P 5: Poster I

Time: Tuesday 14:00–16:00 Location: P

P 5.1 Tue 14:00 P

Introduction of quasilinear transport models to the Integrated Data Analysis framework — •Michael Bergmann, Rainer Fischer, and Frank Jenko — Max-Planck-Institute für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

Combining the analysis of multiple diagnostics, well-chosen priors and Bayesian probability theory the Integrated Data Analysis (IDA, see [Fischer 2010]) is capable of providing density and temperature radial profiles of fusion plasmas. These profiles are then used for further analysis such as the simulation of discharges. Since IDA considers uncertain measurement data from a heterogeneous set of diagnostics but no transport physics, the estimated profiles and their gradients can be in contradiction to the profiles from transport solvers. Using transport solvers such as QLK and their much faster neural network models e.g. QLKNN we have created a loop in which simulated profiles are fed back into IDA as another prior thus providing constraints about the physically reasonable parameter space. This work feeds into a broader effort to make IDA more robust against measurement uncertainties by combining multiple transport solvers with different accuracies and computing costs in a multi-fidelity approach.

P 5.2 Tue 14:00 P

Dynamic structure factor of the magnetized one-component plasma — •Hanno Kählert — Christian-Albrechts-Universität zu Kiel, ITAP, Leibnizstr. 15, 24098 Kiel

Magnetized plasmas are known for a multitude of different wave modes. In this contribution, the focus is on the effect of strong particle interactions on waves in the magnetized one-component plasma. In particular, the dynamic structure factor is computed from molecular dynamics simulations. Collective modes that occur in a weakly coupled state are traced as the system enters the strong coupling regime. The resulting modification of the mode spectrum is studied for a variety of different magnetization parameters. The simulation results are complemented by analytical results for the dynamic structure factor of a magnetized plasma.

P 5.3 Tue 14:00 P

Ab Initio Plasmon Dispersion of the Warm Dense Electron Gas — •Paul Hamann[1], Tobias Dornheim[2], Jan Vorberger[3], Zhandos Moldabekov[2], and Michael Bonitz[1] — [1]Christian-Albrechts-Universität zu Kiel, Germany — [2]Center for Advanced Systems Understanding, Görlitz, Germany — [3]Helmholtz-Zentrum Dresden Rossendorf, Germany

The plasmon dispersion ω(q) and damping γ(q) contain important information on the state of warm dense matter. On the other hand, x-ray Thomson scattering (XRTS) experiments provide accurate data for the dynamic structure factor S(q, ω) that is directly linked to the plasmon spectrum [1]. However, details of this link depend on the quality of the theoretical model for the dielectric function. Here we present the first ab initio data for the dielectric function that is obtained by quantum Monte Carlo simulations [2]. This allows us to obtain high quality results for ω(q) and γ(q) of the electron component at warm dense matter conditions that differ significantly from previous models. Second, we critically analyze the commonly used weak damping approximation for the dispersion and improve it by performing the analytic continuation of the retarded dielectric function. This yields results that apply at strong damping and large wave numbers as well, which is the basis for a more accurate comparison with XRTS experiments [3].

[1] Glenzer et al., Phys. Rev. Lett.98, 065002 (2007) [2] Dornheim et al., Phys. Rev. Lett.121, 255001 (2018) [3] Hamann et al., Contrib. Plasma Phys.60, e202000147 (2020)

P 5.4 Tue 14:00 P

Full-6D Kinetic Simulations of Magnetically Confined Plasmas — •Mario Räth, Klaus Hallatschek und Katharina Kormann — Max Planck Institute for Plasmaphysics, Garching bei München, Germany

With the increase in computational capabilities over the past years it is possible to simulate more and more complex and accurate physical models. Gyrokinetic theory was introduced in the 1960s and 1970s to describe a plasma more accurately than with fluid equations, but still eliminate the complexity of the fast gyration about the magnetic field lines. Although current gyrokinetic computer simulations are in fair agreement with experimental results in core physics, the assumptions in the derivation make them unreliable in regimes of higher fluctuation amplitudes and stronger gradients, such as the tokamak edge. To correctly describe all phenomena in such regimes, more involved simulations might be necessary. We have developed a novel optimised and scalable semi-Lagrangian solver to simulate ion-temperature gradient modes with the full 6D kinetic equations. It has been verified extensively in the regime of gyrokinetics, including the growth of linear modes and the turbulent saturation. Furthermore, the excitation of high frequency Bernstein waves has been shown in the non-linear saturation phase. The presence of such waves provide a first insight into physics beyond gyrokinetic theory.

P 5.5 Tue 14:00 P

A research data management workflow for applied plasma science — •Markus M. Becker[1], Ihda Chaerony Siffa[1], Hans Höft[1], Fabian Hoppe[2], Detlef Loffhagen[1], Nick Plathe[1], Harald Sack[2], Volker Skwarek[3], Tabea Tietz[2], Simon Tschirner[3], and Laura Vilardell Scholten[1] — [1]Leibniz Institute for Plasma Science and Technology (INP) — [2]FIZ Karlsruhe – Leibniz-Institut für Informationsinfrastruktur — [3]Hamburg University of Applied Sciences

The necessity and potential of systematic archiving and publication of digital research data is currently a hot topic in the scientific landscape, due to various benefits such as ensuring reproducibility of research results and providing the basis for data-driven science. This requires measures to ensure data quality and particularly a documentation of stored data by means of metadata, which is understandable to both humans and machines. Machine-actionable metadata is not only important for findability and interoperability of the data but also enables automated data processing. This contribution introduces a workflow for data and metadata, which uses programmatic data aggregation, electronic lab notebooks, ontology-based metadata, and blockchain protocols for partly automated processing and documentation of raw data as well as quality assured data publication, respectively. The practical relevance of the suggested (meta)data workflow is demonstrated at the example of highly resolved current measurements for pulsed dielectric barrier discharges in a nitrogen-oxygen gas mixture.

This work was supported by the BMBF under grants 16QK03A, 16QK03B, 16QK03C and the DFG under grant 408777255.

P 5.6 Tue 14:00 P

Optische Manipulation von Mikropartikeln in einer kapazitiv gekoppelten Zwei-Frequenz-Entladung — •Jessica Schleitzer, Viktor Schneider und Holger Kersten — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel, Leibnizstr. 19, 24108 Kiel, Deutschland

Innerhalb der letzten Jahrzehnte wurde die Idee umgesetzt, extern injizierte, kleine Mikropartikel als nicht-invasive Sonden zu verwenden, die durch verschiedene Kräfte und Energieflüsse im Plasma beeinflusst werden. In dieser Arbeit werden optisch eingefangene Mikropartikel in einer optischen Pinzette verwendet, um die Randschicht einer Zwei-Frequenz-CCRF-Entladung zu untersuchen. Diese Entladung ist vornehmlich für ihre Besonderheit bekannt, den Ionenfluss und die Ionenenergie getrennt und unabhängig voneinander unter Ausnutzung elektrischer Asymmetrien im Plasma zu beeinflussen. Die Messgröße, welche bei der Verwendung optischer Pinzetten von besonderer Bedeutung ist, ist die äußere Kraft, die auf die Mikrosonde einwirkt. Diese erhält man, indem die Verschiebung des Partikels in der optischen Falle gemessen wird, während die eingefangene Mikrosonde durch das Plasma und die Randschicht und damit relativ zur Entladung bewegt wird. Anhand der erhaltenen Kraftprofile wird die Stärke der elektrischen Feldkraft in der Randschicht in Abhängigkeit vom Druck, sowie die Abhängigkeit vom Abstand der Mikrosonde zur HF-Elektrode und die Ausdehnung der Randschicht bestimmt. Dies wird sowohl für eine Ein- als auch für eine Zwei-Frequenz-Entladung geprüft.

P 5.7 Tue 14:00 P

Ion flux measurements in an expanding H_2 plasma utilizing a Mach probe — •Vinzenz Wolf[1], David Rauner[1], and Ursel Fantz[1,2] — [1]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

Density gradients and electromagnetic fields in a low pressure plasma lead to a particle flux. In order to determine the orientation and the magnitude of the ion flux, a mach probe can be used, which typically consists of a specifically arranged set of differently orientated contacts with a limited collection angle. Using the ratio of currents measured with two opposed contacts, the ion flux direction and ion velocity (i.e. the Mach number) can be calculated, the latter relying on models for calibration factors. These are used to describe the influence of the plasma parameters on the ion flow towards the probe and are thus valid for a certain set of plasma parameters.

For characterization purposes a four pin mach probe is used in a cylindrical ICP discharge (1 MHz, 2 - 8 Pa, 200 - 800 W), consisting of a quartz glass tube (Ø 9 cm) where a hydrogen plasma is generated and expands into a stainless steel chamber (Ø 32 cm). The ion flux is determined in a two-dimensional section perpendicular to the cylinder axis of the plasma vessel. The influence of a variation of gas pressure and RF power on the ion flux is investigated, as well as plasma drifts induced by applying an external magnetic field in the expansion region.

P 5.8 Tue 14:00 P

Nitrogen-doped $NiCo_2O_4$ on carbon paper as a self-supported air cathode for Rechargeable Zn-air batteries — •He Li, Jan Benedikt, and Sadegh Askari — Institute of Experimental and Applied Physics, Kiel University, Germany

A noble-metal-free bifunctional oxygen evolution/reduction catalyst with outstanding activity and stability is of great importance for the development of rechargeable Zn-air batteries. $NiCo_2O_4$, a typical spinel oxide, is considered as one of the most promising bifunctional catalyst, but the electrocatalytic performance of this material is still unsatisfactory due to its poor conductivity and low surface area. Herein, we report an effective way to fabricate nitrogen-doped $NiCo_2O_4$ on carbon paper as a binder-free air cathode for rechargeable Zn-air batteries. After nitrogen plasma treatment, this modified material exhibits higher electrocatalytic performance than pristine $NiCo_2O_4$ because of the enhanced conductivity and more active sites. Both the liquid-state and the flexible all-solid-state Zn-air batteries with engineered nitrogen-doped $NiCo_2O_4$ show high operating potentials and excellent stability. This work provides an efficient and reliable approach for the modification of self-supported catalysts, thereby contributing to the development of rechargeable Zn-air batteries.

P 5.9 Tue 14:00 P

ZrO2 based layers investigated by the 3ω method — •Vitali Bedarev, Philipp A. Maass, Marina Prenzel, Marc Böke, and Achim von Keudell — Experimental Physics II, 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 and can be used for galvanic isolation. 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 a 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 thermal conductivity of the sample. 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 5.10 Tue 14:00 P

Terahertz time-domain spectroscopy as a novel plasma diagnostic — •Jente Wubs, Klaus-Dieter Weltmann, and Jean-Pierre van Helden — Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany

In non-thermal plasmas, electrons determine, to a large extent, the plasma chemical behaviour, meaning that electron density measurements are crucial for understanding plasma chemical phenomena. In the case of low-pressure plasmas, Langmuir probes are commonly used for determining electron-related plasma parameters. However, at atmospheric pressure, these probes can no longer be reliably used due to their perturbative characteristics. Terahertz time-domain spectroscopy (THz-TDS) is a novel diagnostic technique for spectroscopic investigations of plasma densities, independent of the pressure. This technique requires ultrafast femtosecond laser pulses for the generation and detection of a broadband electromagnetic signal in the THz range. The signal is sampled in the time-domain using the principle of asynchronous optical sampling (ASOPS) and is subsequently Fourier transformed to obtain spectral information, with a resolution of 1 GHz. This approach allows for electron density measurements with high temporal resolution, whilst simultaneously yielding information on molecular densities within the plasma. This contribution explains the working principle of ASOPS-based THz-TDS. In addition, an exploratory characterisation of the experimental setup will be presented, including an overview of the possibilities and limitations for measuring with spatial resolution.

P 5.11 Tue 14:00 P

Quenching microwave plasmas via gas injection into the effluent: Effects on the conversion of CO_2 — •Christian Karl Kiefer[1], Ante Hecimovic[1], Federico Antonio D'Isa[1], and Ursel Fantz[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]University of Augsburg, 86159 Augsburg, Germany

Negative-emissions technologies are required to reach the goal of the Paris Agreement that limits the global mean temperature increase to a maximum of 1.5°C. A plasma torch powered by 2.45 GHz microwaves offers a unique possibility to be used as a power-to-gas technology and thermally dissociate CO_2 into carbon monoxide and oxygen at high energy efficiencies. Very fast cooling of the plasma is essential to prevent recombination reactions towards CO_2, thereby maintaining the degree of conversion. For this purpose, an extension for the microwave plasma torch was developed that allows one to inject colder (room temperature) gases into the effluent of the plasma via four radial gas inlets. Experiments with atomic (He or Ar) as well as molecular (N_2 or CO_2) gas admixture were performed in the pressure range of 100 mbar up to atmospheric pressure, covering regimes of diffuse plasma as well as regimes of contracted plasma. The conversion of CO_2 was measured by the application of a mass spectrometer. To further characterize the setup, optical emission spectroscopy was used to determine the rotational and vibrational temperatures of the plasma.

P 5.12 Tue 14:00 P

Electrical characteristics of a coaxial dielectric barrier discharge for CO2 splitting at elevated pressure — •Rezvan Hosseini Rad, Milko Schiorlin, Michael Schmidt, Volker Brüser, and Ronny Brandenburg — Leibniz Institute for plasma science and technology, Greifswald, Germany

CO2 splitting using nonthermal plasmas is investigated for CO2 utilisation into valuable chemical compounds like methanol. In this work, an asymmetric, coaxial dielectric barrier discharge reactor for CO2 decomposition into CO is investigated. Beside the operation at atmospheric pressure, the effect of an increase up to 1.6 bar is studied. At first, the operation parameters for a full discharging in the reactor has to be carried out to keep the operating voltage amplitude moderate (below 10 kV) at elevated pressures. So, the electrical characteristics of the plasma reactor with three different inner electrode materials (stainless steel, copper, and aluminium) and with the addition of argon as an inert, electropositive gas with lower breakdown voltage than CO2 are studied in detail, and correlated with the CO formation. The discharge power, effective capacity, burning voltage, and area fraction covered by plasma in the reactor are determined by voltage-charge plots. The addition of Ar to CO2 (ratio Ar:CO2 =4:1) reduces the sustaining voltage and enables full plasma coverage in the reactor with voltage amplitudes below 10 kV even at the highest pressure. Increasing pressure or decreasing the argon admixture decreases the current peaks intensity as well as the discharge power. Stainless steel shows higher CO2 conversion, but copper shows higher CO generation.

P 5.13 Tue 14:00 P

Cold Atmospheric Plasma Sterilization for Planetary Protection — •Alisa Schmidt[1], Meike Müller[2], Markus H. Thoma[1], and Hubertus Thomas[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Gießen, Germany — [2]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt e.V., Oberpfaffenhofen, Germany

In the search for extraterrestrial life, decontamination of the surface of spacecraft and lander is of great importance. Since currently used methods - dry heat and hydrogen peroxide - are effective but material damaging for sensitive surfaces, in this contribution the application of cold atmospheric surface micro-discharge (SMD) afterglow plasma sterilization for spacecraft decontamination was investigated. Inactivation tests were performed with Bacillus atrophaeus spores on stainless steel carriers placed at the bottom of stainless steel tubes with varying heigths and diameters. It could be shown, that spore inactivation was achieved inside the tubes but much slower than outside at a treatment time of 60 min. Furthermore, the height of the diffusion barriers did not result in significant differences in inactivation rates but with increasing diameter the sporicidal effect increased respectively. By operating a fan to circulate the gas in the treatment chamber, higher inactivation rates could be achieved at unchanged treatment times. Moreover, it could be demonstrated, that the method of applying spores to the sample carrier influences the inactivation rate of the plasma treatment.

P 5.14 Tue 14:00 P

RF-atmospheric pressure plasma jets as a source of vacuum-UV photons for photoionisation — •Natascha Blosczyk[1], Tristan Winzer[1], Judith Golda[1,2], and Jan Benedikt[1] — [1]Institute for Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]current address: Experimental Physics, Ruhr-Universität Bochum, Bochum, Germany

Vacuum-UV(VUV) radiation has great use, not only as a means of analysing gas mixtures by their emission and absorption spectra, but also as a way to induce chemical reactions in a target gas. Therefore, the aim of this work is to study VUV-radiation of different atmospheric plasma sources and develop a way to efficiently use it for photoionisation at atmospheric pressure. The VUV-radiation of helium and helium/argon plasmas with excimer continua and line-radiation is measured by VUV-spectroscopy in the 60 to 200 nm range as function of the input power and admixture of different reactive gases.

Acetylene is used as a model precursor to investigate the use of VUV-photons for photoionisation and follow-up chemistry, where the generated primary ions and ions formed in the polymerization reactions are detected by positive ion mass spectrometry. The VUV-generation in the plasma is separated from the diluted acetylene gas via a controlled gas flow. To further study the effects of the photons on the chemistry, the FTIR-spectrometry will be used to study the properties of deposited thin films from the VUV-photon activated gas mixture.

P 5.15 Tue 14:00 P

Self-similar expansion of a plasmoid supplied by pellet ablation — •Alistair Arnold, Pavel Aleynikov, and Per Helander — Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald

Cryogenic pellet injection is an important means of refuelling and terminating fusion plasmas, with fuel pellets exhibiting a range of phenomena beneficial to confinement and the energy balance between ions and electrons. We consider the self-similar expansion along magnetic field lines of the plasmoid produced by a small pellet. In particular, we consider the case when the expansion timescale is comparable to the time taken for the pellet gas cloud to cross a field line. It is shown that plasmoid ions acquire a significant fraction of the energy that is transferred to plasmoid electrons via collisions with the ambient plasma. This expansion is insensitive to the details of the profile of the gas cloud and details of ionisation - the plasma flux emerging from the gas cloud is the only quantity that affects the expansion.

P 5.16 Tue 14:00 P

Linear MHD stability analysis of pedestals in magnetically perturbed tokamak equilibria — •Jonas Puchmayr[1,2], Mike Dunne[2], Erika Strumberger[2], and Hartmut Zohm[2] — [1]Department of Physics, Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 München, Germany — [2]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

In the regime of high confinement (H-mode), a region of self-organized suppression of turbulent transport at the plasma edge forms resulting in steep gradients of pressure, temperature and density evolve. The edge gradients provide free energy for a new type of instability, Edge Localized Modes (ELMs). These instabilities are well-described by linear MHD and can be identified as coupled peeling-ballooning modes. Experimentally, ELMs cause large quasi-periodic bursts of particle and energy loss, that will lead to severe damage in future fusion devices. For this reason, control of ELMs is inevitable for H-mode operation in future machines. Resonant magnetic perturbation (RMP) fields are observed to mitigate or suppress ELMs. These perturbation fields break the axisymmetry of tokamak equilibria, resulting in weakly 3D configurations.

In this work, the code CASTOR3D is used to study (non-)ideal MHD stability of weakly 3D tokamak equilibria. Toroidal mode coupling is observed and the ideal MHD energy functional, which is newly implemented in CASTOR3D, is used to analyze the eigenfunctions and understand the change that the 3D structure has on stability.

P 5.17 Tue 14:00 P

Challenges and expectations for the magnetic diagnostics during high-performance experiments at Wendelstein 7-X — •K Rahbarnia[1], S Vaz Mendes[1], J Schilling[1], H Thomsen[1], J Schmitt[2], M Khokhlov[1], T Bluhm[1], B B Carvalho[3], M Zilker[1], and Wendelstein 7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Auburn University, Auburn, AL, USA — [3]Instituto de Plasmas e Fusao Nuclear Instituto Superior Tecnico, Lisbon, Portugal

During the last experimental campaign at the Wendelstein 7-X stellarator the magnetic diagnostics were successfully operated. That involves equilibrium sensors, such as Rogowski coils, diamagnetic and saddle loops as well as Mirnov coils. The latter were used to study magnetohydrodynamic activity, which was mainly found within the frequency range up to 400 kHz and is of Alfvénic nature. Identifying their driving mechanism is crucial to understand the influence on plasma confinement properties. The measured data of the equilibrium sensors are suitable for equilibrium reconstructions, which are also relevant for the previously mentioned studies. In addition plasma energy and current measurements are directly embedded in machine safety systems, like the plasma heating interlock, and will in future campaigns also be integrated in the quench detection system. Fast and potentially critical plasma collapses are tracked and the impact on the main magnetic field coil system can be analysed. For future high-performance experiments electrical and mechanical improvements were implemented including an upgrade of the DAQ systems.

P 5.18 Tue 14:00 P

Characterization and driving mechanisms of dominant Alfvén eigenmodes at the W7-X Stellarator — •Sara Vaz Mendes, Kian Rahbarnia, Christoph Slaby, Thomsen Henning, Jonathan Schilling, Christian Brandt, Matthias Borchardt, Ralf Kleiber, and Axel Könies — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

Electromagnetic Alfvén waves are often present in different scenarios of the W7-X stellarator plasmas. Induced magnetic fluctuations (between 100-450 kHz) were observed for 727 discharges during different magnetic configurations, heating scenarios and general plasma parameters. The measurements were performed using a system of 125 Mirnov coils, located in four out of five modules of W7-X.

The Alfvénic nature is proven through the scaling of dominant magnetic fluctuation frequencies with the plasma density. In addition, the correlation of the observed Alfvénic activity with different plasma parameters is being analyzed.

In the future operation of W7-X a bigger population of energetic particles (EPs) is expected and the possible resonant wave-particle transport of EPs must be avoided since it can result in degradation of plasma confinement or even damaging of plasma facing components. To better understand these risks the conditions for enhanced Alfvénic activity at W7-X are studied and possible driving mechanisms are discussed.

P 5.19 Tue 14:00 P

Development of a model based early heating advanced scenario for ASDEX-Upgrade — •Raphael Schramm, Alexander Bock, Maximilian Reisner, Jörg Stober, Hartmut Zohm, and The ASDEX Upgrade Team — Max-Planck Institut für Plasmaphysik, Garching, Germany

Advanced Tokamak scenarios offer improved stability, confinement and pulse length compared to standard scenarios due to an increase of the plasma's bootstrap current ($j_{bs} \propto q\nabla p$). They are accessed by manipulating the safety factor profile q through external actuators, which can be applied during the current ramp-up (early heating), or after an equilibrium is reached (late heating). The former allows for a longer discharge and more varied current distributions, but due to the volatility of the early plasma, creating such a scenario experimentally, with feed-forward control usually takes a lot of trial and error.

To combat this, a model, capable of predicting the plasma response to actuator changes with reasonable accuracy and a run-time of only a few minutes, has been developed in the transport code ASTRA. It includes Gyro-Bohm based core transport, edge transport according to a recently developed scaling law as well as the L/H-transition based on the heating power at the separatrix. Multiple fitting factors have been scaled according to a set of reference discharges and a good agreement between simulation and experiment has been achieved.

Using this model, an advanced scenario with early heating and an elevated q-profile has been developed and successfully tested at ASDEX-Upgrade.

P 5.20 Tue 14:00 P

Statistical analysis of confinement data from pellet fueled high-density plasmas in ASDEX Upgrade — •Tobias Engelhardt[1], Peter Lang[2], Martin Prechtl[1], and ASDEX Upgrade Team[2] — [1]Hochschule Coburg — [2]Max-Planck-Institut für Plasmaphysik

A dataset of pellet-fueled discharges in the high density regime of ASDEX Upgrade (AUG) has been collected, covering 8 years of operation. It comprises scenarios with moderate performance, as well as attempts to achieve high performance by applying either N-seeding or high shaping. This data show that the H06 scaling [1] is more appropriate to describe plasma confinement in this regime, than the H98(y,2) scaling [2]. Additionally, the enhanced confinement gained by the different methods cannot be maintained when the density n_e exceeds the Greenwald density n_{Gw}.
According to observations at JET (with carbon wall), see e.g. [3], higher H-factors (H98(y,2)) at constant n_e/n_{Gw} were observed when the triangularity δ was increased. Whether this trend is also present at AUG (with tungsten wall and- divertor) will be investigated. The reduction of confinement when exceeding n_{Gw} can possibly be attributed to a rising separatrix density $n_{e,sep}$. The assumption that primarily the divertor density n_0^{Div} influences $n_{e,sep}$, may turn out to be too shallow. Therefore, potential other correlations between $n_{e,sep}$ and several other plasmaphysical parameters are planned to be analysed.
[1] Johner, FST **59** (2011), 308; [2] IPB, NF **39** (1999), 2175;
[3] Mukhovatov, PPCF **45** (2003), A235

P 5.21 Tue 14:00 P

Effects of thin surface oxide films on deuterium uptake in self-damaged tungsten - Evidence for permeation barrier effect — •Kristof Kremer[1,2], Thomas Schwarz-Selinger[1], and Wolfgang Jacob[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Deutschland — [2]Physik-Department E28, Technische Universität München, 85747 Garching, Germany

In a fusion reactor, the uptake of deuterium (D) and tritium fuel into the plasma-facing tungsten (W) components is a critical issue with respect to fuel loss and radioactive inventory. However, the possible influence of natural surface oxides on the D uptake in W is not fully understood yet.

Therefore, we investigated the D uptake in W through 33 and 55 nm thick oxide films. To trace the D, a 2 μm thick layer of self-ion-damaged W was created underneath the oxide. It acts as a getter layer and traps any D that permeates the oxide film. The sample was then exposed to a "gentle" D plasma (<5eV/D ion) at 370 K to a fluence of 10^{24} D/m^2. We measured the depth-resolved concentration of D and oxygen with nuclear reaction analysis and Rutherford backscattering spectroscopy and the surface modifications of the oxide film with scanning electron microscopy.

We observed a strong influence of surface oxide films on D uptake, i.e., the oxide films completely block D uptake into metallic W, although high D concentrations were found in the oxide film itself. We explain this by the difference in the heat of solution between W oxide and metallic W.

P 5.22 Tue 14:00 P

Comparing ion energy distributions of a symmetric capacitively coupled plasma with 1D-PIC/MCC simulations: an alternative approach to estimate γ coefficients? — •Christian Schulze[1], Zoltán Donkó[2], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Institute for Solid State Physics and Optics, Wigner Research Center for Physics, Hungary

Secondary electron emission (SEE) is an important effect since it directly influences not only the plasma ignition but also the plasma properties. Changes in plasma properties can be utilized to estimate SEE coefficients under realistic conditions for example from the I-V-characteristics of magnetron discharges [D Depla et al 2008 J. Phys. D: Appl. Phys. **41** 202003]. But plasma density, plasma potential and sheath thickness also have an impact on the ion transport through the sheath and on the ion energy distribution function (IEDF). Here, we critically discuss potentials and challenges of using energy resolved ion mass spectrometry measurements of IEDFs and their comparison to 1D-PIC/MCC simulations for the estimation of SEE coefficients.
Two identical symmetric capacitively coupled plasma (CCP) electrodes are coated with Al and Al_2O_3, respectively, to investigate the impact of changed surface properties on the IEDF of Ar^+ ions. Since pressure, electrode distance and neutral gas temperature can have a similar impact on the IEDF as the SEE coefficient, their impact on the IEDFs need to be analyzed and they need to be determined with sufficient precision to avoid systematic errors.

P 5.23 Tue 14:00 P

Optimisation and characterisation of an ion-beam-driven permeation experimental setup — •Philipp Sand[1,2], Armin Manhard[1], Rodrigo Arrendondo Parra[1], and Udo von Toussaint[1] — [1]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [2]Technical University Munich, 85748 Garching, Germany

Hydrogen permeability is an important property for many materials in future technologies such as, e.g., nuclear fusion. One method to determine permeation properties is to implant deuterium ions from a mass-filtered ion beam with a well-defined flux and energy into a sample foil. At the rear side of the foil, the effusion flux of the permeating species is then measured by a quadrupole mass spectrometer. The ion optics of such a setup is characterised for a 4.7 keV $D_3{}^+$ ion beam. The ions are decelerated by the sample bias voltage to implantation energies of 500 eV per D. The settings are optimised in order to obtain a high ion current to reach reasonable signal intensities and affordable experiment times. Another goal for the optimisation is to minimise the flux of charge exchange neutrals, which are created in the beamline. They will not be decelerated by but impinge on the sample with their full energy. They lead to degradation of the sample material due to displacement damage and sputtering and can also affect the permeation signal. The neutral fraction can potentially be minimised by electrostatically deflecting the beam after passing the volume of highest neutral generation rate. Photographs of the beam footprint are obtained using ion-induced fluorescence on a quartz plate.

P 5.24 Tue 14:00 P

Spectroscopic investigation of W7-X detachment induced via nitrogen seeding — •Frederik Henke, Maciej Krychowiak, Ralf König, Felix Reimold, Dorothea Gradic, and Thomas Sunn Pedersen — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

As power exhaust is one crucial aspect of a future fusion power plant, dissipation of the localized heat fluxes striking the divertor is needed. The regime, in which a large fraction of the input power is radiated isotropically into full solid angle while the peak heat- and particle-fluxes to the target are strongly reduced, is called detachment.
Stable detachment is accessible via two different paths in the island divertor of W7-X. First, increasing the density via hydrogen fueling can lead to the transition into the detachment regime with carbon as the intrinsic impurity being the main radiator. Because in a future power plant carbon will not be used at any first wall components due to strong tritium retention, extrinsically seeded low-Z impurities are investigated as the second way to reach detachment.
In this work nitrogen seeding experiments are analyzed applying a spectroscopic line-ratio model of singly ionized nitrogen to measure the local plasma parameters electron density n_e, electron temperature T_e and impurity concentration c_Z. From the analysis of data acquired in the previous operation campaign possible upgrades of the diagnostic, as well as extensions of the physics model to i.e. analyse carbon radiation are explored.

P 5.25 Tue 14:00 P

Determination of (quasi) coherent mode properties at the edge of improved confinement plasmas — •Joey Kalis[1,2], Gregor Birkenmeier[1,2], Michael Griener[2], Peter Manz[3], Takashi Nishizawa[2], Luiš Gil[4], and Ulrich Stroth[1,2] — [1]Physik-Department E28, TUM, Garching — [2]Max-Planck-Institut für Plasmaphysik, 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 the high confinement modes without type-I ELMs. In the past years, several natural ELM-free operation scenarios, such as the EDA H-mode, the I-mode and the QH-mode, have been achieved in ASDEX Upgrade. Each scenario is characterized by the appearance of quasi coherent fluctuations at the plasma edge, which may be responsible for the stabilization of the ELMs. For the comparison with theory, it is important to analyze the properties of all edge modes in more detail to identify their underlying driving forces and outline possible similarities and differences. The first focus is on the quasi-coherent mode (QCM), being present in the EDA H-mode. Due to its high spatial and temporal resolution, the He-beam diagnostic is used to outline different QCM properties. First, a time series analysis is performed to investigate the interaction of the QCM with other modes and general plasma parameters. Second, the propagation velocity and the wavenumber of the QCM is determined by means of spectral methods and compared with theoretical predictions.

P 5.26 Tue 14:00 P

Characterization of lanthanum-hexaboride electron emitters as cathodes in pressure gauges for strong magnetic fields — •Bartholomaeus Jagielski, Uwe Wenzel, Mirko Marquardt, Jiawu Zhu, and Thomas Sunn Pedersen — Max Planck Institute for Plasma Physics, Greifswald, Germany

In order to evaluate the particle exhaust rate at the sub-divertor, the neutral gas pressure can be measured. In the last operation phase (OP 1.2) of the Wendelstein7-X (W7-X) nine newly developed Crystal Cathode Pressure Gauges (CCPG) were tested during pressure recordings. While cathodes from thoriated tungsten regularly bent under the influence of the j x B forces (2,1T), the CCPGs, equipped with emitters made of lanthanum hexaboride, functioned satisfactorily[1]. The LaB_6 cathodes of the CCPGs have a simple geometry and due to the low work function of 2.5eV, the heating current was reduced to 2-3 A in W7-X in hydrogen atmosphere, whereby the stress under Lorentz forces was further reduced[2]. This makes the LaB_6-emitter a promising candidate for precise manometers in a range between 10^{-6} and 1mbar and an application in future fusion plants (ITER, DEMO).

Recently three different cathode designs have been tested in different environmental conditions and compared: a 8mm and a 6mm long cathode, and a new 2-emitter design. Results of the investigations within an external magnetic field of 3T, latest optimization and future plans for the CCPGs are presented.

[1] U. Wenzel et al, J. Instrum.12(09), C09008 (2017).
[2] U. Wenzel et al, Rev. Sci. Instrum., 90, 123507 (2019).

P 5.27 Tue 14:00 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. Most of 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. For the confined region a first experimental case has been matched by using both core and edge models. Fully integrated simulations during ramp-up, flat-top and ramp-down are planned for the future.

P 5.28 Tue 14:00 P

Structure-property relations for thin drawn tungsten wires — •Maximilian Fuhr[1,2], Bailey Curzadd[1,2], Batuhan Sancak[1,2], Till Höschen[1,2], Martin Balden[1], Wolfgang Pantleon[3], Jürgen Almanstötter[4], Johann Riesch[1], and Rudolf Neu[1,2] — [1]Max-Planck-Insitut für Plasmaphysik, Garching, Deutschland — [2]Technische Universität München, Garching, Deutschland — [3]Technical University of Denmark, Lyngby, Dänemark — [4]OSRAM GmbH, Schwabmünchen, Deutschland

Tungsten (W) shows a ductile-to-brittle transition and fractures brittle below, but ductile above a certain transition temperature. This transition temperature, which is far above room temperature for coarse-grained W, can be shifted towards lower temperatures by wire drawing or other working processes. Wires drawn to very small diameters can deform ductilely at room temperature. The correlation between plastic deformation and the shift of the transition temperature is not fully understood, but the microstructure is thought to play a crucial role. In order to gain further insight into the open question of the enhanced ductility of worked tungsten, we investigated the mechanical properties (via uniaxial tensile testing) and microstructure (by EBSD) of four chemically identical wires drawn to diameters between 16 μm and 490 μm. Thorough quantitative analysis reveals the strong influence of the particular microstructure of the wires consisting of highly elongated grains with strong {110} fiber texture on their mechanical behavior and allow for formulating structure-property relations.

P 5.29 Tue 14:00 P

Heat conduction simulation in plasmas with magnetic field lines of mixed topology — •Gregor Pechstein, Brendan Shanahan, and Per Helander — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald

Fusion devices must dissipate heat before it reaches the plasma-facing components. For this purpose the W7-X stellarator relies on a chain of magnetic islands close to the plasma edge channelling the plasma to a divertor. Detachment, a scenario in which energy is radiated due to collisions with neutrals, is a promising method for reducing heat flux onto the divertor. First divertor experiments on W7-X exhibit stable detachment, whose main features are reproduced by the EMC3-Eirene edge transport code. With an increase in the radiated power fraction the position of the radiation front approaches the X-point and the separatrix of the magnetic islands. Here we seek to understand the stability and position of the detached radiation front using a heat conduction model. In contrast to 1-d analytical heat conduction models used in Tokamak divertors, perpendicular transport cannot be ignored in the islands of W7-X. The importance of transport perpendicular to the magnetic field is due to the long connection lengths in the islands. Accordingly, we perform 2-d heat conduction simulations in slab geometry with an island. These simulations employ a simplified radiation function as a heat sink. Depending on the parameter varied the radiation front exhibits different patterns and stability. Concomitant to the simulations, analytical limits of the parameter space are investigated. The implications for stable detachment in W7-X will be discussed.

P 5.30 Tue 14:00 P

PIC-Simulations of Perpendicular Collisionless Shocks in Multiple-Ion GRB Plasmas — •Jonas Graw, Martin Weidl, and Frank Jenko — Max Planck Institute for Plasma Physics

Ultra-high-energy cosmic rays (UHECRs) are electrically charged particles, which move throughout the universe with energies greater than about 1 EeV. Understanding where and how these particles are created, i.e., unravelling the nature of cosmic accelerators, is one of the biggest challenges in present-day astrophysics. One likely source of UHECRs are gamma-ray burst (GRBs). The latter eject gas parallel to the axis of rotation with high velocities. Shocks are formed in these jets, in which particles are believed to be accelerated to extremely high velocities. Due to such high energies, protons and neutrons fuse to alpha particles. In our research, we simulate an astrophysical plasma consisting of multiple ion species in a mildly relativistic shock. Presently, we examine both real and phase space and we explore how the highest energetic particles behave in such a plasma. We analyze different modes that both come from analytical considerations and simulations. Particularly interesting are the modes that do not exist in an electron-proton plasma. The acceleration of UHECRs is thereby strongly connected to particle-wave interactions inside the plasma. In our analysis, we deepen the understanding of the nature of possible acceleration mechanisms.

P 5.31 Tue 14:00 P

Current Filamentation Instabilities of Proton Beams in Proton Driven Wakefield Accelerators — •Erwin Walter[1], Martin S. Weidl[1], John P. 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. However, for alternative beam parameters, the electromagnetic Weibel-like beam filamentation instability could result in magnetic field amplification, perpendicular scattering, emittance growth and possibly even the formation of a collisionless shock.

Our research investigates which beam parameters are required for filamentation to dominate and whether this parameter regime is accessible to the AWAKE experiment. We present and compare results of linear theory, quasi-static simulations and full-PIC simulations.

P 5.32 Tue 14:00 P

Generalized Fluid Models for Edge Turbulence Simulations — •Christoph Pitzal, Andreas Stegmeir, and Frank Jenko — Max Planck Institute for Plasma Physics, Garching, Germany

Fluid models are a useful tool for simulations in the field of Plasma Physics. On the one hand, fluid models are less computationally intense than kinetic models. On the other hand, the models have limited predictive capabilities, since not all effects are captured, that 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. Every fluid model introduces a hierarchy of moments, which connects a fluid moment with the next higher one and needs to be closed for the model to become applicable. Models with a collisional closure, as the Braginskii model [1], significantly overestimate for example the parallel heat conductivity due to the absence of Landau damping. By using particular closure approximations instead of the commonly used collisional closure the model can mimic certain kinetic effects, as first shown with Landau damping in [2]. The scope of this project is to study different kinetic effects and their applicability for current plasma fluid codes, such as GRILLIX [3]. Further steps will be the implementation of such a model and to compare the increase of fidelity and computational effort. [1] S. Braginskii and M. Leontovich Reviews of plasma physics, 1965. [2] G. W. Hammett and F. W. Perkins Phys. Rev. Lett., vol. 64, pp. 3019-3022, Jun 1990. [3] A. Stegmeir, A. Ross, T. Body, et al. Phys. Plasmas, vol. 26, p. 052517, 2019.

P 5.33 Tue 14:00 P

TALIF on H_2 Plasmas in Preparation of its Usage for Negative Ion Sources — •Frederik Merk, Christian Wimmer, Stefan Briefi, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, Garching, Germany

Two-photon absorption laser induced fluorescence (TALIF) offers the possibility to measure both the velocity distribution function and the density of ground state H atoms in H_2 plasmas. Here, the atoms are excited via the simultaneous absorption of two photons followed by the emission of fluorescence which is used for diagnostic purposes. In order to generate the necessary 205.08 nm photons, a pulsed, frequency tripled dye laser is employed. In addition to the complexity of such an instrument, the diagnostic as a whole needs to be characterized thoroughly and calibration is necessary. This was done at a planar ICP where a 600 W, 13.56 MHz RF generator is used to drive H_2 plasmas. Here, TALIF is supplemented by optical emission spectroscopy on the Balmer lines and the molecular Fulcher-α transition in order to determine basic plasma parameters. The measurement results of scanning gas pressure and RF power coupled to the plasma are presented in this contribution. They are used to gain insight into the particle reactions taking place in the plasma. In addition, the implementation of TALIF at the H^-/D^- ion source BATMAN Upgrade is prepared from the knowledge that was gained at the ICP.

P 5.34 Tue 14:00 P

Performance of neutral pressure gauges using LaB6-emitters in deuterium plasmas — •Victoria Haak[1], Uwe Wenzel[1], and Gen Motojima[2] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]National Institute for Fusion Science, Toki, Japan

Neutral pressure gauges using a LaB6-crystal as an emitter, an advanced type of neutral pressure gauge optimized for the use in high magnetic fields are used to measure the neutral gas pressure in fusion experiments. They were successfully operated in hydrogen plasmas in Wendelstein 7-X (W7-X) during OP1.2b [1]. Due to the low heating current of 2-2.5 A, LaB6 neutral pressure gauges present a promising concept for measurements of the neutral gas pressure in future fusion devices. Two LaB6-neutral pressure gauges were installed and tested in the Large Helical Device for the last two campaigns in order to study the effect of neutrons on the electron emission properties of LaB6.

Both crystals showed stable electron emission during operation in hydrogen and helium atmosphere and were operated at a low heating current of 1.7 A. One of the emitters experienced an increase of the heating current from 1.7 to 4 A during deuterium operation. Apart from damage to the crystal, the neutral pressure gauge cannot be reliably used for measurements once the heating current reaches a given limit. As stability of the emission properties is essential for the use of LaB6 in neutral pressure gauges, degradation of the emission properties is studied in this contribution, in particular the role of neutron damage.

[1] U. Wenzel et al, Rev. Sci. Instrum., 90, 123507 (2019).

P 5.35 Tue 14:00 P

Generic Determination of Rotating and Locked MHD Mode Amplitudes on ASDEX Upgrade — •Felix Klossek, Marc Maraschek, Anja Gude, Hartmut Zohm, Louis Giannone, and the ASDEX Upgrade Team — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

When approaching a disruption in tokamaks, the plasma typically becomes unstable regarding a tearing mode which locks to the vessel. For the disruption to occur, multiple phase-locked tearing modes with different poloidal mode numbers m are considered necessary for producing a thermal shortcut by stochastisation. For rotating modes it has been possible for a long time to differentiate between different poloidal mode numbers at ASDEX Upgrade. Similar observations for locked modes could not be made until now, as the pick-up coils used for rotating modes rely on induction. The saddle coils used for locked mode detection are located at only one poloidal position on the high field side and therefore cannot resolve the poloidal mode numbers m.

A new method for evaluating magnetic mode signals, in particular the mode amplitude and phase, by projecting the signals on appropriate sine and cosine base vectors with the desired mode number is introduced. With this method, no compute intensive FFT algorithms are needed. For detecting the poloidal mode structure of locked modes for the first time the inactive RMP coils at ASDEX Upgrade are used in addition to the locked mode detector. It is shown that the mode structure is changed during the locking phase prior to the disruption.

P 5.36 Tue 14:00 P

Fast characterization of plasma states in W7-X with permutation entropy — •Juan Fernando Guerrero Arnaiz[1,2], Andreas Dinklage[1,2], Bernd Pompe[1], Matthias Hirsch[2], Udo Höfel[2], Christian Brandt[2], Henning Thomsen[2], Jonathan Schilling[2], Kian Rahbarnia[2], Tamara Andreeva[2], Ulrich Neuner[2], and the W7-X Team[2] — [1]Universität Greifswald, Greifswald Germany — [2]Max-Planck-Institut für Plasmaphysik, Greifswald Germany

Permutation entropy (PE) is applied on time series of plasma measurements. PE is a single number that represents the information rate to derive the ordinal properties of a time series. Here, we systematically characterize, by means of the PE, highly sampled multi-variate signals from a 32-channel electron cyclotron emission radiometer. Being capable to detect changes in bulk data, core localized spatio-temporal bifurcations of the plasma states were revealed from changes of the PE. Hereby, spontaneous transitions to high core-electron temperatures (Te) were detected at different heating powers and densities in the so-called low-iota configuration of W7-X. The transitions have been seen to go along with the occurrence of low frequency MHD activity, which ceases when Te increases. It is this MHD activity which PE is sensitive to. While visual a-posteriori inspection of the (noisy) data results in similar findings, the time to identify changes is much reduced. Therefore, PE is suggested to be employed for machine learning techniques to identify plasma state changes.

P 5.37 Tue 14:00 P

Tackling turbulence in the plasma edge pedestal with a revised version of the GENE code — •L. A. Leppin, P. Crandall, 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 a new modification of the well-established gyrokinetic, Eulerian, delta-f code GENE (genecode.org), which enables numerically stable global, electromagnetic simulations at high beta values. This new "f-version" utilizes a slightly different definition of the underlying distribution function. The new f-version is fully integrated into the GENE code and can e.g. make use of block-structured grids in velocity space, which lower the resolution requirements dramatically. We demonstrate the successful implementation and give an outlook with first applications of the new GENE f-version to the plasma edge. By simulating turbulence at different timepoints within an edge localized mode (ELM) of an ASDEX Upgrade discharge we contribute to the characterization of turbulence in the pedestal within an ELM cycle.

P 5.38 Tue 14:00 P

Collisional Relaxation of an Anisotropic Two-Species System as a Verification of a Simplified Fokker-Planck-Type Collision Operator — •Philipp Ulbl[1], Dominik Michels[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

Collisions have significant effects on the properties of edge and scrape-off-layer turbulence in magnetic confinement fusion devices. State of the art simulations of plasma turbulence are built on the gyrokinetic equations and require the addition of a so-called collision operator. The typical choice in a plasma, a Fokker-Planck collision operator does yield physically accurate results but also heavily impacts the computational performance of numerical codes. Therefore, it can be beneficial to use simplified Fokker-Planck-type collision operators that capture most of the physics and are faster to calculate. In this work, we present the Lenard-Bernstein/Dougherty (LBD) collision operator [1, 2] that has been implemented in the gyrokinetic turbulence code GENE-X [3]. We show a verification of the physics based on the collisional relaxation of an anisotropic electron-deuterium system. Further, we compare the results with analytical estimations and with results from a Bhatnagar-Gross-Krook (BGK) collision operator [4].

[1] A. Lenard, and I. B. Bernstein, Phys. Rev. 112, 1456 (1958)
[2] J. P. Dougherty, Phys. Fluids 7, 1788 (1964)
[3] D. Michels, et. al., Comput. Phys. Commun. 264, 107986 (2021)
[4] P. L. Bhatnagar, et. al., Phys. Rev. 94, 511 (1954)

P 5.39 Tue 14:00 P

Disruption simulations in ASDEX Upgrade with JOREK-STARWALL — •Nina Schwarz, Matthias Hoelzl, Javier Artola, Gabriella Pautasso, and Mike Dunne — Max Planck Institute for Plasma Physics, 85748 Garching, Germnay

During major disruptions or due to a loss of the control system in tokamaks, the plasma becomes vertically unstable and eddy currents are induced in the conducting structures and halo currents appear in the SOL. The magnitude of the resulting vertical forces have not been successfully extrapolated to reactor sized tokamaks yet [Hender2007]. Also, horizontal forces can appear, when the plasma shows asymmetric features that may rotate. To estimate the magnitude and the distribution of halo currents as well as the forces during disruptions the extended non-linear MHD code JOREK is used together with the electromagnetic code STARWALL to study the evolution of halo currents and forces during disruptions and hot VDEs in ASDEX Upgrade.

In particular, the discharge #25000 the vertical control system was intentionally shut off to produce a hot VDE and has been analyzed in detail [Pautasso2011]. This shot has been modelled before in the two dimensional codes DINA [Lukash2010] and TSC [Nakamura2010] to study the halo current magnitude during disruption following the vertical displacement. The aim of this contribution is to show first 2D calculations in JOREK to validate the magnitude of the halo currents at a given halo width and temperature. This will later be used as a basis to extend the simulation to 3D and observe non-axissymmetric effects of the plasma and halo current evolution.

P 5.40 Tue 14:00 P

Transport Studies in ASDEX Upgrad via Gaspuff Modulation Experiments — •Christian Schuster[1,2], Elisabeth Wolfrum[1], Emiliano Fable[1], Rainer Fischer[1], Michael Griener[1], Clemente Angioni[1], Ulrich Stroth[1,2], and ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching — [2]Physik-Department E28, Technische Universität München, Garching

To obtain sufficient fusion power in a future reactor, the core plasma has to be hot and dense. A large part of the radial density increase occurs at the edge of the plasma. Apart from the impact on fusion power the density profile also influences many different phenomena such as the L-H transition [Shao, PPCF 2016] or the achievable pedestal top pressure. The processes that determine the edge density profile are however still not understood sufficiently to be able to extrapolate to future devices.

Apart from particle transport, which we model by diffusion and a convection called pinch, fueling of the plasma by neutral atoms contributes to the density profile. The individual contributions cannot be distinguished by analyzing stationary profiles. We therefore modulate the gas flow and analyze the plasma response measured with various diagnostics in an integrated data approach. We find that the modulation, among other effects, causes a cold pulse whose propagation into the core can only be explained by time dependent transport models.

P 5.41 Tue 14:00 P

Impurity parallel transport in ITER using improved collisional closure in the SOLPS-ITER code — •Sergei Makarov[1], D Coster[1], V Rozhansky[2], E Kaveeva[2], I Veselova[2], S Voskoboynikov[2], I Senichenkov[2], A Stepanenko[3], V Zhdanov[3], and X Bonnin[4] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]SPbPU, St.Petersburg, Russia — [3]MEPhI, Moscow, Russia — [4]TER, St-Paul-Lez-Durance Cedex, France

Impurity transport in the Scrape-off layer of a tokamak is a challenging problem. Impurities occur in fusion plasmas naturally, for instance helium ash as a product of the D-T reaction, and artificially, for instance noble gasses are seeded into the tokamak for additional radiation and divertor target protection. When the impurity mass is significantly larger than the mass of the main ions the multispecies extension of the single ion Braginskii approach can be applied. However, usually impurity/main ion mass ratio can not be assumed infinitely large, and the Grad's 21N-moment method should be used for the transport coefficients estimation. This approach takes into account masses of ions are present in the plasma for coefficients calculation. It is the major improvement in comparison to the previous approach applied for the SOLPS-ITER code. This approach is implemented into the SOLPS-ITER code for multiple ion parallel transport description in collisional plasmas. The change in the impurity transport behavior in ITER is studied using improved method and taking into accout masses of ions. Significant differences are found in the ion transport, where the masses of ions are not sufficiently different.

P 5.42 Tue 14:00 P

Positron accumulation in a multi-cell Penning-Malmberg trap — •Martin Singer[1], Patrick Steinbrunner[1], Stephan König[2], Matthew R. Stoneking[1], James R. Danielson[3], Lutz Schweikhard[2], and Thomas Sunn Pedersen[1,2] — [1]Max Planck Institute for Plasma Physics, Germany — [2]Institute for Physics, University of Greifswald, Germany — [3]hysics Department, University of California, San Diego, USA

Positron-electron plasmas, which are examples of pair plasmas, are just beginning to be studied experimentally. Due to their equal mass constituents, many features that are found in electron-ion plasmas will not occur in pair plasmas, and they are expected to be extraordinarily stable when magnetically confined. The APEX collaboration aims to create the first magnetically confined, low energy pair plasma with a spatial dimension of several Debye lengths so that collective behavior can be observed. To create such a plasma numerous obstacles must be overcome, since positrons are rare. One crucial challenge is the accumulation of large numbers of moderated positrons. Therefore, a device is needed which is capable of storing up to 10^{11} positrons without heating and particle loss. One solution is the multi-cell Penning-Malmberg trap (MCT) concept, which separates the space charge of the positrons into an array of small Penning-Malmberg traps. We present first measurements with electrons stored in a single Penning trap that serves as the master-cell as well as in a prototype MCT. This MCT will be used to confine plasmas simultaneously in multiple cells, to investigate the confinement and different injection and ejection schemes.

P 5.43 Tue 14:00 P

Modeling the beam emission Balmer-α spectrum in neutral beam heated plasmas at Wendelstein 7-X — •Sebastian Bannmann[1], Oliver Ford[1], Udo Höfel[1], Peter Poloskei[1], Jakob Svensson[1], Benedikt Geiger[2], and Robert Wolf[1] — [1]IPP Greifswald — [2]University of Wisconsin, Madison, US

The optimized stellarator Wendelstein 7-X (W7-X) is equipped with a neutral beam injection (NBI) system. Knowledge about the particle and heat deposition of the beam in NBI shots is essential for further plasma physics analysis. The deposition depends on the beam and plasma parameters and information can be provided by measuring the Balmer-α light emitted by excited beam and halo particles. As the whole spectrum is too complex to be unambiguously fitted, a modular Bayesian inference network called Minerva is used. This requires implementing a detailed forward model with which one can infer beam and plasma parameters from the measured spectra. Existing modeling tools deploy Monte-Carlo techniques which is not feasible to use in combination with a Bayesian inference framework. The presented work focuses on the modeling of the neutral beam halo including collisional radiative processes to determine the fraction of neutrals in excited states. It is shown that the ballistic transport of halo particles can be described by a steady-state charge exchange diffusion equation. The possibility of inferring ion temperature profiles from the halo Balmer-α emission is investigated.

P 5.44 Tue 14:00 P

Proof of concept of a fast surrogate model of the VMEC code via neural networks in Wendelstein 7-X scenarios — •Andrea Merlo, Daniel Böckenhoff, Jonathan Schilling, Udo Höfel, Sehyun Kwak, Jakob Svensson, Andrea Pavone, 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 magnetohydrodynamic (MHD) model is used to self-consistently calculate the effects the plasma pressure induces on the magnetic field used to confine the plasma. The VMEC is the most widely used to evaluate 3D ideal-MHD equilibria, however, considering the computational cost, it is rarely used in large-scale or online applications. Access to fast MHD equilbria is a challenging problem in fusion research, one which machine learning could effectively address. In this work, we present artificial neural network (NN) models able to quickly compute the equilibrium magnetic field of Wendelstein 7-X. Magnetic configurations that extensively cover the device operational space, and plasma profiles with volume-averaged normalized plasma pressure $\langle\beta\rangle$ ($\beta = \frac{2\mu_0 p}{B}$) up to 5% and non-zero net toroidal current are included in the data set. The achieved normalized root-mean-squared error ranges from 1% to 20% across the different scenarios. The model inference time for a single equilibrium is on the order of milliseconds. Finally, this work shows the feasibility of a fast NN drop-in surrogate model for VMEC, and it opens up new operational scenarios where target applications could make use of magnetic equilibria at unprecedented scales.

P 5.45 Tue 14:00 P

Modifications of the fusion reactor systems code PROCESS to general stellarators — •Jorrit Lion, Felix Warmer, and Robert C. Wolf — Max Planck Institute for Plasma Physics, D-17491, Greifswald, Germany

Stellarators are attractive candidates for a fusion power plant, owing to their inherent steady-state capability and absence of plasma-current driven instabilities. A convenient way to study different power plant designs is by applying systems codes, which aspire to model an entire fusion power plant within a single framework by using simplified 0D or 1D models to capture relevant reactor constraints. In this work, we report on modifications of the fusion reactor power plant systems code PROCESS to a general class of stellarator configurations. This is achieved by introducing a set of new models in PROCESS, which reflect the stellarator specific constraints of a fusion reactor, like inhomogeneous neutron wall loads, coil-force magnitudes, wall loads by fusion born alpha particle wall loads or stellarator specifics operational boundaries by an electron cyclotron resonance heating scheme. Previous models, as introduced in [1], were adapted and generalized to generic stellarators. Using these modifications, PROCESS now allows for a combined technological, physical and economical assessment of a very general class of stellarator power plants within a systems code framework.

[1] F. Warmer, et al., "Implementation and verification of a HELIAS module for the systems code PROCESS", Fusion Eng. Design, vols. 98 99 (2015)

P 5.46 Tue 14:00 P

A novel MMC-like topology for ASDEX Upgrade Toroidal Field Coils Power Supply — •Antonio Magnanimo[1], Markus Teschke[1], and Gerd Griepentrog[2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Technische Universität Darmstadt, 64283 Darmstadt, Germany

The modular multilevel converter (MMC) has become one of the most attractive converters for high-power applications such as fusion devices power supplies. This converter, thanks to the discrete-leveled output voltage and its identical submodules (SMs) by which it is composed, represents a promising alternative to replace the flywheel generator (FG) that actually provides electrical power to the toroidal field (TF) coils of ASDEX Upgrade (AUG). Due to the pulsed DC operation of these coils and their high power needs for each experiment, a small-scale adapted version of the MMC is under development with some differences compared to conventional ones: SM capacitors have been replaced with supercapacitor (SC) modules to increase the amount of available stored energy while SMs belonging to different arms are interconnected to simplify their control and increase the reliability of the converter. This poster shows first an overview of the conceptual full-scale converter that could replace in future one of the FGs of AUG and then the development and the operation of a single IGBT full-bridge (FB) SM highlighting advantages and challenges of this configuration.