P 12: Poster II

Time: Wednesday 17:30–19:00 Location: HSZ EG

P 12.1 Wed 17:30 HSZ EG

Laser-induced charge ablation in surface DBD — •Robin Labenski, David Steuer, Henrik van Impel, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — Ruhr-University Bochum, D-44801 Bochum, Germany

In the emerging field of plasma catalysis, atmospheric pressure plasmas turned out to be promising candidates. Especially micro cavity plasma arrays allow for fundamental investigation of the interaction between the plasma and catalytic surfaces. As this reactor is a surface DBD, the used dielectric (e.g., catalyst) plays a crucial role in its discharge behavior since it can be charged during ignition. To visualize these charges and investigate their impact on catalysis, the array (15kHz, 400-800V) is irradiated using a nanosecond Nd:YAG-laser (20Hz, 532nm/1064nm) to ablate the charges during/after ignition. The impact of the laser is detected using global (and eventually local) electrical measurements as well as optical emission spectroscopy. While global electrical measurements involve current and charge measurements (i.e., Lissajous- figures), local measurements are planned to be performed using a Picoamperemeter directly picking up the ablated charges. Measurements show a lower/higher ignition voltage in the consecutive (half-) cycle and a decrease of charge in the Lissajous-figure immediately after laser irradiation.

This work is supported by the DFG via SFB 1316 (project A6).

P 12.2 Wed 17:30 HSZ EG

Characterization of the atmospheric plasma source HelixJetS: generation of silicon nanoparticles — •Leonie Mohn, Maren Dworschak, and Jan Benedikt — Institut of Experimental and Applied Physics, Kiel University, Germany

Silicon nanoparticles are of interest in developing new technologies such as next generation solar panels. Low-pressure discharges can produce silicon nanoparticles reliably but the cost effective and modular nature of atmospheric discharges makes them compelling to study. The atmospheric plasma source HelixJetS is analyzed to determine its ability to produce such silicon nanoparticles. The HelixJetS, a scaled down version of the HelixJet, has two electrodes that form a double helix, one of which is driven by RF power. The jet is operated with gas mixtures consisting of He, Ar, H_2 and SiH_4. To minimize the material deposition, there are two spatially separated gas inlets for He/H_2 on the outer diameter and for $He/Ar/SiH_4$ on the jet axis. The flow rates are simulated with Comsol to find those that achieve laminar flow. The Jet is characterized by varying the gas composition and the power deposited into the plasma and analyzing the resulting plasma by means of optical emission spectroscopy. The resulting nanoparticles are analyzed in regards to size, composition and photoluminescence. A Scanning mobility particle sizer is used to obtain the size distributions. FTIR and *in situ*-FTIR are used to determine the chemical composition of the particles. If the silicon nanoparticles crystallize, they exhibit photoluminescence, which is also qualitatively analyzed.

P 12.3 Wed 17:30 HSZ EG

Deposition of thin films from organosilicon precursors by means of photochemistry with VUV-radiation from an atmospheric pressure plasma jet — •Christina Reiser, Tristan Winzer, and Jan Benedikt — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

Deposition of thin films using atmospheric pressure plasma (APP) is still limited due to the high collision rates and in the case of many precursors (C_2H_2, SiH_4) also due to fast formation of particles in the gas phase, resulting from the fast polymerization of negative molecular ions. Activation of these precursors with VUV-photons should avoid the formation of the negative ions and, therefore, also particles.

In this work, a high purity noble gas plasma is used for producing intense VUV-radiation from noble gas excimer species. The gas flow through the plasma is guided in such a way, that the plasma and the effluent have no contact with the precursor gas flow, while the emitted radiation produces ions and radicals in the precursor gas flow directly in front of the treated surface. For optimizing deposition rates and film quality, parameter variations are carried out in which the photochemistry of organosilicon precursors is analyzed by ion mass spectrometry. Deposited films are characterized using Fourier transform infrared spectroscopy (FTIR).

P 12.4 Wed 17:30 HSZ EG

Numerical modeling of CO_2 microwave discharges: first verification steps of electromagnetics — •Pirmin Almanstötter[1], Dominikus Zielke[1], and Ursel Fantz[1,2] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching — [2]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg

To optimize the efficiency of CO_2 conversion processes, microwave plasmas (2.45 GHz) are very promising. Examples are the plasma torch (pressure 20-1000 mbar, power: 0.3-3 kW, flow: 3-100 slm), which can even operate at atmospheric pressure and the surfaguide (pressure 0.3-100 mbar, power: 0.3-1.2 kW, flow: 0.3-10 slm). To accompany experimental optimization efforts and for a systematic investigation, a numerical model is needed that describes the electromagnetics and plasma self-consistently. Before the model can be applied with confidence verification and validation is necessary. This is done for the electromagnetics and the discharge part separately, which consequently will be coupled. The contribution covers the verification of the electromagnetics part. As a first example, solutions of waveguides in cylindrical and rectangular geometries with either dielectric or conducting walls are investigated. It is shown that the solutions obtained by the numerical model match the analytical results.

P 12.5 Wed 17:30 HSZ EG

Durability of metal-organic-frameworks (MOFs) in non-equilibrium atmospheric pressure plasmas — •Alexander Quack[1], Kerstin Sgonina[1], Hauke Rohr[2], Norbert Stock[2], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Institute of Inorganic Chemistry, Kiel University

Metal-organic-frameworks (MOFs) have a large surface area and different metallic structures, which gives them good catalytic properties. Nevertheless, MOFs mostly can not withstand high temperatures, which are needed for their activation in classical catalytic reactions. Non-equilibrium atmospheric pressure plasmas provide reactive and internally excited particles and allow for plasma assisted catalysis at lower temperatures. For these processes MOFs can be used as a catalyst, if they withstand the plasma conditions.

We have developed a dielectric barrier discharge (DBD) reactor (21 kHz, up to 17 kV_{pp}) to determine the stability and suitability of different MOFs for plasma assisted catalysis. Reactive plasmas using gas mixtures based on N_2, H_2 and CO_2 gases and post- and in-plasma treatment under externally controlled temperature up to 200 °C have been applied to several MOFs including Zif-8, Zif-67 and MAF-6. Structural MOF analysis (XRD, FTIR) allows us to judge the stability of the MOF in the applied plasma treatments.

P 12.6 Wed 17:30 HSZ EG

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

Hydrogen is often envisioned as the energy carrier and green fuel of the future. However, new energy efficient and greenhouse gas free production methods are needed to utilize hydrogen as energy carrier on larger scales. A promising production method is the pyrolysis of methane in a microwave plasma. Here, we present a microwave plasma torch operated in an argon methane mixture (60 slm total flow rate, up to 35 % methane admixture) at atmospheric pressure. Microwaves with a frequency of 2.45 GHz and up to 6 kW of forward power are used to sustain the plasma. The methane is converted to hydrogen, solid carbon, acetylene and ethylene inside the plasma. The emission spectrum from the plasma is dominated by black body radiation from hot carbon particles and the dicarbon Swan bands. Broadband spectra of the black body radiation and high-resolution spectra of the dicarbon Swan bands are used to estimate the space resolved gas temperature from the black body temperature and the dicarbon rotational temperature. In the center the plasma reaches temperatures of up to 4600 K with large gradients of about 500 K in radial direction and 50 K in axial direction.

P 12.7 Wed 17:30 HSZ EG

Exploration of New Use Cases of Cold Atmospheric Plasma in Medicine, Surface Decontamination and Astronautics

— •Alisa Schmidt and Markus H. Thoma — Justus-Liebig-Universität, Gießen, Deutschland

Wound healing, the corona pandemic and manned spaceflight - how can a connection be drawn between all these different areas via physics?

All of these three areas have their own problems: the healing of chronic wounds, for example, can be inhibited by wound healing disorders and infections, in the corona pandemic there were supply shortages of protective equipment and respiratory masks - which led to the reusability of protective equipment becoming a subject of discussion - and finally manned space flight, according to NASA, aims to bring humans to the moon again in 2025 and even fly them to Mars by 2040 - however, there is the problem of keeping the closed life support systems on space vehicles and future lunar or even planetary stations clean.

We have approached these problems with a common solution approach - treatment with physical cold atmospheric plasma. Experimental design and results will be presented in this contribution.

P 12.8 Wed 17:30 HSZ EG

Research data management in plasma science — •Markus M. Becker[1], Kerstin Sgonina[2], and Marina Prenzel[3] — [1]Leibniz Institute for Plasma Science and Technology (INP) — [2]Institute of Experimental and Aplied Physics, Kiel University (CAU) — [3]Research Department Plasmas with Complex Interactions, Ruhr-University Bochum (RUB)

Implementation of data management standards and adoption of the FAIR data principles are more and more requested by funding agencies in recent years. This results in several new challenges for the scientific community. Research in low-temperature plasma physics is characterized by table-top experiments and a large variety of plasma sources and measurement devices, which are often first developed in the course of the research. Therefore, there are usually no established research data management (RDM) standards. Moreover, the documentation of research results is extremely heterogeneous. This not only complicates the implementation of structured RDM, but also reduces the comparability and reusability of data. To overcome this challenges, research groups at INP, RUB and CAU have joined forces to develop common RDM standards and tools. In monthly workshops, local requirements are discussed and gradually transformed into proposals for community standards, see https://www.plasma-mds.org. The poster reports on the status of the activities and presents how everyone can contribute and use the already developed tools for their own work.

The work was supported by grants 16QK03A (BMBF) and 327886311 (DFG).

P 12.9 Wed 17:30 HSZ EG

Dust flows around an obstacle under microgravity — •Stefan Schütt, Christina Knapek, Daniel Maier, Daniel Mohr, and André Melzer — University of Greifswald, Greifswald, Germany

Dust flows around an obstacle in three-dimensionally extended dusty plasmas have been investigated on parabolic flights. A fixed tungsten wire has been installed in the plasma chamber perpendicular to the observation plane of a video microscopy setup and serves as an obstacle. Three different situations were created. First, the dust flow around the wire was investigated during the pull-out phase at the end of each parabola, when gravity sets in and the dust cloud moves downward past the wire. Second, a dust motion with respect to the fixed wire was generated by modulation of the electrode bias. And third, the wire was electrically biased and the reaction of the dust to bias voltage changes was studied. In this contribution, a first evaluation of all three situations will be presented.

This work was supported by DLR under grant no. 50WM1962.

P 12.10 Wed 17:30 HSZ EG

Development of a holographic optical trap design — •Christian Theden, Natascha Blosczyk, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

In the research focus of dusty plasmas, a controlled manipulation of dust particle position is considered a major challenge. Especially in the field of binary mixtures, there is great interest in being able to control the positions of the particles to create binary crystals or liquids with periodic particle arrangement. First experiments show that optical tweezers can manipulate single particles in a dusty plasma [1, 2]. The problem here is that only one particle can be moved at a time. This is different for holographic-optical tweezers. Here the basic idea is to generate digitally a hologram and displayed on a spatial light modulator (SLM). Laser illumination of the SLM can create arbitrary light field and thus realize multiple tweezers at once. In this way, several tweezers can be projected at the same time. In addition, the hologram can be varied dynamically. The aim of this work and the first step towards such a powerful device is a single tweezer setup with a SLM. To determine the forces in the plasma that a holographic-optical tweezer exerts on a particle, the radiation pressure and the gradient forces are examined. This allows to develop a trap design and implement the holographic-optical tweezers in a dusty plasma experiment.

[1] V. Schneider, H. Kersten, 2018 Rev. Sci. Instrum. 89
[2] J. Schablinski, F. Wieben and D. Block, 2015 Phys. Plasmas 22

P 12.11 Wed 17:30 HSZ EG

Influence of the ion focus on diagnostics and simulations in 2D dusty plasmas — •Natascha Blosczyk, Yang Liu, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Evaluating dust particle properties is an important part in the field of dusty plasmas as properties such as charge can strongly influence the behaviour of single particles and, because of their coupling, of the entire system. A current interest is the description and evaluation of wave propagation in a 2D cluster, especially in clusters of binary mixtures. For this purpose, phonon dispersion relations and configurational temperature can be used as diagnostics to evaluate wave frequencies and charge respectively. These methods rely on a full and correct description of the interaction forces. Until now it has been mostly assumed to be a purely repulsive Yukawa interaction, disregarding the influence of a positive ion focus charge. Based on MD simulations, this poster will discuss the importance of the ion focus in simulations and diagnostics and wether it can really be disregarded.

P 12.12 Wed 17:30 HSZ EG

Creating nanodust clouds with different electrode geometries — •Franko Greiner, Andreas Petersen, and Alexander Schmitz — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

In a radio-frequency driven parallel plate reactor, nanodusty plasmas are created by means of reactive argon acetylene or argon silane plasmas. Switching off the reactive gas admixture creates a pure dusty plasma, consisting only of electrons, ions, and dust with a predeterminable radius. Using Mie polarimetry, Video aided extinction measurements (VAEM), and dust density wave diagnostic (DDW-D), the nanodusty plasma can be fully diagnosed [1]. For our standard setup of 60 mm circular electrodes with a 32 mm electrode gap we found dust densities of up to $6 \cdot 10^{13}\mathrm{m}^{-3}$, creating a strongly electron-depleted plasma. We investigate the impact of different electrode geometries on the dust and plasma parameters of the created nanodusty plasmas. [1] A. Petersen et al, Communications Physics (2022), https://doi.org/10.1038/s42005-022-01060-5 (open access)

P 12.13 Wed 17:30 HSZ EG

Anaylsis of microparticle trajectories during free fall — Andreas S. Schmitz[1], •Luisa Hanstein[1], Michael Kretschmer[1], Christoph Lotz[2], and Markus H. Thoma[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany — [2]Instititut für Transport- und Automatisierungstechnik, Gottfried Wilhelm Leibniz Universität Hannover, Germany

In a radiofrequency plasma chamber microparticles were placed in a low-pressure plasma, where they became charged and levitated against gravity by an electric field. The argon-filled chamber was installed in the University of Hannover's drop tower, the Einstein Elevator. As the setup fell, the microparticles spread into the bulk plasma due to the electric field and were imaged with a CCD camera. The trajectories of the microparticles, which were determined by image analysis, were used to determine the electric forces acting on the microparticles. Considering fluid dynamic simulations, we were able to determine the electric field acting on the microparticles.

P 12.14 Wed 17:30 HSZ EG

Investigation of Screw-Like Wave Phenomena in DC-Discharged Plasma with PK-4 — •Lukas Wimmer and Markus H. Thoma — Justus-Liebig-University Gießen, Germany

If micrometer to nanometer-sized microparticles are introduced into a plasma, it is referred to as dusty or complex plasma. The Plasmakristall-4 facility (PK-4) is the fourth and latest version of a successful series of experiments for the fundamental research of complex plasmas. If PK-4 is operated at low pressure, p < 25 Pa, as well as at low energy, and the dust particle size falls below a certain limit, screwed-like wave phenomena appear in ground-based experiments. Local system properties show that the wave structure is caused by the two-stream instability of ions and dust particles, assigned to the regime of dust-acoustic waves, and the superposition of longitudinal and transversal waves causes the curvature of the waves. Deeper analysis gives us information about the ion drag force in the low-pressure regime and the local electric field in the boundary region.

P 12.15 Wed 17:30 HSZ EG

Particle Chains in Dusty Plasmas under microgravity — •Daniel Maier, Michael Himpel, Stefan Schütt, and André Melzer — Institut für Physik der Universität Greifswald, Greifswald, Deutschland

Chain-like structures of charged dust particles have been observed in dusty plasmas under microgravity conditions. These structures appear near the mid-plane and around the particle free zone (void) of the plasma. The previous 2-dimensional investigations of the chains have difficulties in separating chains from each other, proofing their authenticity or observing them at full length. The described experimental set-up, containing four high speed cameras allows a stereoscopic, 3-dimensional observation and investigation of these structures and the interaction of the included particles with high temporal resolution (up to 200 fps). Here a simple model to identify chains and first results of the stereoscopic investigations will be shown.

P 12.16 Wed 17:30 HSZ EG

Ion emission of various materials from laser plasmas using a pre-pulse — •Qëndresa Ibraimi, Lars Torben Schwabe, Jan Riedlinger, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Plasmas generated by ultra-short, intense laser pulses have high density and temperature, are far from equilibrium, and their dynamics is dominated by several transient processes. Therefore, the ion dynamics in the early phase of these plasmas is difficult to predict. Here, we present experimental data of the ion emission driven by single-digit-fs laser pulses with intensities up to $10^{17}\,\mathrm{W/cm^2}$ focused on various solid targets. The ions reach kinetic energies of several tens of keV and were characterized in terms of species, direction, and energies by a Thomson parabola spectrometer. The differences of the spectra for distinct materials and pre-plasma conditions may allow conclusion on processes during and after laser-surface interaction. These findings are presented and discussed.

P 12.17 Wed 17:30 HSZ EG

Influence of a pre-pulse on ultra-short laser-induced plasma emission — •Timo Wenier, Steffen Mittelmann, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

In the versatile field of Laser-Induced Breakdown Spectroscopy (LIBS), ultra-short laser pulses in the femtosecond range are promising tools for detecting impurities and material composition with very high lateral and depth resolution. It has been shown that double-pulse or pre-pulse systems may significantly enhance the emission of the detected spectral lines of atoms and ion species present in the laser-induced plasma. This effect is systematically studied in this work: We investigate the influence of a pre-pulse on the emitted spectral lines in a vacuum LIBS setup with laser pulses of durations in the sub-10-fs range. The main pulse delay is varied up to 800ps and the influence on plasma parameters and ablation yield is examined on polished copper and silicon samples. First results give evidence that there are regimes where higher ionization degrees and temperatures can be achieved. Significantly decreased ablation yield is observed at the same time, which is attributed to plasma shielding effects. These results path the way for further optimization of ultra-short pulse LIBS with even higher spatial resolution.

P 12.18 Wed 17:30 HSZ EG

Experimental determination of the phase shift upon reflection — •Johanna Köchling, Nico Potzkai, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Interferometry can determine the expansion of laser plasmas in their early stage with a temporal resolution down to 10 fs. However, with measurements in the reflection geometry, the phase shift of the light reflected at the surrounding undisturbed material must be known precisely as a reference. In this contribution, we present experimental results for this reflective phase shift for a series of thin metal layers of different thickness. The results are compared with with theory and extrapolated to other regimes.

P 12.19 Wed 17:30 HSZ EG

Interplay of turbulent density and momentum transport in TJ-K plasmas — •Ralph Sarkis and Mirko Ramisch — IGVP, University of Stuttgart, Germany

Turbulent fluctuations of the potential and density in the magnetically confined plasma at the TJ-K stellarator are coupled as to give rise to radial turbulent cross-field transport of particles and poloidal momentum. Both transport phenomena have mutually exclusive prerequisites, being a strong density-potential cross-coupling for the Reynolds stress and decoupling for the particle transport. A poloidal Langmuir probe array is used to understand the turbulent transport phenomena in dependence of the geometry. This also allows to examine temporal alternations in the density-potential cross-coupling as a possible explanation for their coexistence. Conditional sampling and cross-correlation of transport with respect to the occurrence of zonal-potential events is used to establish a temporal and spatial relation, unravelling the dependence and coupling factors at play in both turbulent processes. Spectral analysis is also applied to address the interplay and to distinguish amplitude from phase modulations.

P 12.20 Wed 17:30 HSZ EG

The sticking machine: measuring electron sticking coefficients using dusty plasmas — •Armin Mengel and Franko Greiner — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel

A central property of (micro-)particles in laboratory plasmas is the strong negative charge they accumulate. It is, among other things, dependent on the electron sticking coefficient of the particle material. In many descriptions of plasma-surface interaction, the electron sticking coefficient is, due to lack of better knowledge, assumed to be 1. However, recent quantum-mechanical calculations[1] hint at significantly smaller values for dielectric surfaces at low energies, while metallic surfaces are known to have a sticking coefficient very close to unity. Subsequent excitation and long-distance-microscopy measurements with SiO_2 and metal-coated particles under the same plasma conditions allow for the determination of the ratio of the particles' charge and sticking coefficient. We present a study comparing metal-coated particles with SiO_2 particles in order to obtain the sticking coefficient of the latter. This enables us to determine the low-energy sticking coefficient of dielectric materials using dusty plasma.

[1] F.X.Bronold et al., Plasma Phys. Cont. Fusion **59** (2017) 014011, https://iopscience.iop.org/article/10.1088/0741-3335/59/1/014011

P 12.21 Wed 17:30 HSZ EG

Characterization of low-pressure plasmas in highly porous and lightweight aeromaterials — •Karin Hansen[1], Lena M. Saure[2], Rainer Adelung[2], and Franko Greiner[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Institute for Materials Science, Kiel University, Kiel, Germany

Plasma catalysis is a research field of growing interest due to the ongoing challenges in environmental protection. For the understanding of plasma catalysis, the interaction between the plasma and the catalyst surface plays an important role. Highly porous materials are used to provide a large surface area for a catalytic reaction processes. As the interplay of a plasma with porous material is not well studied, but crucial for further research, we investigate aeromaterials, micron-sized frameworks with nano-sized walls, in low-pressure plasmas. Highly porous ($>99.9\,\%$) and lightweight ($<2\,\mathrm{mg\,cm^{-3}}$) aeromaterials are developed in the group of R. Adelung at Kiel University and can be generated from different materials and with different porosity and conductivity.

In this work we explore the interaction of aeromaterials with low-pressure argon plasmas. To this end, a radio-frequency argon plasma is ignited in cylindrical cavities in aeromaterial cylinders. The impact of the aeromaterial wall interfaces on the plasma is studied with optical emission spectroscopy (OES) and electrostatic probes.

P 12.22 Wed 17:30 HSZ EG

Effect of magnetic islands on fast ion confinement in toroidal devices — •David Kulla[1], Samuel Lazerson[2], Athina Kappatou[1], Robert Wolf[2], and Hartmut Zohm[1] — [1]MPI für Plasmaphysik, Garching — [2]MPI für Plasmaphysik, Greifswald

Fast ion transport and confinement is an important area of fusion research: the fast ions have to heat the thermal plasma collisionally to reach self-sustaining conditions, and must not be lost e.g. to the vessel wall beforehand. Tokamaks are largely axisymmetric, but suffer from magnetic perturbations which can break this property and lead to increased fast ion transport. Stellarators are intrinsically three-dimensional in their magnetic configuration, but are generally less prone to transient perturbations in their field. In present experiments, one of the main methods of generating fast ions is neutral beam injection (NBI). Magnetic islands arise from helical perturbations of the background magnetic field, either internally from the plasma or externally from magnetic coils.

BEAMS3D is a Monte Carlo code that simulates NBI deposition and collisional slowing down in stellarator and also tokamak plasmas. We present results of verification against NUBEAM as well as validation against experimental data at the ASDEX Upgrade tokamak using fast-ion D-alpha light (FIDA). The results show good agreement between the codes and to experimental data both in on- and off-axis NBI heating phases, demonstrating the capability of BEAMS3D. Additionally, first results comparing simulations and experimental data of plasmas with internal islands are presented.

P 12.23 Wed 17:30 HSZ EG

Towards non-linear hybrid simulations of the interaction between energetic particles and the plasma in realistic tokamak geometry — •Felix Antlitz, Xin Wang, and Matthias Hoelzl — Max Planck Institute for Plasma Physics, Garching b. M., Germany

Future burning plasma experiments will feature a high supra-thermal particle pressure which strongly interact with magneto-hydrodynamic instabilities. To describe these dynamics accurately in simulations, realistic tokamak geometry, the self-consistent evolution of the plasma equilibrium, and a full-f treatment of the energetic particle population are needed. This contribution describes developments towards this goal based on the non-linear MHD code JOREK, in which a hybrid mode for energetic particles had recently been introduced based on a pressure coupling and tested linearly. The non-linear evolution of fishbone instabilities is foreseen as one of the first applications.

P 12.24 Wed 17:30 HSZ EG

Thermal equilibrium for non-neutral plasma in a magnetic dipole trap — •Patrick Steinbrunner[1], Matthew R. Stoneking[2], Thomas M. O'Neil[3], and Daniel H. E. Dubin[3] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]Lawrence University, Appleton, USA — [3]University of California San Diego, La Jolla, USA

The confinement of a non-neutral plasma in a thermal equilibrium state is known to be possible in the uniform magnetic field of a Penning-Malmberg trap. We generalize the theory of these states to include inhomogeneous magnetic dipole fields. We present computational results for local thermal equilibria along magnetic field lines as well as global thermal equilibria and there respective zero-temperature limits. The distribution function of a global thermal equilibrium state is obtained by maximizing the plasma entropy subject to fixed values for the total number of particles, total energy and total canonical angular momentum. If a non-neutral plasma arrives in this state, there is no conceptual limit on the confinement time. Such a configuration also confines a quasi neutral plasma for a finite amount of time, making it an attractive candidate for the creation of an electron-positron pair plasma as planned by the APEX collaboration.

P 12.25 Wed 17:30 HSZ EG

Influence of Radial Electric Field and Ideal Ballooning Stability on the Pedestal Width — •Lidija Radovanovic[1], Elisabeth Wolfrum[2], Mike Dunne[2], Marco Cavedon[3], Georg Harrer[1], Friedrich Aumayr[1], and ASDEX Upgrade Team[4] — [1]Institute of Applied Physics, TU Wien, 1040 Vienna, Austria — [2]Max Planck Institute for Plasma Physics, 85748 Garching, Germany — [3]Universit'a di Milano-Bicocca, 20126 Milano, Italy — [4]see author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006

Understanding the physical processes which govern the pedestal is crucial for reliable prediction and control of the plasma conditions and for its stability. The first experimental method investigates if the ideal ballooning modes at the pedestal top could cause additional transport and limit the pedestal width. A variation in the plasma stability is achieved by modifying the shape of the plasma. Increasing the triangularity of the plasma widens the electron pressure pedestal at a fixed gradient, which correlates with the minimum ballooning stability. The second method assumes that the turbulence in the plasma edge is suppressed due to the presence of a critical shear flow originating from radial electric field gradients. The radial electric field is varied by changing the density in discharges which use different heating systems to achieve the same total power, but which apply a different amount of torque to the plasma. It is shown that the electron density changes with shaping and the ion temperature with torque of heating method. Therefore it seems as if there is no clear actuator for the pedestal width, but each component is influenced individually by different physical processes.

P 12.26 Wed 17:30 HSZ EG

Causal coupling between small-scale fluctuations and zonal flows at the stellarator TJ-K — •Nicolas Dumérat and Mirko Ramisch — IGVP, University of Stuttgart, Germany

Convergent cross mapping (CCM) is a causality inference technique used to identify causal links and directions of influence between variables. In this work, Langmuir probe measurements of plasma potential and density fluctuations across TJ-K's whole poloidal cross section are used as input for the CCM to map causal links between turbulent phenomena across distant flux surfaces.

Thus, zonal potential (ZP) structures are found to be causally related to density fluctuations in the core, which could reflect equilibrium density modulation via transport regulation by ZP through the shearing of drift-wave structures. Causal coupling between plasma potential and ZP fluctuations has been found to exhibit a strong bi-directional relation around the region of both maximum Reynolds stress and turbulent particle transport. Moreover, ZP is found to be caused by small-scale density and potential fluctuations with density dominating over potential. This is in line with vortex tilting and subsequent zonal flow drive in consequence of strong density-potential coupling drift-wave turbulence. The expected predator-and-prey relationship between background turbulent structures and zonal flows is unveiled with CCM and further analysis concerning its poloidal locality is under investigation.

P 12.27 Wed 17:30 HSZ EG

Divertor spectroscopy during Detachment in Wendelstein 7-X — •Frederik Henke, Maciej Krychowiak, Ralf König, Felix Reimold, Erik Flom, and Dorothea Gradic — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

Detachment is a mandatory regime for running long discharges with high power in W7-X in order to not reach the power load material limits of the walls. As a future stellarator reactor will run steady state, the detachment regime has to be investigated. In this work, the mainly used diagnostic system is divertor spectroscopy. Various important aspects during this regime can be assessed using different spectroscopic methods. One challenging aspect is the density build up in detachment as high pressures are needed to have good impurity and density control via pumping. To measure this in the SOL, the Stark broadening of Balmer lines is analysed. Another important aspect is the composition of the SOL plasma. Radiation of a large fraction of the input power is necessary to enter the detachment regime. For reaching these radiation levels, hydrogens radiation capabilities are insufficient. Therefore, the intrinsic impurity carbon or seeded impurities nitrogen, neon or argon are needed. As carbon is no reactor relevant wall material, it is crucial to understand the behaviour of the seeded impurities. Only very low concentrations of impurities can be tolarated in the core plasma of future reactor because of fuel dilution and radiation, while they are needed at the edge. This aspect is investigated via line ratio divertor spectroscopy combined with CXRS in the core.

P 12.28 Wed 17:30 HSZ EG

Measurement and Modeling of radiation losses in the stellarator TJ-K — •Izel Gediz and Alf Köhn-Seemann — IGVP, University of Stuttgart, Germany

In the stellarator TJ-K cold plasmas of up to 20 eV are routinely produced. An 8-channel gold-foil bolometer is used to observe the radiation emitted by the plasma. Following the principle of a "camera obscura" the 8 channels observe the plasma through a small slit, allowing for reconstruction of the spatial profile of the emitted radiation. In this manner line integrated power profiles can be recorded, giving information about the absolute numbers of radiated power as well as the relative spatial distribution of the radiation. This diagnostic was recently reestablished and newly calibrated to aid parameter studies, including plasma density and temperature measurements. Line radiation is the major contributor to the radiation losses of typical plasmas in TJ-K. Information about the absolute loss term due to radiation will give further insights in the efficiency of confined plasmas as well as increase the accuracy with which other loss-terms (e.g. diffusion terms) in energy- and particle-balance equations can be estimated. Furthermore the spatial radiation profiles can reveal interesting parameter regimes where e.g. fast electrons in the plasmas edge regions could be observed. The radiation profiles are also being calculated and compared with the measurements, enabling adjustments of the model used to estimate the radiative loss term so far.

P 12.29 Wed 17:30 HSZ EG

Machine Learning Applications in Control at ASDEX Upgrade — •Johannes Illerhaus[1,2], Wolfgang Treutterer[1], Alexander Bock[1], Rainer Fischer[1], Paul Heinrich[1], Frank Jenko[1,2], Ondrej Kudlacek[1], Gergely Papp[1], Tobias Peherstorfer[1,4], Bernhard Sieglin[1], Udo von Toussaint[1,5], Hartmut Zohm[1,3], and the ASDEX Upgrade Team[6] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]Technische Universität München, Garching, Germany — [3]Ludwig Maximilian Universität, Munich, Germany — [4]Technische Universität Wien, Vienna, Austria — [5]Technische Universität Graz, Graz, Austria — [6]see the author list of U. Stroth et al. 2022 *Nucl. Fusion* 62 042006

Plasma control is essential for the operation of fusion devices. The individual control tasks depend on high-dimensional and possibly noisy input data and typically have a latency requirement of milliseconds to be real-time capable. Machine learning (ML) models are well suited for this application. While they are often computationally expensive to train, they generally have a cheap, low-latency inference process. Additionally, deep learning models have been shown to be capable of extracting complex hidden interactions in high-dimensional, noisy data. This contribution will illustrate two ML applications in plasma control: real time capable approximations of high-fidelity offline models for kinetic profiles, and deep-learning-based augmentations to the accuracy of the pellet fragment analysis used in the development of the shattered pellet injection disruption mitigation system tested on ASDEX Upgrade for use in ITER.

P 12.30 Wed 17:30 HSZ EG

Non-linear free boundary simulations of resonant magnetic perturbations in ASDEX Upgrade — •Verena Mitterauer[1], Matthias Hoelzl[1], Matthias Willensdorfer[1], and ASDEX Upgrade Team[2] — [1]Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching - Germany — [2]See author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006

Resonant Magnetic Perturbations (RMPs) are used routinely in tokamaks to control type-I Edge Localized Modes (ELMs). To improve the understanding of the effect of the helical magnetic field perturbations, numerical simulations of their penetration into the plasma are carried out using the free boundary non-linear MHD code JOREK-STARWALL. The use of free boundary conditions allows a self-consistent development of the plasma response within the complete computational domain.

Several aspects of RMP physics are investigated in simulations based on ASDEX Upgrade discharges with fully realistic plasma parameters and profiles. The comparison of the field line corrugation to experimental measurements shows that a valid representation of the plasma response is achieved. In subsequent simulations, the transition from ELM mitigation to suppression is shown, which allows the investigation of hypotheses concerning RMP-ELM suppression mechanisms, including the role of magnetic island positions relative to the pedestal, mode coupling and the impact of profile evolution on plasma stability. An extension of the fluid model to kinetic effects is on its way, which will allow the inclusion of the neoclassical toroidal viscosity.

P 12.31 Wed 17:30 HSZ EG

Enabling GENE for Exascale Computing via Modern Data Science — •Luciana Tanzarella[1], Tilman Dannert[2], Tobias Görler[1], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, Garching — [2]Max Planck Computing and Data Facility, Garching

The GENE (Gyrokinetic Electromagnetic Numerical Experiment) code represents the state-of-the-art in turbulence simulation in plasma physics, based on the Eulerian approach. Since these codes solve differential equations in 5 or 6 dimensions, over a very large parameter space, they require a very considerable computational power. Higher speed, lower communication and energy costs are all benefits of lower precision arithmetic, but the outputs must be accurately assessed. GENE allows for either single or double precision computations. The national DaREXA project's specific objective is to develop methods and architectures that will decrease the amount of data required for fusion research. The first steps in this direction, in particular, entail the creation and application of lower precision methods in selected operations performed by GENE. The precision must be scaled using existing libraries in addition to assessing how it impacts calculations as not every hardware supports arbitrary*precision. To ascertain how much the discretization order influences the outputs on grids, this must be done on each of GENE's several sections. The operation will be done on the stencil part first. In order to accurately evaluate the gain from implementing this reduced precision, an error model for the estimation of stencil and moments must be written.

P 12.32 Wed 17:30 HSZ EG

Enabling GENE for Exascale Computing via Modern Data Science — •Luciana Tanzarella[1], Tilman Dannert[2], Tobias Görler[1], and Frank Jenko[1] — [1]Max Planck Institute for Plasma Physics, Garching — [2]Max Planck Computing and Data Facility, Garching

Theoretical plasma turbulence studies are typically based on numerical solutions of integro-differential equations in 5 or 6 dimensions over a very large parameter space. So the required computational power is huge. Higher speed, lower communication and energy costs are all benefits of lower precision arithmetic, but the outputs must be accurately assessed. Particular focus is put on the world-leading gyrokinetic plasma turbulence code GENE, based on the Eulerian approach. GENE allows for either single or double precision computations.The national DaREXA-F project's specific objective is to develop methods to reduce the amount of data for transfer operations and leverage the power of reduced precision arithmetics on modern architectures. The first steps in this direction entail the creation and application of lower precision methods in selected operations performed by GENE. The precision must be scaled using existing libraries in addition to assessing how it impacts calculations as not every hardware supports arbitrary precision. To ascertain how much the discretization order influences the outputs on grids, this must be done on each of GENE's several sections. The operation will be done on the stencil part first. In order to accurately evaluate the impact of implementing this part with reduced precision, a respective error model has to be developed.

P 12.33 Wed 17:30 HSZ EG

Modeling of diagnostics for radiated power studies in Wendelstein 7-X — •G. Partesotti[1], F. Reimold[1], A. Demby[2], G. Wurden[3], and D. Zhang[1] — [1]IPP, HGW, DE — [2]UW-Madison, WI, US — [3]LANL, NM, US

In the field of magnetically confined fusion plasmas, stellarators like Wendelstein 7-X promise a more stable, steady-state operation, at the cost of increased, three-dimensional complexity of the magnetic field geometry. One of the many implications is the asymmetric distribution of impurities, which in turn causes radiative losses in the plasma to follow an inherently 3-D asymmetric pattern [1,2].

Given that radiation is a primary power dissipation mechanism, reliably estimating and predicting these patterns is crucial to accurately control the heat load on the divertor targets, so as to mitigate erosion and avoid exceeding material limits. For this purpose, it is therefore necessary to develop adequate 3-D signal post-processing techniques and diagnostic tools.

This contribution describes how the response of infra-red and resistive foil bolometer cameras was modeled with ray tracing [3], and how the so-obtained synthetic measurements can be combined to improve radiation tomography in W7-X. First, a set of emc3-calculated radiation patterns is studied to assess the 3-D aspects of the radiation distribution. Then, Gaussian Process Tomography is applied, combining physical and experimental constraints from multiple diagnostics and a newly designed Compact Bolometer Camera [4].

[1] Braun 2010, [2] Zhang 2021, [3] Carr 2018, [4] Moser 2020

P 12.34 Wed 17:30 HSZ EG

Overview of the neutral gas pressures in Wendelstein 7-X under boronized wall conditions — •Victoria Haak, Sergey Bozhenkov, Yuhe Feng, Amit Kharwandikar, Thierry Kremeyer, Dirk Naujoks, Valeria Perseo, Georg Schlisio, and Uwe Wenzel — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Gas exhaust is a key requirement for density control in a fusion device and, apart from the pumping speed and the subdivertor geometry, strongly dependent on the neutral gas pressure in the subdivertor and in front of the pumps. 13 neutral gas pressure gauges measured the neutral gas pressure in different locations in the plasma vessel of the stellarator Wendelstein 7-X during the first test divertor campaign, allowing for a detailed analysis of the neutral gas pressures, the compression ratios and the particle exhaust rates via the turbomolecular pumps in the different magnetic field configurations. Neutral gas pressures on the order of few 10^-4 mbar were measured in the subdivertor region, while the highest neutral gas pressure of 1.75*10^-3 mbar was obtained in the so-called high iota configuration featuring 4 edge magnetic islands per cross section. While measurements are only available in specific locations of the subdivertor, finite element simulations provide a detailed picture of the pressure distribution in the subdivertor volume.

P 12.35 Wed 17:30 HSZ EG

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

One of the challenges in understanding the energy and particle transport processes in the core plasma of a magnetic confinement fusion device is to quantify how they are affected by turbulent dynamics. This work considers a multiscale approach to modelling this problem, where the numerical solution is obtained for coupled models describing processes on different spatial and temporal scales. Furthermore, we investigate epistemic and aleatoric uncertainties in the profiles of the quantities transported in this model. This work proposes an application of a surrogate modelling technique to reduce the computational cost of resolving a quasi-steady state solution on the microscale when it is sufficient to capture only statistics of the turbulent dynamics. We study a Multiscale Fusion Workflow that utilizes turbulent energy and particle fluxes computed with a gyrofluid turbulence code GEM in flux tube approximation to calculate the transport coefficients for core transport code ETS. In this work, a data-driven probabilistic surrogate model based on Gaussian Process Regression is used to infer flux values computed by a turbulence code for given core profiles and to calculate related uncertainties. We use the VECMA/SEAVEA toolkit to perform uncertainty quantification as well as to train, test, and utilize surrogate models.

P 12.36 Wed 17:30 HSZ EG

Self-consistent neutral gas description in the edge turbulence fluid code GRILLIX — •Konrad Eder, Andreas Stegmeir, Wladimir Zholobenko, and Frank Jenko — Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany

The edge turbulence fluid code GRILLIX employs a diffusive neutral gas model to describe plasma-neutrals interactions arising from ionization, recombination, and charge exchange processes [1]. This inclusion of neutral gas physics has been found to significantly improve the agreement of simulated plasma profiles with experiment data [1,2,3].

Presently, the model requires prescribing the neutrals density at the divertor, introducing a new free parameter to the code. As we move toward simulations of detached plasmas, we seek to alter this boundary condition in order to self-consistently describe the recycling fluxes at the targets. For this purpose, a diagnostics framework has been developed to verify the implementation of recycling boundary conditions and assess particle conservation properties of the code.

[1] W. Zholobenko et al., 2021 Nucl. Fusion, 61 116015.
[2] D.S. Oliveira and T.Body et. al., 2021 Nucl. Fusion 62 096001.
[3] K. Eder, 2022 Technical University of Munich, Master thesis.

P 12.37 Wed 17:30 HSZ EG

Simulation of electromagnetic turbulence in the stellarator W7-X — •Yann Narbutt, Aleksey Mischchenko, Alessandro Zocco, and Per Helander — Max Planck Institute for Plasma Physics, Wendelsteinstraße 1, 17489 Greifswald, Germany

Abstract. Fusion plasmas need high $\beta = \langle p \rangle / (B^2/2\mu_0)$, i.e. the ratio of plasma pressure to magnetic pressure. Going from low to high β first weakens ion-temperature-gradient mode activity and then causes strong kinetic-ballooning-mode (KBM) activity [1], with the latter being inherently electromagnetic. This can lead to particle and energy fluxes [2] which degrade plasma confinement. It is therefore of great importance to understand KBM turbulence for attaining high-performance plasmas. This poster presents first results of linear and non-linear simulations of KBM activity in the geometry of the stellarator Wendelstein 7-X using the global gyrokinetic code Euterpe [3].

References

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P 12.38 Wed 17:30 HSZ EG

Structure-preserving hybrid code, STRUPHY: energy-conserving hybrid MHD-driftkinetic models — •Byung Kyu Na[1,2], Stefan Possanner[1], Florian Holderied[1], and Yingzhe Li[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technical University of Munich, Garching, Germany

STRUPHY (STRUcture-Preserving HYbrid codes) is a Python package for the simulation of energetic particles (EPs) in plasma. The package features a collection of PDE solvers for hybrid fluid-kinetic systems in curved three-dimensional spaces where the bulk plasma is treated as a fluid and the EPs are described kinetically (Particle-In-Cell method). The discretization is based on the GEMPIC framework. We will introduce energy-conserving hybrid MHD-driftkinetic models which were newly implemented in STRUPHY. Existing hybrid MHD-kinetic models often suffer from not conserving the total energy, especially when reduced kinetic models are used to describe EPs such as driftkinetic or gyrokinetic. However, this property was recently recovered by adding additional terms derived from variational principles. The investigation of the conservation laws on the discrete level will be considered with some simulation results.

P 12.39 Wed 17:30 HSZ EG

Modelling the effects of geometry modifications on the divertor heat loads of W7-X — •Amit Kharwandikar, Dirk Naujoks, Felix Reimold, Ralf Schneider, Thomas Sunn Pedersen, and The W7X Team — Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany

Wendelstein 7-X (W7-X) is an advanced stellarator device operated in Greifswald, Germany, to provide the proof of principle that the stellarator concept can meet the requirements of a future fusion reactor. It employs the island divertor concept to handle the heat and particle fluxes. In the recent experimental campaign OP1.2, unacceptably high heat loads limited the operation of the device. This immediate concern and the need to investigate a subsequent transition to fusion reactor relevant material (e.g. tungsten) for plasma facing components (PFCs) motivate the need for an improved divertor design. This poster discusses the investigation of such an optimized divertor via modelling. The simplified heat transport code, EMC3-Lite, is used as a fast tool to assess different design modifications of the current high-heat-flux (HHF) divertor. Moreover, using the functionalities of the code, a further reduced model for heat load calculations primarily depending on the inclination of magnetic field lines on the plasma-facing surface (PFS) and their connection lengths is derived. This new model introduces the possibility to gain insights into the main parameters determining heat loads and add more physics effects (e.g. radiation loss) in an attempt to fit with experiments. Finally, an iterative scheme for finding an optimum PFS is proposed.

P 12.40 Wed 17:30 HSZ EG

Characterisation of edge-SOL turbulence with `GRILLIX` in single null and advanced divertor configurations — •Jan Pfennig, Wladimir Zholobenko, Andreas Stegmeir, and Frank Jenko — Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching bei München, Germany

Turbulent transport across the magnetic field in magnetic confinement fusion devices, especially in the plasma edge and scrape-off layer (SOL), where steep gradients are observed, is of key interest because of two main reasons:

(i): It has a severe impact on the heat exhaust and hence on the energy confinement of the device

(ii): It is also responsible for the exhaust of helium ashes produced by the fusion reaction

Turbulence phenomena remain difficult to analyze experimentally and are not fully captured by transport codes due to non-local drive of turbulence as well as intermittent, ballistic transport of filaments (blobs) into the SOL. Hence, high-fidelity global turbulence simulations in realistic diverted geometries represent an important tool in quantitative predictions of tokamak plasma turbulence. Here we present in-depth analysis of global turbulence simulations performed with the `GRILLIX` code, which implements the two-fluid Braginskii equations in the flux-coordinate indepented (FCI) approach. Thus, abirtrarily complex magnetic geometries can be investigated.

P 12.41 Wed 17:30 HSZ EG

Conceptualization of an EM-upgrade for the gyrokinetic full-f code picls — •Annika Stier and Alberto Bottino — IPP, Garching, Germany

The gyrokinetic particle-in-cell code picls is a full-f finite element tool to simulate turbulence in the tokamak scrape-off layer. Up until now however, picls is a purely electrostatic code with a constant background magnetic field. In order to adequately model the phenomena of the scrape-off layer, taking into account electromagnetic effects is a necessity. To this end, the contribution at hand identifies due changes in the theoretical foundation of picls and proposes suitable modifications in its field solver and particle pusher stages.

P 12.42 Wed 17:30 HSZ EG

Hybrid gyrokinetic simulations for weakly magnetized plasmas — •Sreenivasa chary Thatikonda, Felipe nathan De Oliveira lopes, Aleks Mustonen, Daniel Told, and Frank Jenko — Max planck institute for plasma physics, Garching, Germany

We aim to study instabilities, turbulence and reconnection phenomenon in weakly magnetized plasmas. Such conditions may found in natural plasmas such as the solar wind, but also in laboratory applications, e.g. in the edge of fusion plasmas. Due to steep gradients in the edge of fusion plasmas and high frequencies in space plasmas, the ordering assumptions of gyrokinetic theory (like low frequency or moderate gradients) may be challenged, particularly for ions. To overcome these limitations, the group derived equations for a hybrid model that includes fully kinetic physics for the ions, but gyrokinetic physics for the electrons. Thereby, only the slower ion gyration needs to be followed, while still benefitting from a faster treatment of the electrons and this approch also saves computation costs. The numerical implementation of the hybrid model for electrostatic version has been implemented into the existing simulation code ssV, ssV was developed initially at the department of Theoretical Physics I at RUB, Bochum. Semi-Lagrangian schemes (e.g. the PFC scheme) are employed in ssV. This approach tracks down characteristics from the mesh point backwards in time to get the new value of flutter. Ongoing work on ssV involves the addition of electromagnetic capabilities, which will enable application to space and astrophysical plasmas.

P 12.43 Wed 17:30 HSZ EG

Interaction of relativistic electrons with MHD activity during disruptions — •Hannes Bergstroem, Konsta Särkimäki, and Matthias Hoelzl — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching b.~M., Germany

In spite of all the promise that fusion energy holds, there are several obstacles that one must overcome before commercially viable fusion reactors can be realized. One issue that looks to be ever more prominent in future tokamak reactor designs such as ITER is the type of operational failure known as disruptions, triggered by a sudden loss of plasma confinement. During these off-normal events it is possible for electrons to be accelerated towards relativistic velocities. These highly energetic particles could then accumulate and strike the wall, causing sub-surface melting which is difficult to repair. As such, disruption events could potentially put reactors out of commission for extended periods of time, which cannot be tolerated. In order to fully understand the evolution and consequences of disruptions it is vital that the dynamics of the relativistic electrons are studied in detail, which includes aspects such as how they are generated, to what extent they interact with the bulk plasma, what the transport looks like and where they eventually strike the wall. This work aims to answer these questions by extending the non-linear MHD code JOREK to kinetic particle-in-cell treatment for the phase-space evolution of relativistic electrons. In addition we use ray-tracing methods to determine where the particles intersect a 3D wall, allowing us to estimate localized heat loads.

P 12.44 Wed 17:30 HSZ EG

Tungsten-copper composites based on additively manufactured tungsten preforms for high heat flux applications — •Robert Lürbke[1,2], Alexander von Müller[2], Alexander Feichtmayer[1,2], Thomas Bareth[3], Armin Rieser[3], Georg Schlick[3], and Rudolf Neu[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Deutschland — [2]Technische Universität München, 85748 Garching, Deutschland — [3]Fraunhofer IGCV, 86159 Augsburg, Deutschland

In future fusion reactors, plasma-facing components (PFCs) have to sustain high heat fluxes and neutron irradiation. This creates the need for advanced materials that can withstand such an environment. Tungsten (W) is considered the preferred plasma-facing material for use in fusion devices due to its low hydrogen retention, high melting point as well as its low physical sputtering yield. Against this background, additive manufacturing (AM) of W can be considered a useful tool to provide tailored W structures for reinforcing copper (Cu) based heat sinks due to a tailored thermomechanical behaviour. The present contribution will illustrate the possibilities of tailoring macroscopic properties of W-Cu PFC materials. In this context, basic observations like rules of mixture for composite materials will be discussed. Based on that, it will be shown how the exploitation of complex composite structures can open up new possibilities for material and component design.

P 12.45 Wed 17:30 HSZ EG

Analysis of Nonlinear Dynamics of Shear Alfvén Waves Driven by Energetic Trapped Particles — •Farah Atour — IPP Garching

In controlled fusion devices, shear-Alfven waves can be driven unstable by resonant interactions with energetic alpha particles. This results in many issues regarding the confinement of the particles and therefore can prevent the thermalization of the plasma core or increase the thermal load on the material's wall. The source of these particles is either the nuclear fusion reaction produced by the background plasma and/or external heating systems. Due to the importance of these issues, there exists an extensive literature on this topic. These studies mostly focus on the nonlinear dynamics of passing particles since they have more significant impacts. However, the nonlinear dynamics of shear-Alfven waves driven by energetic trapped particles deserves also depth analysis and will be the focus of this study. The overall goal of this work is to investigate on a deeper level the fundamental physical processes regarding both the linear stability properties and the nonlinear saturation mechanisms for single and multi modes. For this reason, to keep the context of the dynamical study simplified, these phenomena are investigated by HMGC code, which has a simple circular geometry and is based on the hybrid reduced MHD gyrokinetic model.