P 11: Helmholtz Graduate School - Poster

Time: Tuesday 16:15–18:15 Location: Redoutensaal

P 11.1 Tue 16:15 Redoutensaal

Investigation of the pump-out effect by resonant magnetic perturbations in ASDEX Upgrade — •Nils Leuthold[1], Wolfgang Suttrop[1], Matthias Willensdorfer[1], Marco Cavedon[1], Mike Dunne[1], Luis Gil[2], Luis Guimarais[2], the ASDEX Upgrade Team[1], and the MST1 Team[3] — [1]Max-Planck-Institut fuer Plasmaphysik, Boltzmannstr. 2, 85748, Garching, Germany — [2]Instituto de Plasmas e Fusao Nuclear, Instituto Superior Tecnico, Universidade de Lisboa, Portugal — [3]see H. Meyer et al 2017 Nucl. Fusion 57 102014

Future fusion reactors are foreseen to run in the high confinement mode at low collisionality due to the confinement requirements for self-sustained fusion power generation. However, this regime is accompanied by edge localized modes, which expell particles and energy in a pulsed manner. Since this instability has the potential to damage the first wall material, it has to be mitigated or suppressed. While resonant magnetic perturbations (RMPs) can achieve this, they have the drawback of causing a strong reduction of density. Theories trying to explain the transport mechanism underlying this "pump-out" effect are tested experimentally in ASDEX Upgrade. The results indicate that the resonance between the location of penetrating RMP fields and resonant surfaces is not crucial for the pump-out. Reflectometry measurements reveal the presence of toroidally asymmetric turbulence in the steepest gradient region. Those fluctuations correlate well with D-alpha light measurements in the scrape-off layer. Experiments with a modulation of the RMP field strength show, that the change in density happens first also in this region of asymmetric turbulence.

P 11.2 Tue 16:15 Redoutensaal

Towards nonlinear simulations of full ELM cycles — •Andres Cathey, Matthias Hoelzl, and Francois Orain — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany

Edge localized modes (ELMs) in tokamak fusion plasmas have been studied extensively both experimentally and theoretically in particular due to the strong associated heat fluxes which potentially exceed material constraints in ITER. Presently, ELM crash simulations are typically started from a peeling-ballooning unstable equilibrium reconstructed from experiments just before an ELM crash occurs. This way many aspects of single ELM crashes have been reproduced successfully in numerical simulations, but their characteristic periodicity still needs to be simulated consistently. In order to produce a more complete description of ELMs including inter-ELM phase and ELM onset, the full cyclic behaviour has to be consistently modelled. An overview of ELM physics will be given along with plans and first steps towards investigating full ELM cycles using the non-linear MHD code JOREK.

P 11.3 Tue 16:15 Redoutensaal

Energy-conserving Implicit Time Discretisation for the GEMPIC Framework — •Benedikt Perse[1,2], Katharina Kormann[1,2], and Eric Sonnendrücker[1,2] — [1]Max-Planck-Institute for Plasma Physics, Garching, Germany — [2]TU München, Zentrum Mathematik, Garching, Germany

For this poster, we consider an energy-conserving implicit time discretisation for the GEMPIC framework by reviewing the "Exactly energy conserving semi-implicit method" of Lapenta.

We adapt the method for the finite element discretisation of the GEMPIC framework, modify the splitting to gain higher order of accuracy for the electromagnetic fields and examine the performance of an 1d2v code in some test cases in regard of the conservation of energy and Gauss' law and the dependence of the accuracy on the time step. Furthermore, we compare the method to the explicit time stepping based on a Hamiltonian splitting proposed for the GEMPIC framework and another semi-implicit method using an average vector field scheme.

P 11.4 Tue 16:15 Redoutensaal

T_{rot} and T_{vib} determination in a CO_2 plasma — •Federico Antonio D'Isa[1], E. Carbone[1], A. Hecimovic[1], S. Gaiser[2], A. Schulz[2], M. Walker[2], S. Soldatov[3], G. Link[3], J. Jelonnek[3], N. Britun[4], and Ursel Fantz[1] — [1]IPP, 85748 Garching, Germany — [2]IVGP, 70569 Stuttgart, Germany — [3]KIT, 76344 Eggenstein-Leopoldshafen, Germany — [4]University of Mons, B7000 Mons, Belgium

Energy storage on demand is of critical importance for an energy grid with proper integration of renewable energies. The power to gas concept aims to store energy in excess into gas by conversion of CO_2 into chemical fuels such as syngas or methanol. To achieve a conversion effiency high enough to make the process advantageous, the CO_2 molecule must be preferentially dissociated by means of vibrational excitation which requires less energy than direct electron impact dissociation. The determination of the vibrational and rotational temperatures of the molecule in CO_2 plasma is crucial for understanding the conversion mechanism. In this work several CO_2 plasmas excited by microwaves have been studied by optical emission spectroscopy. The emission of the excited states of the C_2 ($d^3\Pi_g$ state) molecule and of the CN ($B^2\Sigma^+$ state) molecules is used to determine the rotational and vibrational temperature at pressures between 0.3 to 1 bar by fitting the measured spectra with a simulation done using on PGOPHER and MassiveOES. From the emission of the CO ($B^1\Sigma^+$ state) the rotational temperature has been determined at a pressure of 2 mbar. The results with the fitting routine will be presented and discussed.

P 11.5 Tue 16:15 Redoutensaal

Beam asymmetry and homogeneity characterization at the large negative ion source ELISE — •Isabella Mario, Dirk Wünderlich, Ursel Fantz, and Federica Bonomo — Max-Planck-Institut für Plasmaphysik, Garching, Germany

The ITER neutral beam injection (NBI) system is based on RF sources for production of negative ions (H^-/D^-). The ELISE test facility (source size is half the size of the source for ITER NBI) is an intermediate step in the European R&D roadmap towards the full size ITER source. The aim of ELISE is to fulfill the basic ITER requirements regarding extracted ion current, electron ion ratio at low filling pressure ($\leq$ 0.3 Pa) up to one hour pulse. On the beam side, at the exit of the acceleration stage, local maximum deviation from the averaged beam power density must be less than 10% in order to ensure good beam line transmission. For ELISE, with a beam of about 1 m^2, the lowest achievable beam divergence is about 17 mrad and vertical asymmetry and inhomogeneity are mainly caused by the interplay of plasma drift, non-uniform negative ion production as well as beam deflection by magnetic field. Aim of this work is to improve the understanding of the correlation between locally resolved beam properties with global electrical measurements from beamline components and source parameters. For this purpose we make use of two beam diagnostics: beam emission spectroscopy placed at 2.7 m downstream the extraction system, with a vertical resolution of 5 cm, and the infrared calorimetry on a diagnostic calorimeter at 3.5 m, with a resolution of 4 cm. Both diagnostics provide beam divergence and accelerated current.

P 11.6 Tue 16:15 Redoutensaal

Magnetic field configurations for reducing co-extracted electrons from an ITER NBI relevant ion source. — •Ivar Mauricio Montellano, S. Mochalskyy, D. Wünderlich, and U. Fantz — Max- Planck-Institut für Plasmaphysik, 85748 Garching, Germany

The ITER NBI system is based on powerful large-scale RF sources for negative hydrogen or deuterium ions. In order to improve the insight into the complex physics of the low pressure, low temperature plasma close to the extraction system of the ion source the application of self-consistent models is mandatory. The presence of two different magnetic fields, the filter field and the electron deflection field, which are perpendicular to each other, breaks the symmetry of the system making the application of a 3D model necessary. The 3D Particle in cell (PIC) code ONIX is capable to simulate the plasma volume close to one extraction aperture of the ITER prototype source. So far, ONIX has been applied in order to reproduce the generation and extraction of negative hydrogen ions and of co-extracted electrons. Of particular importance is the ratio of co-extracted electron current to extracted ion current which has to be kept below one for ITER. In the experiment several parameters can be modified to reduce and stabilize the co-extracted electrons, for example the strength topology of the magnetic fields. In order to improve the physical insight and as first step towards predictive calculations, different magnetic field configurations are simulated with ONIX to determine their effect in the co-extracted electron current. Presented are the results of these simulations and the discussion about the influence of different magnetic field configurations.

P 11.7 Tue 16:15 Redoutensaal

Spectral discretization for the Vlasov Equation — •Anna Yurova and Katharina Kormann — Max-Planck-Institut für Plasmaphysik, Garching b. München, Deutschland

Solving the full kinetic equations can help in understanding possible shortcomings of gyrokinetics. We consider a Galerkin method with Fourier discretization in space and generalized Hermite functions in velocity. The generalized Hermite functions allow for exact integration and resemble the structure of the solution in velocity space. Therefore, it is possible to simulate an unbounded domain in velocity instead of cutting it as it is currently done in mesh-based methods. We investigate the influence of the scaling and shift of the basis functions on the numerical solution of the Vlasov equation. We study different choices of the parameters in order to find a setup with a good representation of the initial distribution and, at the same time, long-term numerical stability.

P 11.8 Tue 16:15 Redoutensaal

Investigation of optically grey electron cyclotron harmonics in Wendelstein 7-X — •Neha Chaudhary, Matthias Hirsch, Hans Oosterbeek, Robert Wolf, and W7-X Team — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald, Germany

Electron cyclotron emission (ECE) is a standard diagnostic to measure electron temperature profiles in magnetized plasmas. In W7-X with a magnetic field of 2.5T, ECE from the second harmonic X-mode (120-160GHz) is scanned using a heterodyne radiometer. For the X2 mode, re-absorption of microwaves in the plasma is strong enough for the plasma to be considered as optically thick. Hence ECE can be taken as blackbody emission representing an electron temperature.

Other than the optically black X2 mode the ECE spectrum also has higher harmonics. Due to lower absorption coefficients these harmonics are optically grey. In case of overdense plasmas the X2 mode reaches its cutoff. Then higher harmonics provide the only access to ECE emission and hence the physics of core electrons.

The aim of this work is to perform a broadband scan of the ECE spectrum using a Michelson Interferometer in W7-X and compare it to the already existing radiation transport calculations (TRAVIS). Stray radiation from non-absorbed electron cyclotron resonance heating is an issue as it is in the middle of the X2 emission spectrum. Therefore a stray radiation filter is required. The design for such a filter consisting of multiple dielectric layers has been tested and will be presented.

P 11.9 Tue 16:15 Redoutensaal

Characterisation of the Wendelstein 7-X divertor plasma with Langmuir probes — •Lukas Rudischhauser[1], Kenneth Charles Hammond[1], Michael Endler[1], Boyd Douglas Blackwell[2], and the W-7X Team[1] — [1]Max-Planck-Insitute for Plasma Physics, Greifswald, Germany — [2]Australian National University, Canberra, Australia

During the operation phase 1.2a of the stellarator Wendelstein 7-X, 40 Langmuir probes embedded in the newly installed divertor were used to investigate the scrape-off layer. Temperatures, densities and plasma potentials were measured over a range of distances from the pumping gap, sampling different topological regions of the magnetic island divertor field.

Capabilities and limitations of the diagnostic are briefly introduced. The data are combined with observations of optical and spectrographic diagnostics as well as upstream probes to characterise the behaviour of the divertor plasma with respect to global plasma parameters. We present results of experiments on impurity seeding, pellet fuelling, radiative edge cooling and discuss indications for detachment in detail.

P 11.10 Tue 16:15 Redoutensaal

Radial Electric Field Studies in the Near Scrape-off Layer of ASDEX Upgrade using Charge Exchange Recombination Spectroscopy — •Ulrike Plank[1,2], Thomas Pütterich[1,2], Marco Cavedon[1], Michael Griener[1], Eleonora Viezzer[3], Ulrich Stroth[1], and ASDEX Upgrade Team[1] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Faculty of Physics, Ludwig Maximilian University of Munich, Germany — [3]Department of Atomic, Molecular and Nuclear Physics, University of Seville, Spain

The high confinement mode (H-mode) is a regime of magnetically confined fusion plasmas with improved particle and energy confinement. It exhibits a transport barrier in the confined region, close to the last closed flux surface (LCFS). This barrier is caused by a shear of the radial electric field (E_r). However, it is still discussed whether the E_r shear in the near scrape-off layer (SOL), i.e. outside the LCFS, influences the formation of the transport barrier and, therefore, the transition into H-mode. In order to measure E_r in the near SOL, a new charge exchange (CX) recombination spectroscopy diagnostics was installed at ASDEX Upgrade, which is capable of measuring E_r with high radial resolution by investigating CX reactions of low-Z impurity ions with injected neutrals. The new system utilizes a piezo valve for the injection of neutrals, which provides locally high neutral densities in the near SOL. The characterization of different CX lines from fully and partially ionized impurities will be presented together with first measurements of the new diagnostics.

P 11.11 Tue 16:15 Redoutensaal

Semi-Lagrangian drift-kinetic simulations in toroidal geometries — •Edoardo Zoni[1,2], Yaman Güçlü[1], and Eric Sonnendrücker[1,2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — [2]Zentrum Mathematik, TU München, 85748 Garching, Germany

A semi-Lagrangian simulation code is currently under development within the framework of the *SeLaLib* object-oriented Fortran library [1], in order to perform global electrostatic simulations of drift-kinetic ions and adiabatic electrons in toroidal geometries. The code employs field-aligned interpolation and splitting [2] to reduce significantly the number of poloidal planes and hence the memory footprint of the simulations.

The curvature of the background magnetic field in toroidal geometries causes complications in setting up initial conditions corresponding to a stable kinetic equilibrium, in applying non-constant boundary conditions for the interpolation in the radial and the velocity domains, and in the treatment of the O-point.

Solutions to these problems are presented and discussed, including the development of the corresponding computational tools in *SeLaLib*.

Verification tests in cylindrical geometry with a screw-pinch magnetic field configuration as well as preliminary results of standard testcases in toroidal geometries are presented. Helpful collaboration with the GySeLa team is acknowledged.

[1] *SeLaLib*: *Se*mi-*La*grangian *Lib*rary, http://selalib.gforge.inria.fr/.
[2] Latu et al., Journal of Scientific Computing, 2017, ISSN 1573-7691.

P 11.12 Tue 16:15 Redoutensaal

ELM heat loads on the ASDEX Upgrade divertor in high density discharges — •Davide Silvagni[1,2], Thomas Eich[1], Michael Faitsch[1], Bernhard Sieglin[1], Dominik Brida[1,2], Pierre David[1], and ASDEX Upgrade team[1] — [1]Max-Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany — [2]Physik-Department E28, Technische Universität München, 85747 Garching, Germany

A reliable prediction of the Edge Localised Mode (ELM) induced heat loads on the divertor of larger devices such as ITER is crucial, since it defines the operational range of future devices as well as the need for mitigation techniques. A recent scaling of the ELM (peak) energy fluence predicts unacceptable heat loads on the ITER divertor tiles in the $Q = 10$ scenario, if no mitigations are applied. For this reason, in this work the ELM power loads on the divertor of ASDEX Upgrade will be studied in discharges with high plasma edge density and detached divertor to discern whether a reduction of the ELM energy fluence can be found. However, in the presence of detachment the measurement of the divertor target temperature with standard infrared cameras is not possible because of the enhanced Bremsstrahlung radiation nearby the divertor tiles. For this reason, in 2018 ASDEX Upgrade will be equipped with a new infrared diagnostics that is expected to provide more reliable measurements of the divertor temperature (and heat flux) in plasma scenarios with high edge density. In this work, the new infrared diagnostics is presented as well as the most recent studies on ELM heat loads.

P 11.13 Tue 16:15 Redoutensaal

Assessment of particle and heat loads to the upper open divertor in ASDEX Upgrade and comparison with SOLPS simulations — •Ivan Paradela Perez[1,2], Mathias Groth[1], Andrea Scarabosio[2], and ASDEX Upgrade Team[2] — [1]Aalto University, Finland — [2]IPP Garching, Germany

Drifts and divertor geometry play a fundamental role in power, momentum and particle transport. An experiment has been carried out in the upper open divertor of ASDEX Upgrade to characterize their impact. Infra-red thermography measurements of the heat flux profiles in upper single-null, low confinement mode discharges in ASDEX Upgrade show that the heat loads onto the upper low-field side target increase by factors up to ~ 8 when changing from unfavourable ($B_T < 0$, ∇B drift downwards) to favourable ($B_T > 0$, ∇B drift upwards) toroidal field directions. The evolution of the heat loads with increasing plasma current and core density is different for both field directions. Increasing plasma current has a greater impact on heat flux profiles in favourable direction while the effect of increasing core density (in attached conditions) is more pronounced in unfavourable direction. Power detachment is observed for both B_T directions. This dependence on the B_T direction of the evolution with increasing plasma current and core density of the target profiles has also been observed in the collected ion saturation current, I_{sat}, measured by the Langmuir probes. However, the roll-over of I_{sat} is only observed for $B_T < 0$. Lower closed divertor AUG discharges and SOLPS simualtions will be used to improve the understanding of the large impact of drifts and divertor geometry.

P 11.14 Tue 16:15 Redoutensaal

SOLPS Modeling of Partially Detached Plasmas in ASDEX Upgrade — •Ferdinand Hitzler[1,2], Marco Wischmeier[1], Felix Reimold[3], Matthias Bernert[1], Xavier Bonnin[4], Arne Kallenbach[1], the ASDEX Upgrade Team[1], and the EUROfusion MST1 Team[5] — [1]IPP Garching, Germany — [2]TU München, Garching, Germany — [3]Forschungszentrum Jülich, Jülich, Germany — [4]ITER Organization, St. Paul-lez-Durance, France — [5]See author list "H. Meyer et al 2017 Nucl. Fusion 57 102014"

Power exhaust will be a critical issue for future tokamak fusion devices. The unmitigated power loads at the divertor targets can easily exceed the foreseen material limit of $10\,\mathrm{MWm}^{-2}$. To prevent severe damage of plasma facing components these power loads have to be reduced significantly. This can be achieved by increased fueling and controlled seeding of impurity species like nitrogen or argon. The resulting high densities and low target temperatures lead to the so-called detachment state, which is characterized by strongly reduced target power fluxes.

In this contribution impurity seeding of nitrogen and argon is investigated via SOLPS modeling. The radiation efficiencies of the seeded impurities are discussed and compared to expectations from atomic databases. It can be observed, that the effective radiation efficiencies in the simulation are enhanced due to impurity transport which leads to a deviation from the coronal equilibrium. The code results will be validated with selected ASDEX Upgrade H-mode discharges with a particular focus on the comparison of the impurity radiation patterns using spectroscopic data and synthetic diagnostics in the simulation.

P 11.15 Tue 16:15 Redoutensaal

The bolometer diagnostic at the stellarator Wendelstein 7-X — •Philipp Hacker[1,2], Daihong Zhang[1], Rainer Burhenn[1], Birger Buttenschön[1], Thomas Klinger[1], and W7-X Team[1] — [1]Max-Planck Institut für Plasmaphysik, EURATOM Association, D-17491 Greifswald, Germany — [2]Ernst-Moritz-Arndt Universität Greifswald, D-17491 Greifswald, Germany

The bolometer diagnostic at the stellarator Wendelstein 7-X (W7-X), using metal resistive detectors, aims to investigate the features of the plasma radiation mainly from the impurities and to provide the total radiated power loss for global power balance study. A two-camera system consisting of detector arrays with blackened gold-foil absorbers has been installed at W7-X. They view the plasma at a triangular cross section horizontally and vertically, respectively. The fan-shaped lines of sight provide full coverage of the studied plasma with a spatial resolution of 5cm. Based on their line-integrated measurements the total radiated power loss of the divertor plasma has been estimated independently. The initial results for helium and hydrogen plasma at different magnetic configurations and heating powers will be presented.

P 11.16 Tue 16:15 Redoutensaal

Calibration and Operation of the Soft X-ray Tomography System (XMCTS) and the Mirnov Diagnostic in the Wendelstein 7-X Stellarator — •Natalie Lauf[1], Christian Brandt[1], Kian Rahbarnia[1], Henning Thomsen[1], Jonathan Schilling[1], Torsten Broszat[1], Alexander Card[1], Ralph Laube[1], Mirko Marquardt[1], Timo Schröder[1], Torsten Bluhm[1], Tamara Andreeva[1], Ulrich Neuner[1], Manfred Zilker[2], and the W7X Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, Garching, Germany

The soft x-ray multi-camera tomography system (XMCTS) is a new diagnostic implemented for operational phase 1.2a (August - December 2017) of the Wendelstein 7-X fusion experimental stellarator. In current operation, 18 pinhole cameras mounted within the vacuum vessel cover 324 lines of sight and will measure x-ray emission from the plasma. The shape of the magnetic flux surfaces and instability dynamics are reconstructed from this data. Supplementary to this diagnostic are 125 poloidally arranged Mirnov coils measuring changes in the poloidal magnetic field component. Phase differences between coils allow mode numbers to be extracted. Calibration and operation of the XMCTS and the Mirnov diagnostic will be presented here facilitating work during following operational campaigns to correlate the reconstructed dynamics from data acquired by the XMCTS and the Mirnov diagnostics with the associated magnetic configuration and data from complementary diagnostics.

P 11.17 Tue 16:15 Redoutensaal

Core temperature collapses driven by ECCD at W7-X stellarator — •Marco Zanini, Heinrich Laqua, Torsten Stange, Robert Wolf, and W7-X Team — Max-Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, D-17491, Greifswald, Germany

The superconducting optimized stellarator Wendelstein 7-X is equipped with a flexible electron cyclotron resonance heating (ECRH) system, that allows up to 7 MW of power to be delivered to the plasma. A localized power deposition is possible and the ECRH itself can be used to drive a net current (ECCD). The negligible presence of toroidal currents makes W7-X a perfect testbed for ECCD experiments.

During ECCD operations, repetitive and periodic collapses of the central electron temperature have been observed; these collapses display a similar behavior to the well known "sawtooth oscillation" present in tokamaks.

An initial 1-D model has been developed to study the current diffusion in the plasma. An ECCD profile is simulated using the ray tracer code TRAVIS, developed at IPP. Due to Lenz's law a counter current is induced, whose time evolution is studied and analyzed. Local changes in the current density profile generate a local modification of the rotational transform, which can reach resonant values usually associated with appearance of plasma instabilities.

The characteristic timescale between the collapses is compared to the time needed by the rotational transform to reach the assumed resonant values.

P 11.18 Tue 16:15 Redoutensaal

Power balance analysis of the geodesic acoustic modes. — •Ivan Novikau[1], Alessandro Biancalani[1], Alberto Bottino[1], Garrard D. Conway[1], Peter Manz[1], Pierre Morel[2], Özgür D. Gürcan[2], and Emanuele Poli[1] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching Germany — [2]LPP, CNRS, École polytechnique, UPMC Univ. Paris 06, Univ. Paris-Sud, Observatoire de Paris, Université Paris-Saclay, Sorbonne Universités, PSL Research University, F-91128 Palaiseau, France

Turbulence in tokamaks generates radially sheared zonal flows (ZFs). ZFs are zero frequency electrostatic ExB modes, damped mainly by collisional processes.The action of the magnetic field curvature on the ZFs gives rise to oscillations of radial electric field called the geodesic acoustic modes (GAMs). GAMs are mainly damped by collisionless wave-particle resonance, i.e, Landau damping. Zonal structures can regulate and suppress turbulence, thus reducing the radial transport. Collisional ZF and collisionless GAM damping rates constitute crucial linear parameters in the nonlinear interaction between the zonal structures and the turbulence.

In this work, the dynamics of linear and turbulence-driven GAMs is investigated with the GK electromagnetic particle-in-cell code ORB5. The development and extension of the power balance diagnostics for the contribution of different particle species in ORB5 are described. Moreover, different reduced models derived from the GK theory are used to study the efficiency of the zero-frequency zonal structures, ZFs, and their oscillatory part, GAMs, in the turbulence suppression.

P 11.19 Tue 16:15 Redoutensaal

Deep Learning for Plasma Diagnostics — •Francisco Matos, Florian Hendrich, Frank Jenko, and Tomas Odstrcil — Max Planck Institute for Plasma Physics, Garching, Germany

At the ASDEX-Upgrade Tokamak, a Soft X-ray diagnostic exists which can be used to perform tomographic inversion (that is, reconstructing the 2D emissivity profile) of the plasma. However, state of the art tomographic algorithms require manual tuning to detect faulty measurements, can be too slow for real-time use, and do not always produce the most accurate profiles.

Our focus is on exploring the application of Deep Learning to convert this soft-x ray data into the full images (reconstructions) of the plasma emissivity profile, with the ultimate goal of producing accurate, noise-resistant, tomographic reconstructions at real-time speeds. The current approach consists in turning the concept of a Convolutional Neural Network upside down, with fully-connected layers processing the input signal, and transpose convolutional layers responsible for learning the image features to generate. We train this network by calculating the loss as the absolute error with respect to the pixels of existing tomograms. For this, we have a dataset consisting of approximately 120 000 measurement/image pairs.

P 11.20 Tue 16:15 Redoutensaal

Minerva neural network based surrogate models for real time inference of ion temperature profiles at Wendelstein 7-X — •Andrea Pavone[1], Jakob Svensson[1], Andreas Langenberg[1], Novimir Pablant[2], Robert C. Wolf[1], and W7-X team[1] — [1]Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, D-17491 Greifswald, Germany — [2]Princeton Plasma Physics Laboratory, 08540 Princeton, NJ, US

At the Wendelstein 7-X stellarator, tens of diagnostics produce a massive amount of data relevant to the measurement of plasma parameters. Forward models of many diagnostics are implemented in the Minerva framework where Bayesian inference is applied to complex systems constituting multiple diagnostics and physics models. Conventional inversion routines can take hours for a single data point, but Artificial Neural Networks (ANNs) can reduce the time by several orders of magnitude, making real-time analysis possible and providing a reliable alternative to such routines. We have trained ANNs exclusively on data synthesized within the Minerva framework, so that the trained ANNs constitute a surrogate model of the full physics model. We also focused on the quantitative estimation of the uncertainties of the ANN*s output, based on the stochastic properties of the optimization and the limited parameter space coverage of the training set with respect to novel measured data points. Results from applying ANNs to ion temperature profile inference from 2D X-ray spectral measurements will be compared with standard inversion routines, showing robustness and reliability for real time plasma parameter inference.

P 11.21 Tue 16:15 Redoutensaal

Hybrid drift kinetic electron - kinetic ion computations for electrostatic fluctuations in astrophysical plasmas — •Karen Pommois[1], Simon Lautenbac[2], Daniel Told[1], and Rainer Grauer[2] — [1]Max Planck Institut fur Plasmaphysik, Garching, Germany — [2]Ruhr Universität, Bochum, Germany

Kinetic numerical simulations, applied to study local heating in the solar wind [1], are computationally expensive due to the different evolution scales involved in the dynamics. The dispersion relation of Alfvén wave and fast magnetic mode were found with different simplified models, such as hybrid fluid-kinetic and gyrokinetic, and were compared in a recent work [2]. It has emerged that hybrid kinetic is well suited to describe high frequency waves, on the other hand it misses electron kinetic effects even at ion scales. Instead, gyrokinetics is able to capture kinetic electron effects but limited to wave frequencies below the cyclotron frequencies of the species involved. Hence, to enlarge the range of frequency of validity of gyrokinetic model for simulations of astrophysical plasmas, we aim to implement a hybrid model that involves a gyrokinetic description for electrons and kinetic for ions. In this poster we will show the first results, where we implemented this new hybrid model in the case of electrostatic dynamics and drift-kinetic electrons in muphy [3], a framework designed to couple different numerical codes for solving plasma problems. References: [1] R. Bruno and V. Carbone. Living Rev. Solar Physics, 2(4), 2005. [2] D. Told et al. New J. Phys., 18(6):065011, 2016. [3] M. Rieke et al. J. Comput. Phys., 283:436-452, 2015.

P 11.22 Tue 16:15 Redoutensaal

Gyrokinetics of electron-positron plasmas — •Daniel Kennedy, Alexey Mishchenko, and Per Helander — Max-Planck-Institut für plasmaphysik

The prospects of creating electron-positron pair plasmas magnetically confined in dipole geometries have been discussed since early 2000*s (Pedersen et al. 2003). In the immediate future, the first experiment aiming at this goal will be constructed (Pedersen et al. 2012). Recently, efficient injection and trapping of a cold positron beam in a dipole magnetic field configuration has been demonstrated by Saitoh et al. (2015). This result is a key step towards the ultimate aim of creating and studying of the first man-made magnetically-confined pair plasma in the laboratory.

It has been shown by Helander (2014) and Helander and Connor (2016) that the pair plasmas possess unique gyrokinetic stability properties due to the mass symmetry between the particle species. For example, drift instabilities are completely absent in pure pair plasma in a slab geometry.

However, in creating and confining a pair plasma experimentally, there will be a timescale, during the positron injection, on which plasma quasineutrality has not yet been established. This could lead to interesting behaviour in the plasma. Here we will present the first steps in the analytical theory of non-neutral pair plasma stability.

We will also present the first steps towards the first numerical simulations of pair plasmas in a dipole geometry using the GENE code.

P 11.23 Tue 16:15 Redoutensaal

Dependence of small Edge Localized Modes on Plasma Parameters — •G. F. Harrer[1,2], E. Wolfrum[2], T. Eich[2], M. G. Dunne[2], P. Manz[2], P. T. Lang[2], H. Meyer[3], M. Bernert[2], B. Labit[4], G. Birkenmeier[2], J. Stober[2], F. Aumayr[1], the EUROFUSION MST1 Team[5], and the ASDEX Upgrade Team[2] — [1]TU Wien, Austria — [2]IPP Garching, Germany — [3]CCFE Culham, United Kingdom — [4]SPC Lausanne, Switzerland — [5]see H. Meyer et al. 2017 Nucl. Fusion 57 102014

The development of small Edge Localized Mode (ELM) scenarios is important in order to understand how to reduce the strain on plasma facing components. One such scenario can be found at high densities, in highly shaped, close to double-null plasmas as small ELMs or type-II ELMs in ASDEX Upgrade, which are characterized by a frequency $f_{ELM} > 300$Hz and a low power loss. Comparing deuterium gas and pellet fuelling showed that this small ELM regime is dependent on the separatrix density, by decoupling it from the pedestal top density. This strong local dependence of small ELMs on the scrape-off layer parameters is in agreement with a ballooning model for the separatrix region. It has also been shown, that changing the vertical plasma position and with that, the plasma shape, the small ELMs shrink in size and get replaced by large type I ELMs. One hypothesis to explain this behavior is a strong dependence of these ballooning modes on the magnetic shear (global and local).

P 11.24 Tue 16:15 Redoutensaal

An algorithm for stellarator coil optimization that takes engineering tolerances into account — •Jim-Felix Lobsien, Michael Drevlak, Thomas Sunn Pedersen, and W7-X Team — Max-Planck Institut für Plasmaphysik, Greifswald, Germany

Recently designed optimised stellarator experiments have suffered from very low construction tolerances. Deviations of the central coil system are unavoidable during fabrication of the coils, and assembly of the coil system. In this paper, we present a new approach that incorporates reduced sensitivity to construction tolerances of the coil system into the optimization routine. The approach was tested within the framework of the existing coil optimization scheme for Wendelstein 7-X. The results are compared with those of a coil set obtained by the original optimisation. The result is a coil system with higher tolerances, such that small deviations do not cause deterioration of the properties important for fusion performance.

P 11.25 Tue 16:15 Redoutensaal

First results of the Coherence Imaging Spectroscopy Systems on Wendelstein 7-X — •Valeria Perseo[1], Ralf Koenig[1], Oliver Ford[1], Dorothea Gradic[1], Florian Effenberg[2], Christoph Biedermann[1], Gabor Kocsis[3], Thomas Sunn Pedersen[1], and W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Greifswald, Germany — [2]University of Wisconsin, Madison, USA — [3]Wigner RCP, Budapest, Hungary

The Coherence Imaging Spectroscopy (CIS) system is a camera based interferometer able to measure 2D impurity flow velocities for a selected visible line from the plasma. A modulation pattern encoding the spectral line properties is generated by the usage of birefringent crystals. The CIS system 2D measuring capability and high optical throughput made the diagnostic attractive for the complex magnetic island topology of Wendelstein 7-X (W7-X). Two CIS systems have

been designed and set up to face the challenging experimental conditions of W7-X. Their views is on the same island divertor, which is observed with nearly perpendicular lines of sight for an easier emission and flow interpretation in the W7-X geometry. First measurements have been performed during the second part of the last experimental campaign OP1.2a, observing the plasma at different magnetic configurations, densities and heating powers. The behavior of multiple impurities, mainly carbon and helium, have been studied. The diagnostic output will be compared with dedicated EMC3-EIRENE simulations.

P 11.26 Tue 16:15 Redoutensaal

First gas balance studies of Wendelstein 7-X — •Georg Schlisio, Uwe Wenzel, Thomas Sunn Pedersen, and W7X Team — MPI für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald, Germany

The advanced optimized stellarator Wendelstein 7-X (W7-X) is currently in its second operation phase (OP 1.2), featuring now a graphite island divertor. The first wall consists of graphite tiles and stainless steel panels. Both divertor and first wall are inertially cooled. With a divertor, plasma-wall interaction changes significantly compared to the first operation with a graphite limiter.

The first wall can act as a source or sink for particles depending on the conditions. This has great influence on the plasma particle balance. The overall gas balance consists of all sources and sinks of particles.

We discuss the methods of the gas balance of OP1.2a with an assessment of all sinks and sources. Since the wall source is not directly accessible, it has to be determined indirectly via the other terms of the balance.

A major part of the gas balance is determined by the particle removal rate Q given by Q=p*S, wherein p is the divertor pressure measured by a set of ASDEX pressure gauges at different locations in the sub-divertor region of W7-X, and S is the effective pumping speed.

Experience from OP1.1 and OP1.2a shows the critical importance of these studies for density control already for the plasmas in OP1.2b but especially for the long-pulse discharges in the upcoming next operational phases with discharge lengths that eventually will exceed 1000s.

P 11.27 Tue 16:15 Redoutensaal

Analysis and Modelling of Neon Seeded JET Discharges with High Radiative Power Fraction — •Stephan Glöggler[1,2], Marco Wischmeier[1], and JET Contributors[3] — [1]IPP, Garching, Germany — [2]Physik-Department E28, TUM, Garching, Germany — [3]See the author list of "X. Litaudon et al 2017 Nucl. Fusion 57 102001"

In future fusion devices as ITER and DEMO the power flux onto the divertor target plates will have to be reduced by impurity radiation. In DEMO a major fraction of the induced radiative power losses must originate inside the last closed flux surface. As radiative power losses within the confined plasma might impact the plasma confinement and the discharge stability it is crucial to determine and understand the underlying physical processes in high radiative discharges.

At JET it could be measured that with the seeding of neon the radial pedestal temperature and densisty profiles degrade at the edge but recover towards the core. An increase of the energy confinement time is observed. An inter-relation of these pedestal profiles with the radial radiation distribution is analyzed.

Numerical simulations with the code package SOLPS-ITER (plasma fluid code B2.5 coupled with the Monte Carlo neutral code EIRENE) of unseeded and neon seeded discharges complement the experimental findings. The impact of neon seeding on the pedestal profiles and on the divertor conditions will be investigated within these simulations.

P 11.28 Tue 16:15 Redoutensaal

SOLPS modelling for future snowflake- and X-divertor configurations in ASDEX Upgrade — •Ou Pan[1,2], Tilmann Lunt[1], Marco Wischmeier[1], David Coster[1], and The ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany — [2]Physik-Department E28, Technische Universität München, 85747 Garching, Germany

High heat loads on the plasma facing components of tokamak divertors impose serious constraints on the achievable performance of future fusion reactors. Instead of a standard single null (SN), an alternative divertor configuration such as snowflake- (SF) [1] or X-divertor (XD) [2] may mitigate these problems. Here we focus on a LFS SF- configuration where a secondary X-point is located at the low field side scrape-off layer (SOL) near the primary one. The geometrical splitting of the SOL as well as the enhanced divertor volume may help to reduce the maximum heat flux. The XD could enhance the divertor thermal capacity through a flaring of the field lines only near the divertor plates. In this work, the SOLPS code package is used to model the L-mode edge plasma for LFS SF- and XD configurations of ASDEX Upgrade upper divertor that will be upgraded in the near future [3]. With sufficient input power and nitrogen gas puff, simulations predict lower heat fluxes to the targets and higher radiative fractions in the LFS SF- case than that in the SN case with similar impurity concentrations at the separatrix. [1] D. Ryutov, et al., Plasma Phys. Control. Fusion 54 (2012) 124050 [2] M. Kotschenreuther, et al., Phys. Plasmas 14 (2007) 072502 [3] T. Lunt, et al., Nucl. Mat. Energy 12 (2017) 1037

P 11.29 Tue 16:15 Redoutensaal

Fast-ion transport study in the plasma periphery of ASDEX Upgrade using FIDA spectroscopy — •A. Jansen van Vuuren, B. Geiger, P.A. Schneider, A. Jacobsen, T. Lunt, and The ASDEX Upgrade Team — Max-Planck-Institut fur Plasmaphysik, D-85748 Garching, Germany

Good confinement of fast-ions is mandatory in fusion plasmas since these supra-thermal particles are responsible for plasma heating and current-drive. However, plasma perturbations such as edge localized modes (ELMs) might degrade the fast-ion confinement and the corresponding losses could even damage plasma facing components.

One powerful tool to study confined fast ions in fusion experiments is fast-ion D-alpha (FIDA) spectroscopy which makes use of Doppler shifted radiation, emitted by fast ions after charge exchange reactions.

The FIDA method has now been applied to study the fast-ion distribution function in the plasma edge of ASDEX Upgrade. A specialized FIDA spectrometer has been designed to acquire simultaneously the FIDA emission and the un-shifted D-alpha emission from background neutrals. The latter allows to estimate the background neutral density profile, the main reaction partner for the charge exchange reaction at the edge. The new system can be operated through a burst mode, allowing measurements with exposure times down to hundreds of microseconds. First measurements show strongly reduced FIDA signal intensities after ELMs that can in part be explained by fast-ion losses.

P 11.30 Tue 16:15 Redoutensaal

Integrated modelling of tokamak plasma confinement combining core and edge pedestal physics — •Teobaldo Luda, Clemente Angioni, Mike Dunne, Emiliano Fable, Giovanni Tardini, Francois Ryter, and ASDEX Upgrade Team — Max-Planck-Institut für Plasmaphysik, Garching

A new theory-based approach to the integrated modelling of tokamak plasma confinement is being developed, which aims at predicting the total stored energy, and the plasma kinetic profiles, only using global plasma parameters of the discharge as inputs, such as the plasma current, the density and the heating powers. As a first step in the development of the model, we use the TGLF model to evaluate the turbulent transport fluxes in the core region, while in the pedestal region, transport is assumed to be purely neoclassical. With the transport code ASTRA, we investigate the applicability of the TGLF transport model to the plasma periphery, and how different assumptions on the pedestal transport affect the core, when the boundary conditions of the simulation are set at the last closed flux surface. We then check with the MISHKA MHD stability code that the heights and widths we are evaluating are consistent with the constraints imposed by peeling-ballooning modes. The long term goal is to obtain a robust model for the entire plasma which can be applied to large experimental databases, in order to identify important hidden dependencies affecting the global plasma confinement, which are difficult to capture by statistical regressions on global parameters.

P 11.31 Tue 16:15 Redoutensaal

Experimental Characterisation of Parametric Decay Instabilities at ASDEX Upgrade — •Søren Kjer Hansen[1,2], Stefan Kragh Nielsen[2], Jörg Stober[1], Jesper Rasmussen[2], Morten Stejner[2], and The ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, D-85748 Garching bei München, Germany — [2]Department of Physics, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark

When high power wave beams are injected into a plasma, e.g. for heating, current drive or diagnostic purposes, the wave amplitude may become so large that the linear approximation breaks down and a parametric decay instability (PDI) is excited. The present work concerns PDIs occurring for gyrotron radiation near the upper hybrid resonance at the ASDEX Upgrade tokamak, and is motivated by observations of strong anomalous (PDI generated) scattering made using the collective Thomson scattering (CTS) diagnostic. We measure the frequency power spectrum generated by the PDI with the high resolution fast receiver CTS system installed at ASDEX Upgrade and characterise its dependence on the injected gyrotron power by means of fast analog modulation of said power. The experimental observations are in reasonable agreement with previously published theoretical results. Apart from characterising anomalous scattering during CTS experiments, the present results may also have relevance for O-X-B heating experiments, planned for Wendelstein 7-X, and 1st harmonic electron cyclotron resonance heating, planned for ITER.

P 11.32 Tue 16:15 Redoutensaal

Impurity studies with Charge Exchange Spectroscopy on W7-X — •Lilla Vanó, Juergen Baldzuhn, Oliver Ford, Robert C Wolf, and the W7-X team — Max-Planck-Institute for Plasma Physics, Greifswald, Germany

Wendelstein 7-X (W7-X) is an optimized stellarator with the goal of demonstrating the stellarator as a promising candidate for a future fusion power plant. Apart from the main plasma species, hydrogen, impurities enter the plasma from the surrounding walls and cause power loss by increasing plasma radiation. Understanding the transport of these ions can help us optimise the stellarator configuration to reduce impurities.

There are several diagnostics that investigate impurity transport, one of them is the Charge Exchange Recombination Spectroscopy (CXRS). On W7-X, neutrals from the Neutral Beam Injection (NBI) will transfer an electron to the fully-stripped low-Z ions in the plasma (e.g. carbon). This allows the characteristics of these ions to be examined. Until the NBI is available, the emission of the passively excited low-Z ions near the plasma edge can also be measured but with lower intensity and as line integrated measurements.

In this work, data from the passive system is analyzed, delivering the temperature profile and the distribution of the Carbon-VI ions. These results will provide information about the primary plasma impurity in the first W7-X campaign with a fully carbon divertor.

P 11.33 Tue 16:15 Redoutensaal

Relaxation of fluid theories by metriplectic dynamics: a method based on a generalization of the Landau collision operator — •Camilla Bressan[1,2], Michael Kraus[1,2], Philip James Morrison[3], and Omar Maj[1,2] — [1]Max-Planck-Institute for Plasma Physics, Garching, Germany — [2]Technische Universität München, Zentrum Mathematik, Garching, Germany — [3]The University of Texas at Austin, Physics Department and Institute for Fusion Studies, USA

The computation of general 3D MHD equilibria plays a fundamental role in Stellarator as well as in Tokamak simulations in which 3D effects (namely islands, ripples and resonant magnetic perturbations) are increasingly important.

A novel relaxation method based on the paradigm of metriplectic dynamics [P.J.Morrison, Physica D, **18**, 410-419 (1986)] is proposed. This specific relaxation mechanism has the same structure as the Landau collision operator, so that its equilibrium points can be understood in terms of local extrema of an entropy functional. No restrictive assumption on the topology of the magnetic field is made. In fact it allows for the formation of magnetic islands and stochastic regions, while maintaining a control on relaxed equilibrium profiles.

The new approach has been numerically tested on both the Euler ideal fluid equations in two dimensions and Grad-Shafranov MHD equilibria. First steps toward a proof of concept for 3D MHD are discussed.