacting with plasma density gratings — •Sophie Opara and Götz Lehmann — Heinrich-Heine-Universität Düsseldorf

The interaction between high-intensity light waves and transient periodic density modulations of underdense plasma has been proven to be a fruitful concept for plasma-based optics in the context of high-power lasers. The plasma density gratings, driven by the ponderomotive force of overlapping laser pulses, can have substantial amplitudes, up to more than 100% in the nonlinear regime. The modulations then subsequently can act e.g. as Bragg-type mirror, polarizer or wave-plate for probe pulses of high intensity. Their holographic nature allows even to convert between different types of laser beams, e.g. from Gaussian to Gauss-Laguerre type. Even concepts for plasma-based pulse compressors for chirped-pulse amplification have been developed. The interaction of density modulated plasma with highly energetic particle beams on the other hand is less well studied, mostly in the context of beam transport through plasmas. In our present work we study the interaction of beams in strongly density modulated systems in the context of radiation generation.

P 10.32 Tue 16:15 ZHG Foyer 1. OG

Plasma-based volume holograms for creation of relativistic Gauss-Laguerre laser beams — •Götz Lehmann and Karl-Heinz Spatschek — Heinrich-Heine-Universität Düsseldorf

Gauss-Laguerre (GL) laser beams have received growing interest in the field of high-intensity laser-plasma interactions over the past years due to their particular doughnut-like intensity distribution, their particular field configuration in the focal region and also for their orbital angular momentum. At moderate intensites, i.e. far away from the ionization-threshold of any material and thus even further away from the (relativistic) intensities discussed in literature, GL beams are obtained e.g. by passing a Gaussian beam through a spiral phase plate, imprinting a helical structure on the phase distribution within the beam. For relativistic focal intensities such solid-state material solutions are not feasible. Plasma-based holograms offer an alternative route to mode conversion. In our work, we show how to write transient plasma density gratings into underdense plasma that then subsequently will act as a hologram and convert Gaussian laser pulses into LG pulses of relativistic intensities.

P 10.33 Tue 16:15 ZHG Foyer 1. OG

Turbulence in Molecular Clouds - A laboratory for understanding waves in partially ionized media — •Christian Heppe[1], Alexei Ivlev[2], and Frank Jenko[1] — [1]IPP, Garching (DE) — [2]MPE, Garching (DE)

Plasma in space are are found in a partially ionized state only. Thus, we need to consider the interaction between ionized and neutral gases. Since the coupling between both gases is modelled via collisions we expect, on scales smaller than their collision frequencies, the gases to increasingly decouple while on larger scales the gases to move in unison. This has immediate consequences for MHD waves in the medium requiring a deviation from a single-fluid treatment, i.e. two-fluid MHD (2FMHD). Although 2FMHD predicts "decoupling gaps" for MHD modes in which propagation is prohibited or strongly damped, simulations of 2FMHD turbulence do not show such a gap. This suggests that within the framework of ideal 2FMHD an as of yet unknown process that mediates energy through this gap is present. As Molecular Clouds (MCs) are of generally high interest in Astrophysics and Astronomy due to their role in star formation and Cosmic Ray (CR) propagation, while covering a vast variety of plasma conditions under turbulent conditions over a wide range of scales, they pose as an ideal "laboratory" to empirically improve current understanding of MHD waves in partially ionized media.

P 10.34 Tue 16:15 ZHG Foyer 1. OG

Thermal and DC Electrical Conductivities of Hydrogen at the Insulator-to-Metal Phase Transition from Ab Initio Calculations — •Martin Preising[1], Ronald Redmer[1], and Marcus Knudson[2] — [1]University of Rostock — [2]Sandia National Labs, USA

The metallisation of fluid hydrogen under high pressures has a profound impact on planetary science [1]. While most experimental campaigns report transition pressures between 100 and 225GPa, a 2015 campaign reports significantly higher pressures around 300GPa [2].

Understanding and resolving this discrepancy requires calculations of thermal conductivities of shocked hydrogen in the vicinity of the metallisation, including ionic thermal conductivities [3].

We report on DC electrical conductivities, thermal electronic and thermal ionic heat conductivities from ab initio simulations. We employ the vdW-DF1 and vdW-DF2 exchange-correlation functional due their superior ability to predict experimental conductivities of dense hydrogen [4].

Electronic contributions show an increase of several orders of magnitude across the metallisation transition. The ionic thermal conductivities do not significantly change but provide the main contribution to the total thermal conductivity in the non-metallic and a significant contribution in the metallic regime.

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P 10.35 Tue 16:15 ZHG Foyer 1. OG

Particle acceleration in core-collapse supernova remnant — •Samata Das[1,2], Robert Brose[2], Dominique M.-A. Meyer Meyer[3], Martin Pohl[2,4], and Iurii Sushch[5] — [1]Theoretische Physik IV, Fakultät für Physik Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]University of Potsdam, 14476 Potsdam, Germany — [3]Institute of Space Sciences , 08193 Barcelona, Spain — [4]DESY, 15738 Zeuthen, Germany — [5]Gran Sasso Science Institute, 67100 L'Aquila, Italy

The complex environments around core-collapse supernova remnants (SNRs) from their massive progenitors, shape spectra and morphology of non-thermal emissions from remnants. We study the effects of hydrodynamics and magnetic field of circumstellar medium on particle acceleration and emission from remnants. We use RATPaC and PLUTO code where hydrodynamic equations with transport equation for CRs and scattering magnetic turbulence, induction equation for magnetic field evolution solved in 1-D spherical symmetry. Our study shows the SNR propagation through hot bubble, for example, bubble by $60M_\odot$, reduce significantly the sonic Mach number of SNR shock that persistently softens the particle spectra with spectral index 2.5, and steepens the radio spectra. SNR with 20 $M_\odot$ Red-Super giant progenitor produces steep radio spectra, and soft pion-decay gamma-ray spectra, briefly during the interaction of the SNR shock with the dense RSG shell. For old remnants inside shocked ISM, we got softer pion-decay emission, consistent with the observed gamma-ray emission

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P 10.36 Tue 16:15 ZHG Foyer 1. OG

Particle Acceleration and Emission Signatures in Relativistic AGN Jets — •Nikita Nikita[1], Frank Rieger[1], Bhargav Vaidya[2], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics (IPP), Boltzmannstraße 2, 85748 Garching, Germany — [2]DAASE, IIT Indore, Simrol, 453552, India

Relativistic outflows from AGNs can extend up to kilo-parsec scales, exhibiting complex morphologies. Using 3D relativistic magnetohydrodynamic (RMHD) simulations of rotating jet using PLUTO, we explore the role of dynamical instabilities in shaping complex jet morphologies and their synchrotron emission. Our analysis based on simulations of a continuously injected jet suggests that current-driven instabilities, notably the |m| = 1 mode, generate ribs-like structures that are seen in some of the recent radio galaxies using MeerKat. In the simulations of the restarted jet, the kink-instability driven ribs-like structures were formed closer to the nozzle. In both cases, the jet dissipates its magnetic energy through these instabilities, transitioning to a more kinetic energy dominant state. The synchrotron emission modeled in these simulations considers only diffusive shock acceleration. Stochastic acceleration, however, can become relevant in large-scale jets at sufficient magnetization, where strong shocks are absent, and turbulent magnetic fields dominate. As a next step, we aim to incorporate stochastic turbulent acceleration into PLUTO using a semi-analytical approach. These findings will contribute to a deeper understanding of the multi-scale processes driving particle acceleration and emission in AGN jets, bridging numerical simulations with observations.

P 10.37 Tue 16:15 ZHG Foyer 1. OG

Understanding the Role of Plasma Instabilities in Blazar-Induced Pair Beams: Laboratory Simulations and Astrophysical Implications — •Suman Dey and Günter Sigl — II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

The interaction of TeV photons from blazars with the extragalactic background produces a relativistic beam of electron-positron pairs streaming through the intergalactic medium, producing a cascade through up-scattering low-energy photons. Plasma instability is considered one of the underlying energy-loss processes of the beams. We employed particle-in-cell (PIC) simulations to study the plasma instabilities of ultra-relativistic pair beams propagating in a denser background plasma, using the parameters designed to replicate astrophysical jets under laboratory conditions. We have investigated the parameter regime where the electromagnetic modes are suppressed, aligning with the physically relevant criteria of Blazar-induced beams. We have used an astrophysically realistic non-Maxwellian distribution for the beam particles, improving upon previous studies. We investigated the interplay between the magnetic field forming from localized currents and transverse beam momentum spread. We calculated the physical limit of density contrast at which the beam achieves optimal suppression of electromagnetic instabilities in laboratory experiments. We extrapolated the non-linear feedback of instability where the beam is energetically broadened. We observed that the instability generates a negligible angular broadening for Blazar-Induced beams.

P 10.38 Tue 16:15 ZHG Foyer 1. OG

Influence of ELMs on O-X mode conversion efficiency — •Shibangi Majumder, Christos Vagkidis, and Alf Köhn-Seemann — IGVP, University of Stuttgart, Germany

Edge Localized Modes (ELMs) constitute a continuous relaxation of the edge plasma pressure gradient. The respective perturbation of the electron plasma density profile can perturb microwaves injected into the plasma for heating purposes. This is particularly true for mode coupling processes like the O-SX-B mode conversion, where an injected O-mode couples to an SX-mode near the cut-off layer. The SX-mode is then reflected and propagates to the upper-hybrid resonance, where it can couple to electron Bernstein waves, which are electrostatic waves that are very well absorbed at the electron cyclotron resonance. The efficiency of the O-SX coupling depends strongly on the injection angle with respect to the background magnetic field. In this work, we explore the effect of ELMs on the O-SX coupling with an FDTD code, providing thus insights into the interplay between ELM-induced edge conditions and microwave heating performance. This further can contribute to a deeper understanding of plasma heating and confinement mechanisms in fusion experiments.

P 10.39 Tue 16:15 ZHG Foyer 1. OG

Study on Fast Electrons Generated in the Stellarator Experiment TJ-K — •José Ignacio Fernández Gómez, Alf Köhn-Seemann, and Mirko Ramisch — IGVP, University of Stuttgart, Germany

The TJ-K stellarator is equipped with a microwave heating system capable of delivering power at three frequencies: 3 kW at 2.45 GHz, 3 kW at around 8 GHz, and 6 kW at around 14 GHz. While the bulk electron temperature is typically around 10 eV, fast electrons with energies ranging from several 100 eV to 100 keV are found in various experimental scenarios. In this work, the trajectories of these fast electrons are simulated in the 3D magnetic field geometry of TJ-K. It is found that these particles, when comparing movement parallel and anti-parallel to the magnetic field, can result in toroidal net currents if the drift surfaces differ sufficiently. Configurations resulting in toroidal net currents are identified and the underlying physics processes are discussed. Selected scenarios are experimentally analyzed to measure the toroidal net current, providing a basis for validating the simulation outcomes.

P 10.40 Tue 16:15 ZHG Foyer 1. OG

Self-consistent eddy and halo current coupling of a 3D non-linear MHD plasma with 3D realistic wall structures — •Raffaele Sparago[1,2], Javier Artola[2], Matthias Hoelzl[1], Nicola Isernia[3], Guglielmo Rubinacci[4], Nina Schwarz[2], Salvatore Ventre[5], and Fabio Villone[3] — [1]Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany — [2]ITER Organization, 13067 St. Paul Lez Durance Cedex, France — [3]Università degli Studi di Napoli Federico II, Via Claudio 21, 80125 Napoli, Italy — [4]CREATE Consortium, Via Claudio 21, 80125 Napoli, Italy — [5]Università di Cassino e del Lazio Meridionale, Via Gaetano di Biasio 43, 03043 Cassino, Italy

An adequate modeling of the electromagnetic interaction of a magnetized plasma with the surrounding machine's conductors is paramount for the correct replication of 3D plasma dynamics. Reproductions of the latter provide useful predictions regarding the evolution of MHD modes and the electromagnetic forces acting on the vacuum vessel when said modes trigger disruptions. The here presented modeling efforts involving the 3D FEM non-linear MHD code JOREK have accomplished the self-consistent coupling of eddy currents in a full MHD physics scenario, with the related validation and simulation, employing the wall code STARWALL. This contribution also features the latest progress concerning the self-consistent coupling of halo currents (which flow from the plasma to the wall and viceversa) with the 3D wall code CARIDDI; this is essential for the prediction of the related rotating sideways forces that could pose a serious threat to future machines.

P 10.41 Tue 16:15 ZHG Foyer 1. OG

Density and Temperature Profiles from Upper Divertor Spectroscopy — •Hannah Lindl[1], Ralph Dux[1], and The ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]See author list of H. Zohm et al, 2024 Nucl. Fusion

Reducing the power load on material surfaces is essential for prolonging the lifetime of plasma facing components. The final goal is to reach plasma detachment, resulting in reduced heat and ion fluxes onto the divertor target. We can accomplish this by significantly reducing the electron temperatures T_e near the target plates compared to the upstream values, resulting in effective ion recombination before they make contact with the first wall.

A new measurement technique based on divertor spectroscopy is proposed to determine T_e profiles in the upper divertor region of ASDEX Upgrade (AUG), where we can observe the plasma with high fidelity. This enables us to obtain local data for all spectroscopic accessible quantities by a fit similar to an Abel transform. We aim to calculate $T_e(r)$ in diverted plasmas by measuring local electron densities n_e through Stark broadening of the high-n deuterium Balmer lines D_δ and D_ϵ. Furthermore, we calculate line emissivity profiles $\epsilon_L(r)$ via a deconvolution of the spectral radiance L. Assuming Saha equilibrium is established between high-n and continuum states of deuterium, we estimate $T_e(r)$ by combining $n_e(r)$ with $\epsilon_L(r)$.

In this contribution, the technique is applied to first measurements of the upper divertor spectroscopy in upper single null discharges at AUG and first n_e and T_e profiles in this region are shown.

P 10.42 Tue 16:15 ZHG Foyer 1. OG

Analysis of the electrostatic potential distribution and drifts in island divertor geometries using fluid turbulence simulations — •Tobias Tork[1], Felix Reimold[1], David Bold[1], Brendan Shanahan[1], Sergei Makarov[1], Peter Manz[2], and the W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Institute of Physics, University of Greifswald, 17489 Greifswald, Germany

In fusion devices, particle and heat exhaust pose a significant challenge. The island divertor concept was developed to address the exhaust problem. In this concept, the magnetic field is perturbed and forms magnetic islands at rational flux surfaces. These islands are intersected by target plates and divert particle and heat fluxes to the targets. In the island divertor of the stellarator Wendelstein 7-X, large poloidal ExB-velocities have been observed. These velocities are expected to significantly contribute to the transport of particle and energy. Current state of the art stellarator simulations are not incorporating drift effects. There is thus little knowledge about the electrostatic potential distribution and hence the ExB-drifts in an island divertor. To address this issue, the 3D-turbulence model Hermes-2 is used. It is applied to simplified geometries that mimic the island divertor topology. As Hermes-2 is a hot-ion drift reduced fluid model, it contains the electrostatic potential and thus the drift effects. The latter will be analyzed on mean field solutions to understand the electrostatic potential distribution and the impact of drifts and currents on the plasma parameters and the transport in the island.

P 10.43 Tue 16:15 ZHG Foyer 1. OG

A new method to characterize instabilities in fusion plasmas using the soft x-ray multicamera system at Wendelstein 7- X — •Charlotte Büschel, Christian Brandt, Henning Thomsen, Kian Rahbarnia, Sara Vaz Mendes, Edith Victoria Hausten, and Wendelstein 7-X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

Soft x-ray tomography is widely used in fusion experiments for the reconstruction of two-dimensional density profiles. The soft x-ray multicamera tomography system (XMCTS) installed in Wendelstein 7-X consists of 20 pinhole cameras [C. Brandt et al. 2020]. Each camera has 18 photodiodes, measuring the line-integrated soft x-ray emissivity of the plasma. As the emissivity is strongly related to the plasma density, the fluctuating part of the signal can be used to analyze instabilities propagating in the plasma. Electrostatic and electromagnetic instabilities affect the particle and energy transport within a plasma and are one of the main reasons for particle and energy losses. To control or even prevent instabilities, their characterization regarding amplitude, frequency, radial location, poloidal structure and propagation direction is important. A new method has been developed to analyze the 360 line-integrated signals of the photodiodes to determine the radial location and the poloidal structure of instabilities with poloidal mode numbers up to m=20. The workflow of the analysis is presented based on artificial data.

P 10.44 Tue 16:15 ZHG Foyer 1. OG

The isotope dependence of the ASDEX Upgrade pedestal structure — •Roxána Takács[1], Michael Dunne[1], Benedikt Zimmermann[1,2], and the ASDEX Upgrade Team[3] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Department of Applied Physics and Applied Mathematics, Columbia University, New York, USA — [3]See author list of H. Zohm et al, 2024 Nucl. Fusionhttps://doi.org/10.1088/1741-4326/ad249d

Future fusion devices, such as ITER, will operate with a deuterium-tritium mixture, whereas current experiments use mainly deuterium or hydrogen. Studying the isotope dependence is, therefore, crucial to accurately predict the performance of these future fusion devices. Previous studies have demonstrated positive isotope mass scaling of the thermal energy confinement time in H-mode plasmas. This phenomenon has been observed in several major tokamaks, including JET [C.F. Maggi], JT-60U [H. Urano], ASDEX [M. Bessenrodt-Weberpals] and ASDEX Upgrade [P. A. Schneider]. To further investigate the isotopic dependence, this analysis compares different isotopic plasmas from the ASDEX Upgrade tokamak, focusing on the pedestal region to understand the specific phenomena where isotopes play an important role. Different main isotopic discharges with matched engineering parameters were selected for comparison. The analysis includes comparison of kinetic profiles (temperature, density, and pressure profiles), stability analysis against peeling-ballooning (PB) modes, and investigation of inter-ELM transport differences.

P 10.45 Tue 16:15 ZHG Foyer 1. OG

Bayesian inference of plasma parameters in the island divertor of W7-X — •Linnéa Björk[1], Felix Reimold[1], Sehyun Kwak[1], Daniel Böckenhoff[1], Udo von Toussaint[2], Sebastian Grosinger[3], and The Wendelstein 7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Max Planck Institute for Plasma Physics, Garching, Germany — [3]Lund University, Department of Physics, Lund, Sweden

The W7-X stellarator is a 3D fusion device with a complex geometry, which make diagnostic measurements of the plasma sparse. This is especially true for the boundary region, known as the scrape-off layer (SOL). Here so-called island divertors are located which manage exhaust for particles and heat. In this region, the plasma interacts with toroidally discontinuous divertor plates, which can lead to strongly toroidally localized effects. Assessing the physics and transport phenomena in this region is therefore not trivial. By using a Bayesian analysis approach, datasets from different diagnostics can be combined in order to obtain information about the underlying plasma parameters, such as the electron density and temperature distributions. This knowledge will ultimately help deepen the understanding of transport at the boundary.

In this contribution, first steps into a Bayesian analysis framework focusing on inference of plasma parameters in the boundary region will be presented. This includes outlier-robust 1D profile fits of electron density and temperature and progress on building a 2D framework for parameter regression.

P 10.46 Tue 16:15 ZHG Foyer 1. OG

Commissioning of a dispersion interferometer for disruption studies at ASDEX Upgrade — •Andrew Moreau[1,2], Alexander Bock[1], Kai Jakob Brunner[3], Riccardo Nocentini[1], Emre Sözer[1], Andreas Burckhart[1], Jens Knauer[3], Thomas Pütterich[1,2], and the ASDEX Upgrade team[4] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Ludwig Maximilian University, Munich, Germany — [3]Max Planck Institute for Plasma Physics, Greifswald, Germany — [4]See author list of H. Zohm et al, 2024 Nucl. Fusion

Disruptions are off-normal events where thermal and particle confinement are lost in magnetic confinement plasma devices. Future reactors carry a high risk of unmitigated disruptions causing unacceptable force and heat loads for the health of the devices. It is essential to develop instruments which can reliably track quantities, such as electron density, through the entire phase of disruptions and their mitigation schemes as we learn to characterize and control the plasma state.

At ASDEX Upgrade, two systems have measured line-integrated electron density, a 195μm interferometer and a 10.6μm two-colour interferometer. These interferometers either refract heavily during disruptions or are extremely noisy from incomplete vibration compensation and both suffer from ambiguities in the phase tracking (fringe jumps). We present the commissioning of a dispersion interferometer, probing at 5.3μm, which uses second-harmonic coherence conservation to intrinsically eliminate vibrational noise and is more resilient against refraction and fringe jumps from the shorter wavelength.

P 10.47 Tue 16:15 ZHG Foyer 1. OG

A new imaging diagnostic for ASDEX Upgrade divertor fluctuation studies — •Manuel Herschel[1,2], Michael Griener[1], Tim Happel[1], Tilmann Lunt[1], and The ASDEX Upgrade Team[3] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University of Munich, Physics Department, Chair for Plasma Edge and Divertor Physics, 85747 Garching, Germany — [3]see author list of H. Zohm et al, 2024 Nucl. Fusion 64 112001

In magnetic confinement fusion devices, so-called divertors are used to distribute heat loads on the wall and control impurity influxes into the main plasma volume. Recently, the ASDEX Upgrade fusion experiment has been equipped with a new flexible upper divertor to study various power exhaust scenarios.

To investigate the effect of the different divertor configurations in ASDEX Upgrade, powerful diagnostics are necessary. In this work, a novel multi-color gas puff imaging system is presented. The system consists of a fast helium injection valve to excite localized light emission from helium neutrals and an optical setup including an image splitter, spectral filters and a fast camera. The diagnostic is optimized for timescales below 10 μs and a spatial resolution of around 1 cm. The simultaneous imaging of two spectral lines allows compensation of shadowing effects. This enables the observation of fast turbulent structure dynamics in the divertor region.

The final setup and the design choices behind the components are presented, as well as the progress towards first measurements under various plasma conditions.

P 10.48 Tue 16:15 ZHG Foyer 1. OG

Overview of a MANTIS-II installation in AUG for runaway electron studies using synchrotron imaging — •Andres Orduna[1,2], Andreas Burckhart[1], Gergely Papp[1], Tijs Wijkamp[3], Mathias Hoppe[4], Artur Perek[5], Yanis Andrebe[5], Tilmann Lunt[1], Ralph Dux[1], and ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Ludwig-Maximilians-Universitat Munchen — [3]Dutch Institute for Fundamental Energy Research — [4]KTH Royal Institute of Technology, Stockholm, Sweden — [5]Ecole Polytechnique Fédérale de Lausanne, Swiss Plasma Center

Study of energy and pitch angle dynamics of runaway electrons (RE) in present-day tokamak experiments requires the analysis of the RE momentum-space distribution function. Synchrotron radiation (SR) imaging using multispectral systems has proven capable of providing this information in TCV and AUG. As a consequence, the multispectral imaging system MANTIS consisting of 6 filtered cameras is planned to be installed in AUG.

Three of the filters are dedicated to SR imaging to constraint the distribution function. Since the SR is emitted along the velocity vector of the electrons, the view port needs to be carefully selected. Camera images using each filter and view are simulated using the SOFT synthetic diagnostic framework. Finally, the cameras have to be placed at a distance from the toroidal field coils and protected from the neutron flux to avoid malfunction and image noise.

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Investigation of benign edge scenarios with the tokamak design suite DYT — •Fabian Leindecker[1,2], Teobaldo Luda[2], Mike Dunne[2], Emiliano Fable[2], Tom Bleher[2], Matthias Willensdorfer[2], Alexander Bock[2], Elisabeth Wolfrum[1,2], and the ASDEX Upgrade Team[3] — [1]Institute of Applied Physics, TU Wien, Vienna, Austria — [2]Max-Plank-Institut für Plasmaphysik, D-85748 Garching, Germany — [3]See Zohm et al 2024 for the ASDEX Upgrade Team

The Design Your Tokamak (DYT) program suite is a collection of modules aiming to explore different configurations and establish reliable boundaries for possible machine designs. In the presented work DYT was used to examine the minimal in-plane coil-to-coil force acting on poloidal field coils during operation in small ELM regimes. The operation within the small ELM regime is determined using the shaping parameters and the normalized pressure gradient in the pedestal region. By comparing various plasma elongations for ASDEX-Upgrade, JET, ITER, and DEMO scenarios, the study identifies a favorable plasma shape that reduces the maximum force exerted on the coils. Building on this approach and recognizing the importance of impurity seeding for power exhaust in large machines like ITER or DEMO, a module to investigate the radiated power within the separatrix for different impurities will be implemented into the simulation tool. The objective is to generate insights and a tool that may enhance the safe and effective construction of future fusion reactors.

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MHD equilibrium reconstructions for Wendelstein 7-X stellarator including soft x-ray emission data — •Edith Hausten[1], Kian Rahbarnia[1], Henning Thomsen[1], Christian Brandt[1], Charlotte Büschel[1], Sara Vaz Mendes[1], and Samuel Lazerson[2] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Gauss Fusion GmbH, Parkring 29, 85748 Garching bei München, Germany

In fusion experiments such as the Wendelstein 7-X Stellarator, knowledge about the plasmas MHD equilibrium is of crucial importance for the interpretation of measurements and to obtain several quantities that are not measured directly. The equilibrium can be reconstructed from experimental data by using the STELLOPT code [S. Lazerson 2015 Nucl. Fusion 55]. It uses an optimization algorithm to find the equilibrium that best matches measured target values of various diagnostics. Currently, the code is being enhanced to incorporate measurements of the XMCTS camera system, a diagnostic measuring the plasmas soft x-ray emissivity within a poloidal plane. The aim is to improve the quality of reconstructions, especially with respect to the Shafranov shift, which can be inferred from soft x-ray observations as previously demonstrated. The Shafranov shift is the outward shift of the magnetic axis compared to the vacuum field, and is increasing in strength with rising plasma beta. First results of reconstructions employing the new STELLOPT feature are presented with a focus on high energy discharges and the obtained Shafranov shift size is compared to analytical estimations as well as pure experimental measurements.

P 10.51 Tue 16:15 ZHG Foyer 1. OG

Helium transport using gas puff modulation at Wendelstein 7-X — •Sali Beppler, Thilo Romba, Felix Reimold, and The W7-X Team — Max Planck Institute for Plasma Physics, Greifswald, Germany

In fusion plasmas, decreased performance due to impurity dilution is to be minimized. As the fusion ash helium is produced in the core region of the plasma but needs to be pumped at the edge, its transport properties are of great interest.

The helium transport in Wendelstein 7-X plasmas is evaluated. A modulated source is introduced to make use of the time dependent term in the transport equation. This restricts the determined transport coefficients more strongly than a conventional steady state approach. The scenario is modeled using the 1D-transport solver pySTRAHL. In order to analyze the sensitivity of input and fitting-parameters, synthetic data is generated. Following the synthetic assessment, the method is applied to experimental W7-X data, aiming to assess changes in helium transport across different magnetic configurations. Besides no fundamental differences across the configurations, a high sensitivity to misalignments in the line of sight geometry is identified.

P 10.52 Tue 16:15 ZHG Foyer 1. OG

Toward a nonlinear Schrödinger equation description for geodesic-acoustic-modes in tokamaks: Analytic gyrokinetic studies of the nonlinear self-interaction — •David Korger[1,2,3], Emanuele Poli[1], Fulvio Zonca[3], and Matteo Falessi[3] — [1]Max-Planck-Institut für Plasmaphysik, Garching, 85748, Germany — [2]Ulm University, Ulm, 89081, Germany — [3]Center for Nonlinear Plasma Science and C.R. ENEA Frascati, C.P. 65, 00044 Frascati, Italy

The geodesic-acoustic-mode (GAM) is a plasma oscillation observed in fusion reactors with toroidal geometry and is recognized to be the non-stationary branch of the zonal flows (ZFs). Prior studies have established that, as a direct consequence of nonlinear gyrokinetic theory, the GAM dynamics is well described by an equation of Schrödinger type - i. e., an equation whose linear contribution is exactly of the same form as the linear Schrödinger equation, while the nonlinear dynamics necessitates an integro-differential expression.

The presented work takes a closer look into the nonlinear contributions by deriving approximate, but well-defined, analytic expressions from the (exact) integro-differential operators. At the lowest order of accuracy, prior numerical studies anticipate the retrieval of a cubic nonlinear Schrödonger equation. This may come unexpected since nonlinear interactions usually have a quadratic structure, such as e. g. the $E{\times}B$-nonlinearity. The third power is found to stem from an interaction of quadratic structures generated by the GAMs (with oscillation frequencies that are either zero or twice the GAM frequency) with the GAM itself.

P 10.53 Tue 16:15 ZHG Foyer 1. OG

Force optimization for novel stellarator-tokamak hybrid coils — •Annika Zettl[1,2] and Sophia Henneberg[1] — [1]Max Planck Institut für Plasmaphysik — [2]Universität Greifswald

The novel perturbed tokamak concept seeks to leverage the strengths of both tokamaks and stellarators in a hybrid machine for magnetic confinement fusion. In recent work, S. Henneberg and G. Plunk (2024), as well as T. Schuett and S. Henneberg (2024) introduced a quasi-axisymmetric (QA) design that offers several advantages, including a low aspect ratio for a large plasma volume, fast particle confinement, and simple coil geometry. As a proof of principle, they developed an initial coil set using conventional poloidal and toroidal tokamak coils along with on single type of nonplanar stellarator coils. However, engineering constraints beyond simple geometrical measures were not considered in their design. This study focuses on optimizing the coils for different candidate configurations to closely match the plasma boundary and maintain the desired QA properties, while incorporating practical buildability limitations. To achieve this, we successfully employed a two-stage optimization process, utilizing a new method by S. Hurwitz et al. (2024) to calculate the forces acting on the coils.

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Design system identification input or the dynamics of the radiated power in Wendelstein 7-X — •Anastasios Tsikouras, Felix Reimold, Maciej Krytzowiak, and Georg Schlisio — Max Planck Institute IPP, Greifswald, Germany

Heat dissipation from the plasma is critical for safe long-pulse operation and reactor-relevant scenarios in all magnetic confinement fusion devices. Impurity seeding in the edge region of the plasma dissipates a portion of its power in all directions by radiation. This action leads in reduced heat loads carried in the last plasma layer in contact with materials, as well as reduced plasma edge temperature. Efficient control of this radiated power necessitates a feedback control system. In Wendelstein 7-X stellarator we aim to design such a feedback system. The seeding actuator is a fast piezo-electric valve [1]. The recently operating divertor bolometry system will provide the radiated power signal. An effective controller requires identifying the dynamics of the investigated plant. This means how the output reacts to different input signals. The success of this identification depends highly on the input signal. For this purpose, we design a multisinusoidal input signal to excite the plant. We excite chosen frequencies within specified limits and perform system identification. The experimental time and the time constants of our system dictate these limits. Preliminary results show moderate but noticeable excitation of the system, with the quality evaluated by the coherence function. This function provides quantitative assessment of the excitation on a 0 to 1 scale. [1] Griener et al. Rev. Sci. Instrum. 88, 033509 (2017