P 5: Poster Session- Helmholtz Graduate School for Plasma Physics

Time: Monday 16:30–19:00 Location: Empore Lichthof

P 5.1 Mon 16:30 Empore Lichthof

Experimental investigation of interactions between ICRF wave fields and SOL plasma turbulence with B-dot, Langmuir, and MHD probes. — •Guillermo Suarez Lopez[1], Roman Ochoukov[1], Jean-Marie Noterdaeme[1,3], Volodymyr Bobkov[1], Helmut Faugel[1], Helmut Fünfgelder[1], and Hartmut Zohm[1,2] — [1]Max-Planck-Institut fürPlasmaphysik, 85748 Garching, Germany. — [2]Ludwig Maximilians University of Munich, Germany — [3]Ghent University, Belgium.

EM waves at the ion cyclotron range of frequencies (ICRF) are used successfully to heat magnetized fusion plasmas. In order to ensure good ICRF wave coupling, ICRF antennas must be placed close to the scrape-off layer (SOL) plasma. A series of toroidally distributed B-dot probes was installed on the LFS of the ASDEX Upgrade Tokamak in order to study ICRF wave fields (10-50 MHz). Initial results in ICRF heated H-mode plasmas, reveal a strong turbulent component which is thought to be due to plasma filaments. It is unclear, how much of this turbulent signal is generated by filaments in the vicinity of the probes, i.e. local turbulence, in comparison with turbulence generated at the ICRF active antennas which are further apart and would point to global turbulence. In order to decouple these spatial scales, several sets of Langmuir and MHD probes will be used. Langmuir probes detect local plasma density changes due to Edge Localized Modes (ELMs) and by magnetic field mapping, their signal can be correlated to the B-dot probes. On the other hand, MHD probes quantify global magnetic instabilities and will be used to support the analysis.

P 5.2 Mon 16:30 Empore Lichthof

Construction and characterization of a new high current ion source for research of impact of hydrogen irradiation on wall materials for use in nuclear fusion reactors — •Rodrigo Arredondo Parra[1,2], Martin Oberkofler[1], Klaus Schmid[1], Arno Weghorn[1], and Rudolf Neu[1,2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Garching, Germany

The HSQ (HochStromQuelle) is a high current DuoPIGatron type ion source used for research in surface properties of wall materials for nuclear fusion reactors. The existing HSQ-I will be replaced by the conceptually identical HSQ-II, currently under construction. Varying the acceleration potential and optimizing gas inflow and beam focusing grid voltage, ion currents before the deflecting magnet between 10 and 875 μA were reached for acceleration voltages of 0.7 to 8 kV. The ion beam footprint will be characterized, and ion optics will be installed before and after the deflecting magnet, capable of bending 10 keV Ar. A monoenergetic beam of a single species (e.g. D_3^+) will finally be used for irradiation of samples in the separate implantation chamber at a base pressure of 10^{-8} mbar. The energy of the impinging particles ranges from 200 eV/D to several keV/D. Fluxes of 10^{15} D/cm^2/s to the target are expected. The temperature of the sample is varied via electron impact heating and the sample weight can be assessed in situ by means of a magnetic suspension balance.

P 5.3 Mon 16:30 Empore Lichthof

Kinetic simulation of parallel electron heat flux in scrape-off layer — •menglong zhao[1,2], alex chankin[1], and david coster[1] — [1]Max-Planck-Institut für Pasmaphysik, Boltzmannstraße 2, 85748 Garching bei München, Germany — [2]Technische Universität München, 80333 München, Germany

Parallel electron heat flux on open field lines is studied with the 1D2V kinetic Vlasov-Fokker-Planck (VFP) code KIPP [1-3]. In order to assess the importance of kinetic effects on the scrape-off layer heat transport in a systematic way, a series of self-similar cases with the stagnation point and one target, logical sheath condition, parabolic ion velocity profiles reaching ion sound speed at the target and 100% recycling of neutrals were run, from which the electron temperature profile and electron parallel heat flux are compared with those from classical fluid model. It shows that, for high collisional plasma parallel conductive electron heat flux is highly consistent with Spitzer-Harm theory[4]. With decreasing collisionality, it is deviating increasingly from the classical theory showing limited heat flux upstream and flux enhancement downstream due to non-local effect. In addition, electron heat transmission coefficient γe varies much with collisionality. Thermal force coefficient is studied as well. It shows consistency with deviation of heat flux, lower than 0.71 upstream and higher downstream for low collisional plasma, however consistent with classical value for high collisional plasma as expectation. Kinetic corrections to electron heat conduction coefficient, heat transmission coefficient and thermal force coefficient are needed for fluid model, which could be done with KIPP.

P 5.4 Mon 16:30 Empore Lichthof

Piezoelectric Valve for Massive Gas Injection in ASDEX Upgrade — •Mathias Dibon[1,2], Albrecht Herrmann[1], Klaus Mank[1], Vitus Mertens[1], Rudolf Neu[1,2], Gabriella Pautasso[1], and Bernhard Ploeckl[1] — [1]Max-Planck-Institute for Plasmaphysics, Boltzmannstr. 2, 85748 Garching, Germany — [2]Technical University Munich, Boltzmannstr. 15, 85748 Garching, Germany

A sudden loss of plasma temperature can cause a disruption, which poses a significant problem for current Tokamaks and future fusion devices. Hence, mitigating forces and thermal loads during disruptions is important for the integrity of the vessel and first wall components. Therefore, high speed gas valves are used to deliver a pulse of noble gas onto the plasma, which irradiates the thermal energy quickly, avoiding localized heat loads and mechanical stress due to induced currents. A new design for such a valve is currently under development. The valve plate is driven by two piezoelectric stack actuators. The stroke of the actuators (0.07 mm) is amplified by a monolithic titanium frame and reaches 2 mm. The frame also serves as spring to pre-load the actuators. In the idle state, it also presses the conical valve plate into the seal, closing the gas chamber (42 cm^3). The actuators accelerate the stem and the valve plate until it is fully opened after 2 ms. The orifice of the valve has a diameter of 14 mm. This allows a peak mass flow rate of the gas up to $8 * 10^4 \frac{Pa*m*}{s}$ after 1.8 ms and an average mass flow rate of $2 * 10^4 \frac{Pa*m*}{s}$ over the evacuation time of 10 ms. Therefore, one valve would be sufficient to deliver the required amount of gas to mitigate disruptions at ASDEX Upgrade.

P 5.5 Mon 16:30 Empore Lichthof

ICRF induced edge plasma convection in ASDEX Upgrade — •Wei Zhang[1,2,3], Yuehe Feng[1], Tilmann Lunt[1], Jean-Marie Noterdaeme[1,2], Jonathan Jacquot[1], Laurent Colas[4], David Coster[1], Roberto Bilato[1], Volodymyr Bobkov[1], Roman Ochoukov[1], and ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma physics, Garching/Greifswald, Germany — [2]University of Ghent, Ghent, Belgium — [3]Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, P. R. China — [4]CEA, IRFM, Saint-Paul-Lez-Durance, France

Ion Cyclotron Range of Frequency (ICRF) heating is one of the main auxiliary plasma heating methods in tokamaks. It relies on the fast wave to heat the plasma. However the slow wave can also be generated parasitically. The parallel electric field of the slow wave can induce large biased plasma potential through sheath rectification. The rapid variation of this rectified potential across the magnetic field can cause significant $E \times B$ convection in the Scrape-Off Layer (SOL). The ICRF induced convection can affect the SOL density, influence the ICRF power coupling and enhance the strength of plasma-wall interactions. To explore these physics, we will not only show the experimental evidences in ASDEX Upgrade, but also present the associated simulation results with the 3D edge plasma fluid code EMC3-Eirene. Further simulations via combination of EMC3-Eirene and a sheath code SSWICH in an iterative and quasi self-consistent way can give good predictions for future experiments.

P 5.6 Mon 16:30 Empore Lichthof

Deuterium accumulation in tungsten at high fluences — •Mikhail Zibrov[1,2], Martin Balden[1], Kirill Bystrov[2], Thomas Morgan[2], and Matej Matej[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, D-85748 Garching, Germany — [2]FOM Institute DIFFER, De Zaale 20, 5612 AJ Eindhoven, The Netherlands

The data on the deuterium (D) retention in tungsten (W) at high fluences ($\geq 10^{27}$ D/m^2) are scarce and the existing results are contradictory. Since retention in W is known to be flux–dependent, the laboratory experiments addressing this issue should be carried out in reactor–relevant conditions (high fluxes of low–energy ions).

In this work the samples made of polycrystalline W were exposed to D plasmas in the linear plasma generator Pilot–PSI at temperatures ranging from 360 K to 1140 K to fluences in the range of $0.3 - 8.7 \times 10^{27}$ D/m^2. It was observed that at exposure temperatures of 360 K and 580 K the D retention was only slightly dependent on the ion fluence. In addition, the presence of blister–like structures was found after the exposures, and their density and size distributions were also only weakly dependent on the fluence. In the case of exposure at 1140 K no surface modifications of the samples after plasma exposure were detected and the concentrations of retained D were very small. At all temperatures used the total amounts of retained D were smaller compared to those obtained by other researchers at lower ion flux densities, which indicates that the incident ion flux may play an important role in the total D retention in W.

P 5.7 Mon 16:30 Empore Lichthof

Deuterium permeation measurements on tungsten using ion-beam-based detection — •Stefan Kapser[1,2], Armin Manhard[1], and Udo von Toussaint[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany — [2]Physik-Department, Technische Universität München, James-Franck-Str. 1, 85748 Garching, Germany

Tungsten (W) is promising for the inner wall of a future fusion reactor, where it will be exposed to high fluxes of hydrogen (H) isotopes. Knowledge of their diffusion in W is important for safety and economic considerations, particularly concerning tritium. A common method to investigate H diffusion in metals are permeation experiments. Typically, gas loading and mass-spectrometric detection are used. Information about the diffusion can be gained from the temporal evolution of the permeation flux, whose magnitude is determined by the permeability (product of diffusivity and solubility). However, for low-permeability metals, the permeation flux can be unmeasurably small. For W this is the case near room temperature. We present a method that circumvents this problem. It is an improved version of experiments on nickel and stainless steel [1,2]. The W is exposed to deuterium (D) plasma on one side and the permeating D is accumulated in a getter on the other side. A cover prevents D gettering from the gas phase. The amount in the getter is analysed by the nuclear reaction D(^{3}He,p)^{4}He.

[1] W. Möller, B.M.U. Scherzer and R. Behrisch, Nucl. Instrum. Methods, 168 (1980) 289 [2] P. Børgesen, B.M.U. Scherzer and W. Möller, J. Appl. Phys., 57, 2733 (1985)

P 5.8 Mon 16:30 Empore Lichthof

Status of the new thermal He-beam diagnostic for electron density and temperature measurements in the scrape-off layer of ASDEX Upgrade — •Michael Griener[1,3], Elisabeth Wolfrum[1], Thomas Eich[1], Albrecht Herrmann[1], Volker Rohde[1], Oliver Schmitz[2], Ulrich Stroth[1,3], and the ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany — [2]Engineering Physics Department, University of Wisconsin-Madison, USA — [3]Physik Department E28, Technische Universität München, 85748 Garching, Germany

In a nuclear fusion device a significant fraction of power is exhausted across the last closed flux surface into the so-called "scrape-off layer". In order to study the transport dynamics to (a) the divertor via parallel heat flux and (b) to the wall via filaments, a diagnostic for the determination of n_e and T_e with high spatial and temporal resolution is required.

These data should be provided by the new thermal He-beam diagnostic, where helium is injected into the plasma by a piezo valve. The principle of this diagnostic is the measurement of line resolved emission intensities of the excited helium. The calculated line intensity ratios of two singlet lines combined with a collisional radiative model then lead to n_e values, whereas singlet-triplet ratios yield T_e values.

The principle of the He-diagnostic as well as emission profiles of several He I transitions measured during the campaign 2015/2016 will be shown. First calculated n_e and T_e profiles will be compared to data from the lithium beam and the Thomson scattering diagnostic.

P 5.9 Mon 16:30 Empore Lichthof

Mode number determination of ELM associated phenomena by improved phase fitting of magnetic pick-up coils — •Felician Mink[1,2], Elisabeth Wolfrum[1], Florian Laggner[1], László Horváth[3], Ulrich Stroth[1,2], and The ASDEX Upgrade Team[3] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany — [2]Physik Department, E28, TUM, 85748 Garching, Germany — [3]Budapest University, Pf 91, H-1521 Budapest, Hungary

Edge localized modes (ELMs) occur as repetitive bursts of magnetohydrodynamic (MHD) activity in high-confinement regimes of tokamak fusion plasmas. As ELMs lead to a sudden release of pedestal stored energy they might cause intolerable high heat fluxes onto the divertor target plates in future fusion devices like ITER. Therefore, it is necessary to get a better understanding of ELM triggering mechanism.

It has been reported from different tokamaks that during the inter-ELM phase mode-like MHD activities that might play an important role for the ELM onset can be observed with defined toroidal mode numbers.

Here the method of determining the toroidal mode numbers of such coherent fluctuations on ASDEX Upgrade from magnetic pick-up coils is reviewed. A significant improvement of the determination of the mode numbers is achieved by ELM-synchronization and consideration of intrinsic coil phases. First results for mode numbers of ASDEX Upgrade inter-ELM oscillations and their connection to kinetic profiles are given.

P 5.10 Mon 16:30 Empore Lichthof

Power loads in the limiter phase of Wendelstein 7-X — •Holger Niemann[1], Marcin Jakubowski[1], Thomas Sunn Pedersen[1], and Glen Wurden[2] — [1]Max-Planck-Institut für Plasmaphysik, Greifswald, Deutschland — [2]Los Alamos National Laboratory, Los Alamos, USA

Wendelstein 7-X (W7-X), an advanced stellarator with five-fold symmetry, will start its initial plasma operation phase(OP1.1) in December 2015. In OP1.1 the plasma-wall interaction is realized with 5 graphite limiters installed on the inboard side of the plasma vessel, which should efficiently intercept >99% of the convective plasma heat load at the plasma edge with the chosen magnetic configuration. Assuming an even distribution of power loads among all 5 limiters, discharges with 2 MW of ECRH heating power could be run for up to a second. Calculations shows typical three separate helical magnetic flux bundles of different connection length in the order of a few tens of meters. These form 3-D structure of magnetic footprints results in localized peaks in the limiter power deposition patterns. The heterogenous temperature distribution pattern will be investigated with two IR cameras. The heat flux density will be evaluated with the THEODOR code from evolution of the surface temperature data. Together with two sets of Langmuir probes in module 5 this provides enough data to resolve experimentally different channels of heat transport towards the limiter in OP1.1 plasmas. Additionally, the obtained data will be compared against the output of EMC3-Eirene calculations to identify the channels of energy transport at the plasma boundary in the first operation phase of W7-X.

P 5.11 Mon 16:30 Empore Lichthof

Development of Real Time System Imaging Software for the Protection of Plasma Facing Components(PFCs) in Wendelstein 7-X — Adnan Ali[1], •Marcin Jakubowski[1], Thomas Sunn Pedersen[1], Alexander Rodatos[1], and Henri Greuner[2] — [1]Max-Planck-Institute for Plasma Physics, Greifswald,Germany — [2]Max-Planck-Institute for Plasma Physics, Garching,Germany

One of the main aims of Wendelstein 7-X, an advanced stellarator in Greifswald, is the investigation of quasi-steady state operation of magnetic fusion devices, for which power exhaust is a very important issue. The predominant fraction of the energy lost from the confined plasma region will be removed by 10 so-called island divertors, which can sustain up to 10 MW/Sq-m. In order to protect the divertor elements from overheating and to monitor power deposition onto the divertor elements, 10 state-of-the-art infrared endoscopes will be installed at W7-X and software is under development for real-time analysis of automatic detection of the hot spots and other abnormal events. The pre-defined algorithms[2] designed for early detection of defects e.g. hotspots, surface layers and delaminations during the discharge are being implemented into the software acquiring the images from the infrared cameras and broadcast them to the main Discharge Control System(DCS). This allows for automatic control of the scenario of the discharge in order to assure safe operation of W7-X. The first online tests of the software will soon be performed at GLADIS in Garching.

P 5.12 Mon 16:30 Empore Lichthof

Numerical Study of the Connection Lengths for Various Magnetic Configurations in Wendelstein 7-X to Optimize the Heat Load on the Divertor — •Priyanjana Sinha, Hauke

Hölbe, and Thomas Sunn Pedersen — Max Planck Institute of Plasma Physics ,Wendelsteinstraße 1, 17491 Greifswald

Fusion has the potential to play an important role as a future energy resource. It has the capacity to produce large-scale clean energy. The two main confinement concepts are the tokamak and the stellarator. The W7-X machine is based on stellarator principle and is using special form of coils to achieve steady-state plasma confinement.

Divertors are used in tokamaks and stellarator to control the exhaust of waste gases and impurities from the machine . The divertor concept of W7-X is a so-called island divertor. The island chain isolates the confinement core from regions where the plasma-wall interaction takes place.

The area of the divertor that receives the main part of the heat loads, the so-called wetted area, increases with the distance along the magnetic field from the outboard midplane to the divertor target. The connection length is relatively short in tokamaks with conventional divertors. In the stellarator island divertor, the connection length can be varied significantly, which should allow for optimization of the wetted area. We present here a numerical study of the achievable connection lengths in various W7-X configurations and discuss the possibilities for running dedicated experiments to understand the physics of what sets the wetted area.

P 5.13 Mon 16:30 Empore Lichthof

Neutralization of positive ions at metallic and dielectric plasma walls — •Mathias Pamperin, Franz Xaver Bronold, and Holger Fehske — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

The main loss channel for positively charged ions in bounded low temperature plasmas is the recombination of ions with the wall. It is often driven by Auger processes and thus accompanied by electron emission. The emission efficiency depends on the electronic structure of the wall and the ion. It is expected to be high in cases where resonant charge transfer initially creates a metastable relay state which then Auger deexcites releasing thereby an electron. For helium ions hitting metallic walls this two-step process leads to robust secondary electron emission due to wall recombination. If however resonant charge transfer is blocked, as it may happen for dielectric walls, secondary electron emission due to ions is much smaller. Secondary electrons result then solely from impacting metastable species produced in the discharge volume. With an eye on tailoring electron emission from the wall, we studied theoretically–using a semi-empirical Anderson-Newns model and nonequilibrium Green function techniques–the interaction of inert gas ions with dielectric and metallic surfaces. Our results demonstrate the importance of metastable relay states and may thus help to design wall materials with custom-made electron emission properties.

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P 5.14 Mon 16:30 Empore Lichthof

A Monte-Carlo scheme for cross-polarization scattering of diffracting wave beams in random media. — •Lorenzo Guidi[1,2], Omar Maj[1], and Emanuele Poli[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Numerical Methods for Plasmaphysics (M16), Garching, Germany

Asymptotic methods are widely used in studying the evolution of high frequency waves in plasmas. In this framework singularities in the configuration space can arise, and a phase-space representation of the model is one of the possible ways to overcome such difficulties; the result is a description of waves in terms of the kinetic wave equation. Fluctuations of the medium and consequent scattering phenomena can be taken into account, allowing the analysis of problems which are considered extremely relevant in the prediction of wave beam performances for the next-generation tokamak machines. The WKBeam code provides a numerical solution of the kinetic wave equation in the phase-space, taking into account random density fluctuations by means of a statistic average and assuming that scattering between different modes, i.e. cross-polarization scattering, can be neglected. The idea of this work is to include cross-polarization scattering phenomena into the WKBeam code, allowing simulations of a wider class of experimental scenarios. In order to obtain this, the Monte-Carlo scheme implemented in WKBeam is extended, providing a description of random jumps of both the refractive index (a continuous process) and the wave mode (a discrete process), due to fluctuations of the medium.

P 5.15 Mon 16:30 Empore Lichthof

Low-Z impurity transport studies using CXRS at ASDEX Upgrade — •Cecilia Bruhn, Rachael McDermott, Ralph Dux, Clemente Angioni, Volodymyr Bobkov, Athina Kappatou, Alexander Lebschy, Thomas Pütterich, Eleonora Viezzer, and the ASDEX Upgrade Team — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, D-85748 Garching, Germany

Impurities in fusion plasmas arise from many sources including the erosion of material from plasma facing components and the intentional injection of impurities for control of the radiation losses. With the charge exchange recombination spectroscopy (CXRS) diagnostics at ASDEX Upgrade (AUG) the density profiles of low-Z impurity species can be measured with high spatial and temporal resolution and can, thus, be used to investigate the transport of these impurities. Previous work on this topic at AUG has focused primarily on steady state profiles, which deliver the ratio of the diffusive and convective transport coefficients. However, from the time response of the density profiles after applying an external perturbation (e.g. a fast impurity puff) the convective and diffusive components of the transport can be separately determined. The work presented here aims to achieve this by an approach that is better suited to the limited time resolution of the CXRS diagnostics; namely, a sinusoidal modulation of the boron densities invoked by modulating the power from the ion cyclotron resonance frequency (ICRF) antennas. We will present the first measurements of the boron density modulation as well as the machine and plasma parameter dependencies of the boron response to the ICRF power.

P 5.16 Mon 16:30 Empore Lichthof

Critical beta of kinetic ballooning modes in simple geometry — •Ksenia Aleynikova, Alessandro Zocco, and Per Helander — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

In a fusion reactor, high density and plasma temperature are necessary to achieve favorable reaction conditions. This requires high plasma betas (the ratio of kinetic to magnetic pressure). However, at high betas, electromagnetic micro-turbulence due to the kinetic ballooning mode (KBM) instability can arise and generate anomalous losses of heat and particles. It is known that fluid magnetohydrodynamic (MHD) ballooning modes become linearly unstable when beta reaches a certain critical value (threshold). The same is expected for their kinetic counterparts - KBMs. Numerical simulations show that the critical beta for KBMs instability can be either higher or lower than the corresponding critical beta for MHD ballooning modes. Such discrepancy has not yet been understood. We consider the KBM as the electromagnetic correction of the ion temperature gradient (ITG) driven instability. An electromagnetic theory of ITG modes was developed in [A. Zocco et. al. P.P.C.F., 57(8), 2015] and the critical beta for their electromagnetic stabilization was derived, but kinetic ballooning modes were completely suppressed by diamagnetic effects. In this work, we first derive a new beta ordering for the electromagnetic theory of ITGs that accommodates KBMs. Then, we derive a new analytical expression for the critical beta of KBMs and numerically verify our predictions with the gyrokinetic code GS2 [http://gs2.sourceforge.net]. Our theoretical results and numerical calculations are in a good agreement.

P 5.17 Mon 16:30 Empore Lichthof

Non-perturbative kinetic influences due to energetic particles on toroidicity-induced Alfvén eigenmodes — •Christoph Slaby, Axel Könies, and Ralf Kleiber — Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, Deutschland

The resonant interaction of shear Alfvén waves with energetic particles is investigated numerically in tokamak and stellarator geometry using a non-perturbative magnetohydrodynamic-kinetic (MHD-kinetic) hybrid approach in the large-aspect-ratio approximation. The focus lies on toroidicity-induced Alfvén eigenmodes (TAEs), which are most easily destabilized by a fast-particle population in fusion plasmas.

While the background plasma is treated within the framework of ideal-MHD theory, the drive of the fast particles, as well as Landau damping of the background plasma, is modelled using the drift-kinetic Vlasov equation. A fast numerical tool, STAE-K, suitable for parameter scans has been developed to solve the resulting eigenvalue problem using a Riccati shooting method.

Energetic particle modes (EPMs) are found when the pressure of the energetic particles becomes comparable to the pressure of the background plasma. It is shown that the presence of energetic particles substantially deforms the continuum such that the mode frequency can leave the toroidicity-induced continuum gap. Furthermore, effects of a finite parallel electric field and of finite gyro-radii of the bulk-plasma ions leading to the so-called radiative damping have been included. As these terms introduce higher-order derivatives to the model, they have the potential to substantially change the nature of the solution.

P 5.18 Mon 16:30 Empore Lichthof

Non-Maxwellian background effects in gyrokinetic simulations with GENE — •Alessandro Di Siena, Hauke Doerk, Tobias Görler, and Emanuele Poli — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

The interaction between fast alpha particles and core turbulence has been proven to be a central issue for a tokamak reactor. For instance, recent results predict a significant stabilization of electromagnetic turbulence in the presence of equivalent Maxwellian distributed fast ions. However, it's well known that to rigorously model fast particles, a non Maxwellian background distribution function is needed. With this aim, the gyrokinetic Vlasov and field equations in the gyrokinetic delta-f code GENE have been derived and implemented for a completely general background distribution function. First verfication studies will be shown, including linear electrostatic benchmarks for the ITG growth rates with GS2 and GKW using a slowing down distribution function for the alpha particles. Furthermore, low beta electromagnetic simulations are presented that are rarely - or not at all - found in the literature. These results are compared with those obtained using an equivalent Maxwellian for modelling the alpha particles.

P 5.19 Mon 16:30 Empore Lichthof

Interpretation of the Electron Cyclotron Emission of hot ASDEX Upgrade plasmas at optically thin frequencies — •Severin Sebastian Denk[1,2], Rainer Fischer[1], Emanuele Poli[1], Matthias Willensdorfer[1], Omar Maj[1], Jörg Stober[1], Ulrich Stroth[1,2], Wolfgang Suttrop[1], and The ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, D-85748 Garching, Germany — [2]Physik-Department E28, Technische Universität München, 85748 Garching, Germany

The electron cyclotron emission diagnostic (ECE) provides routinely electron temperature ($T_{\rm e}$) measurements. "Kinetic effects" (relativistic mass shift and Doppler shift) can cause the measured radiation temperatures ($T_{\rm rad}$) to differ from $T_{\rm e}$ at cold resonance position complicating the determination of $T_{\rm e}$ from the measured radiation temperature profile ($T_{\rm rad}$). For the interpretation of such ECE measurements an electron cyclotron forward model solving the radiation transport equation for given $T_{\rm e}$ and electron density profiles is in use in the framework of Integrated Data Analysis at ASDEX Upgrade. While the original model lead to improved $T_{\rm e}$ profiles near the plasma edge in moderately hot H-mode discharges, vacuum approximations in the model lead to inaccuracies given large $T_{\rm e}$. In hot plasmas "wave-plasma interaction", i.e. the dielectric effect of the background plasma onto the electron cyclotron emission, becomes important at optical thin measured frequencies. Additionally, given moderate electron densities and large $T_{\rm e}$, the refraction of the line of sight has to be considered for the interpretation of ECE measurements with low optical depth.

P 5.20 Mon 16:30 Empore Lichthof

Neutral Argon measurements in a high-power helicon discharge — •Nils Fahrenkamp, Birger Buttenschön, and Olaf Grulke — Max Planck Institute for Plasma Physics, 17489 Greifswald, Germany

The laser-induced-fluorescence (LIF) method is a widely used non-invasive technique to gain information about the velocity distribution, temperature and density of the plasma ions and the neutral gas. It has often been speculated that neutral gas pumping represents an important mechanism limiting the plasma density in high-power helicon discharges. Prometheus-A is an extremely high-power helicon discharge using multiple, spatially distributed helicon antennas to achieve rf power densities up to $P_{rf} \leq 100\,MW/m^{-3}$. The peak plasma density over the discharge shows a transient behavior and decreases with a typical time scale of $\approx 1\,ms$, which indicates the importance of the neutral gas inventory. LIF is used to measure the neutral gas density profile with high spatial resolution. The excitation vacuum-wavelength for the metastable argon atoms of $667.91nm$ is provided by a diode laser system and the fluorescence signal of $750.39nm$ is collected by an external pick-up optic, filtered and detected by a photomultiplier tube. Detailed measurements of the neutral pumping effect for various operation parameters are presented with special emphasis on its effect on the peak plasma density and compared with a zero dimensional reaction rate model developed for low temperature argon plasmas.

P 5.21 Mon 16:30 Empore Lichthof

Optimization of ECR wave polarization for improved heating efficiency — •Ihor Vakulchyk and Nikolai Marushchenko — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, D-17491 Greifswald, Germany

The propagation of electromagnetic waves in an inhomogeneous magnetized plasma is accompanied by continuous power pumping from the main wave mode (ordinary or extraordinary) to another one. When the mode purity has decreased noticeably, this leads to a deterioration of ECRH efficiency and changes of the deposition profile. The purpose of this work is to determine the initial parameters of the wave polarization providing a minimum of spurious modes and to estimate the theoretical limit of the wave-mode purity for ECRH in realistic 3D stellarator plasmas. A preliminary model for the evolution of the wave polarization and the wave-mode coupling is formulated and compared with simplified analytical 2D magnetic field model. A comparison with existing models is found to be satisfactory. The model is applied also to a typical 3D magnetic configuration of the W7-X stellarator. The final aim of the work is the implementation of the model in existing numerical tools for experimental modelling.

P 5.22 Mon 16:30 Empore Lichthof

Investigation of Cs dynamics in RF negative ion sources by means of numerical simulations and laser absorption spectroscopy. — •Alessandro Mimo, Christian Wimmer, Dirk Wünderlich, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, 85748 Garching

The Neutral Beam Injection systems at ITER are based on large and powerful RF sources for negative hydrogen and deuterium ions, in which the main mechanism of negative ion production is the conversion of atoms on low work function surfaces. In order to achieve a low work function of the conversion surface, caesium is evaporated into the source and its temporal and spatial dynamics, which is influenced by plasma parameters, can then affect the homogeneity and stability of the beam. Cesium redistribution is influenced by the plasma drift, due to the presence of the magnetic filter field in the source, which leads to a plasma asymmetry in the vertical direction. The Monte Carlo transport code CsFlow3D, which allows calculating caesium fluxes and coverage onto the source surfaces as well as caesium density along specific lines of sight, was used to investigate the effect of plasma asymmetry on cesium dynamics. The simulated caesium density is calculated for different plasma density profiles and can then be directly compared with the laser absorption spectroscopy experimental data obtained at the IPP prototype RF ion source.

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Stromtrieb durch Neutralteilchen-Injektion an ASDEX Upgrade — •David Rittich, Ursel Fantz, Christian Hopf, Benedikt Geiger, Francois Ryter, Das ASDEX Upgrade Team und Das EUROfusion MST 1 Team — Max-Planck-Institut für Plasmaphysik, Garching

Für lange oder gar stationäre Pulse in einem Tokamak muss der Plasmastrom überwiegend beziehungsweise gänzlich nicht-induktiv getrieben werden. Darüber hinaus lassen sich fortgeschrittene Plasmaszenarien durch gezieltes Formen des Plasmastromprofils erreichen. Dazu ist ein detailliertes qualitatives und quantitatives Verständnis des Stromtriebs vonnöten. Hier wird die Untersuchung des Stromtriebs durch Neutralteilchen-Injektion (NBI) an ASDEX Upgrade vorgestellt.

Vorangegangene Untersuchungen [1] hatten Diskrepanzen zwischen vorhergesagtem und gemessenem Stromprofil dadurch erklärt, dass die schnellen NBI-Ionen einem gegenüber der neoklassischen Vorhersage deutlich erhöhten turbulenten Transport unterliegen. Im Gegensatz hierzu konnte später in ähnlichen Entladungen nachgewiesen werden, dass die radiale Verteilung der schnellen Ionen der neoklassischen Erwartung entspricht [2]. In der hier vorgestellten Studie können durch die Elimination einer Reihe von Problemen bei der Auswertung beide Ergebnisse in Einklang gebracht und im Wesentlichen durch ein geringes Maß an annomalem Transport erklärt werden. Ferner werden Ergebnisse zur Effizienz des NBI-Stromtriebs an AUG präsentiert.

[1] Günter S. at al, 2007 Nucl. Fusion 47 920
[2] Geiger B., 2013 PhD Thesis LMU München

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Modelling of Radial Correlation Doppler Reflectometry using 2D Full Wave Simulations: X- O-mode comparison — •J.R. Pinzon[1,2], T. Happel[1], E. Blanco[3], T. Estrada[3], P. Hennequin[4], U. Stroth[1,2], and The ASDEX Upgrade Team[1]

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The study of plasma turbulence is relevant for the development of a nuclear fusion reactor because it enhances the energy and particle transport in detriment of the confinement. Radial Correlation Doppler Reflectometry (RCDR) is a diagnostic used to study wavenumber ($k_\perp$) resolved density turbulence in fusion plasmas. Among other quantities, it gives an estimate of the radial correlation length L_r of the density fluctuations. Recent results using simple models and synthetic turbulence have shown that under certain conditions, it can be possible to measure elongation and tilting of the turbulent structures.

RCDR is simulated using a 2D Full Wave code which solves the Maxwell equations in a plasma. Synthetic turbulence, linear density profiles and parameters similar to the experiments are used. The suitability of X- and O-mode for RCDR is assessed, as well as the possibility of measuring L_r, elongation and tilting of the turbulent structures. A comparison with experimental data from the ASDEX Upgrade tokamak is presented, results from X- and O-mode RCDR at different $k_\perp$ are shown.

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Further development of the tungsten-fibre reinforced tungsten composite — •Hanns Gietl[1], Martin Aumann[2], Jan Coenen[2], Till Höschen[1], Philipp Huber[3], Rudolf Neu[1,4], and Johann Riesch[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Forschungszentrum Jülich, IEK4, 52425 Jülich, Germany — [3]Lehrstuhl für Textilmaschinenbau und Institut für Textiltechnik (ITA), 52062 Aachen, Germany — [4]Technische Universität München, 85748 Garching, Germany

For the use in a fusion device tungsten has a unique property combination. The brittleness below the ductile-to-brittle transition temperature and the embrittlement during operation e.g. by overheating, neutron irradiation are the main drawbacks for the use of pure tungsten. Tungsten fibre-reinforced tungsten composites utilize extrinsic mechanisms to improve the toughness. After proofing that this idea works in principle the next step is the conceptual proof for the applicability in fusion reactors. This will be done by producing mock-ups and testing them in cyclic high heat load tests. For this step all constituents of the composite, which are fibre, matrix and interface, and all process steps need to be investigated. Tungsten fibres are investigated by means of tension tests to find the optimum diameter and pretreatment. New interface concepts are investigated to meet the requirements in a fusion reactor, e.g. high thermal conductivity, low activation. In addition weaving processes are evaluated for their use in the fibre preform production. This development is accompanied by an extensive investigation of the materials properties e.g. single fibre tension tests.

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Characterisation of the core poloidal flow at ASDEX Upgrade — •Alexander Lebschy[1,2], Rachael M. McDermott[1], Benedikt Geiger[1], Marco Cavedon[1], Michael G. Dunne[1], Ralph Dux[1], Rainer Fischer[1], Athina Kappatou[1], Patrick J. McCarthy[1], Eleonora Viezzer[1], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, D-85748 Garching, Germany — [2]Physik-Department E28, Technische Universität München, D-85748 Garching, Germany

Plasma rotation has a strong influence on the transport of heat, particles, and momentum in fusion plasmas via a variety of mechanisms, for example, by the stabilization of modes and the suppression of plasma turbulence. In tokamaks, the toroidal rotation (u_{tor}) is essentially a free parameter that is usually dominated by the external momentum input from neutral beams used to heat the plasma. The poloidal rotation (u_{pol}), on the other hand, is strongly damped and is predicted to remain at Neoclassical (NC) levels of a few km/s. Measuring the inboard-outboard asymmetry of u_{tor} with charge exchange recombination spectroscopy enables an indirect measurement of u_{pol} and, hence, the measurement of the complete plasma flow on a flux surface.

In order to characterise the nature of u_{pol} at ASDEX Upgrade a poloidal rotation database has been built that contains a large variation in the parameters that, according to NC theory, drive u_{pol}; namely, the main ion temperature and density gradients and collisionality. Initial results from this database and a detailed comparison of u_{pol} to NC theory in interesting plasma scenarios, will be presented in this poster.

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Divertor radiation in the ASDEX Upgrade Tokamak — •Till Sehmer[1], Matthias Bernert[1], Jürgen Koll[1], Hans Meister[1], Felix Reimold[2], Marco Wischmeier[1], Ursel Fantz[1], and The ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching, Germany — [2]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany

To reduce in ITER the expected power flux density onto the divertor target, the plasma-wall interaction in the divertor needs to be strongly reduced. The fundamental path to achieve this is using radiation from seeded impurities, whereas the localization of this radiation (e.g. inside/outside confined region), which could have an impact onto the power balance, is a key challenge. The absolute radiated power distribution can be measured by foil bolometers. To study at the ASDEX Upgrade tungsten divertor the localization and quantification of radiation, the respective line of sight density of the bolometers has been improved by two additional cameras. The divertor radiation enhanced by nitrogen (N_2) seeding has been investigated, using variations of (1) the external heating power or (2) the N_2 seeding rate. While in both cases the inner divertor stays fully detached, measurements indicate that the region of dominant radiation moves from the inner divertor through the X-Point into the confined region. In the outer divertor however, the measurements indicate either an immediate upwards shift or a continuous movement of the radiation away from the target, depending on experimental conditions.

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A discontinuous Galerkin method for the approximation of eigenvalues of a non coercive elliptic operator — •Benedict Dingfelder[1], Ralf Kleiber[2], Axel Könies[2], and Eric Sonnendrücker[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Deutschland — [2]Max-Planck-Institut für Plasmaphysik, Greifswald, Deutschland

Due to the anisotropy introduced by the magnetic field, the equations of ideal MHD show poor convergence properties if they are straight-forwardly discretized by finite elements. In their simplest form, they collapse to a heterogeneous anisotropic diffusion equation with a semidefinite diffusion tensor. The form we consider is given by

$$-\nabla \cdot \left(bb^\top \cdot \nabla\phi\right) = \omega^2\phi \qquad \text{in } \Omega$$

for the two-dimensional periodic domain Ω and direction of the magnetic field b. Despite of its simplicity, the equation reproduces the relevant poor convergence behaviour. A discontinuous Galerkin method with partially aligned cells and a perpendicularly aligned basis is presented which improves the numerical accuracy by roughly two digits in comparison to existing methods with the same computational complexity. The results can be used in more complex applications.

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Current sheet formation during driven magnetic reconnection — •Benjamin Brünner[1], Olaf Grulke[1], and Thomas Klinger[1,2] — [1]Max-Planck-Institut für Plasmaphysik, EURATOM-Association, Wendelsteinstraße 1, D-17491 Greifswald — [2]Institut für Physik, Ernst-Moritz-Arndt Universität Greifswald, Felix-Hausdorff-Straße 6, D-17489 Greifswald

Magnetic reconnection is a plasma phenomenon where magnetic energy is transfered into kinetic energy and heating of the particles during fast topological changes of opposing magnetic field lines. A crucial part of this process is a localized current sheet which forms along the magnetic X-line.

VINETA II is a experimental device with an open field line configuration for the study of magnetic reconnection. The reconnection is externally driven via current-carrying straight conductors inside the vessel to provide an inductive electric field. A plasma gun is used as an electron source to assist the formation of the current sheet.

Previous investigations of the current sheet have been made at driving frequencies much larger then the ion cyclotron frequency, resulting in essentially static ions during the reconnection process. In this work a low frequency drive, which is operating below the ion cyclotron frequency, is presented and the influence of the ion contribution to the current sheet is studied.

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Manufacturing W fibre-reinforced Cu composite pipes for application as heat sink in divertor targets of future nuclear fusion reactors — •Alexander v. Müller[1], Dagmar Ewert[2], Udo Siefken[3], and Jeong-Ha You[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Institut für Textil- und Verfahrenstechnik Denkendorf, 73770 Denkendorf, Germany — [3]Louis Renner GmbH, 85221 Dachau, Germany

An important plasma-facing component (PFC) in future nuclear fusion reactors is the so-called divertor which allows power exhaust and removal of impurities from the main plasma. The most highly loaded parts of a divertor are the target plates which have to withstand intense particle bombardment. This intense particle bombardment leads to high heat fluxes onto the target plates which in turn lead to severe thermomechanical loads. With regard to future nuclear fusion reactors, an improvement of the performance of divertor targets is desirable in order to ensure reliable long term operation of such PFCs. The performance of a divertor target is most closely linked to the properties of the materials that are used for its design. W fibre-reinforced Cu (Wf/Cu) composites are regarded as promising heat sink materials in this respect. These materials do not only feature adequate thermophysical and mechanical properties, they do also offer metallurgical flexibility as their microstructure and hence their macroscopic properties can be tailored. The contribution will point out how Wf/Cu composites can be used to realise an advanced design of a divertor target and how these materials can be fabricated by means of liquid Cu infiltration.

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Parallel ILU and Iterative Sparse Triangluar Solvers for Preconditioning in GENE — •Jürgen Bräckle and Thomas Huckle — Department of Informatics, Technical University of Munich, Boltzmannstr. 3, 85748 Garching, Munich, Germany

When solving large linear systems of equations Ax=b using iterative methods, we usually need to precondition the system to get fast convergence. The Incomplete LU-Factorization (ILU) is a preconditioner of good quality, but lacking parallelization capabilities. In this contribution, we combine ILU with the easy to parallelize concept of Sparse Approximate Inverse Preconditioners (SPAI) to iteratively compute an Incomplete LU-Factorization in parallel. These qualities are then shown in eigenvalue computations in the Plasma Turbulence Code Gene.

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Interplay of light and heavy impurities in a fusion plasma — •Mustafa Gaja[1] and Mikhail Tokar[2] — [1]IPP, Garching — [2]IEK4, Juelich FZ, Juelich

Radiation from impurities eroded from the walls can lead to a broad spectrum of spectacular phenomena in fusion devices An example of such events are breathing oscillations observed in the large helical device (LHD), in long pulse discharges with a stainless steel divertor[1]. They were characterized with oscillations of a period of a second in various plasma parameters. By optimizing magnetic geometry this operation mode, leading to a deteriorate plasma performance, can be avoided. Nonetheless it is of interest and practical importance to understand and firmly predict conditions for breathing phenomenon, in particular, in view of similar impurity environment in W-7 X stellarator. A qualitative explanation for breathing oscillations proposed earlier [2] presumes that they arise due to non-linear synergetic interplay of diverse physical processes. A one-dimensional non-stationary model, describing the generation and transport of main, impurity particles and heat by including the radiation of high-Z (Fe) and low-Z (C and O) impurities is elaborated here. The calculations predict the appearance of oscillations in the relevant range of plasma parameters, reproduce well experimentally observed amplitudes and period of oscillations. It demonstrates that the smaller the fraction of the plasma interaction with a stainless steel surface, the higher the light impurity concentration needed to excite the breathing oscillations. This shows a way to avoid oscillations in future experiments.