P 12: Magnetic Confinement - Poster

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

P 12.1 Tue 16:15 Redoutensaal

The effect of plasma density fluctuations on the propagation of microwave beams used for plasma heating — •Alf Köhn[1,2], Lorenzo Guidi[2,3], Eberhard Holzhauer[1], Omar Maj[2], Emanuele Poli[2], Antti Snicker[2,4], Matthew Thomas[5], and Roddy Vann[5] — [1]IGVP, Universität Stuttgart, Germany — [2]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [3]Technische Universität München, Numerical Methods for Plasma Physics (M16), Garching, Germany — [4]Department of Applied Physics, Aalto University, Finnland — [5]York Plasma Institute, University of York, UK

Microwaves play an indispensable role in plasma experiments for heating and diagnostic purposes. When injected into the plasma or emitted by it the microwaves have to pass the plasma boundary, a region where strong plasma density fluctuations with fluctuation levels up to 100 % can occur. The interaction with the fluctuations can deteriorate the quality of the microwave beam resulting in reduced heating efficiencies or ambiguous diagnostics results. This is in particular a problem for the control of MHD instabilities by localized current drive using microwaves in the electron cyclotron range of frequencies. Here we present numerical simulations of the microwave interacting with the fluctuation layer by means of two different numerical codes, a full-wave code and a wave kinetic equation solver which treats the effects of fluctuations based in the Born approximation. Limitations of the latter treatment are explored and extrapolations towards ITER are drawn.

P 12.2 Tue 16:15 Redoutensaal

Completion of magnetic diagnostics and bootstrap current studies at the stellarator Wendelstein 7-X — •K Rahbarnia[1], T Andreeva[1], T Bluhm[1], B B Carvalho[2], M Endler[1], D Hathiramani[1], J Geiger[1], N Lauf[1], U Neuner[1], J Schilling[1], H Thomsen[1], Y Turkin[1], M Zilker[1], and W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Instituto de Plasmas e Fusao Nuclear Instituto Superior Tecnico, Lisbon, Portugal

About 90% of the magnetic diagnostic system at Wendelstein 7-X (W7-X) has been put into operation during the second operational phase OP1.2a, August-December 2017. The diagnostic system consists of 3 diamagnetic loops, 6 Rogowski coils arrangements, 40 saddle coils and 125 Mirnov coils, distributed in all 5 modules of W7-X. Data recording and storing of raw signal streams into the W7-X archive database has been fully automatized via the central operation control system. Automatized data analyzing software, implemented in the MINERVA framework, calculates magnetic fluxes of all sensors, as well as the compensated diamagnetic energy and plasma current. The pre-analyzed data is written into the W7-X archive database directly after each plasma pulse. Plasma pulse duration of up to 20 s in combination with plasma density feedback control allows detailed studies of the bootstrap current. The experimental results are complemented by theoretical predictions. The minimization of bootstrap currents in dedicated magnetic field configurations, which are optimized for low plasma current and future long pulse operation, has been confirmed.

P 12.3 Tue 16:15 Redoutensaal

Langmuir probe diagnostic at the Vineta II magnetic reconnection experiment — •Tiziano Fulceri, Adrian Von Stechow, and Olaf Grulke — Max Planck Institut für Plasmaphysik, 17489 Greifswald, Wendelsteinstrasse 1, Deutschland

Vineta II is an experiment to investigate magnetic reconnection in a controlled laboratory environment. In its current setup, reproducible magnetic reconnection is driven on a timescale of the order of $10\,\mu$s and the reconnection current sheet and magnetic topology is reconstructed using postionable probes. Central reconnection current sheet properties, such as the time evolution of electron temperature and density as well as electrostatic fields, are measured by a fast swept Langmuir probe. It is biased with an oscillating +/-200V voltage at an adjustable frequency from 50kHz to 200kHz, which allows to record the full probe characteristics on the reconnection timescale. Key parameters are the gradients of electron density and temperature, which contribute significantly to the radial force-balance of the reconnection current sheet. This contribution describes the development of the probe's experimental setup, especially with regards to high frequency circuit optimization (pickup rejection, low inductances), and presents initial measurements results.

P 12.4 Tue 16:15 Redoutensaal

Shearing rate dependence of Reynolds-Stress — •Til Ullmann, Mirko Ramisch, and Bernhard Schmid — Institut for Interfacial Process Engineering and Plasmatechnology - University of Stuttgart

Turbulence generated zonal flows (ZFs) are known to be part of regulating turbulent transport and, therefore, are suspected to be involved in spontaneous transitions from low to high confinement regimes in toroidal fusion plasmas. ZFs are driven by radial gradients of the turbulent Reynolds-Stress $\langle \widetilde{v}_\theta \widetilde{v}_r \rangle$, which de facto measures the tilt of vortices. Hence, equilibrium shear flows constitute a seed flow for initially tilting vortices, initiating the ZF drive and stimulating its selfamplification. In this contribution the dependence of Reynolds-Stress on background flow shearing rates is investigated experimentally. To this end, the poloidal $E \times B$ background flow in the sellarator TJ-K is controlled via plasma biasing. A ring shaped electrode is positioned in the plasma and set on a positive potential with respect to the vacuum vessel. This application even allows to equalize the pressure driven $E \times B$ background flow and, therefore, is found to be minimal. The trend of the Reynolds-Stress with the shearing rate will be analysed and compared to the development of the measured ZFs.

P 12.5 Tue 16:15 Redoutensaal

The Wendelstein 7-X Phase Contrast Imaging Diagnostic — •Adrian von Stechow[1], Olaf Grulke[1,3], Lukas-Georg Böttger[1,3], Eric Edlund[2], Miklos Porkolab[2], and The W7-X team[1] — [1]Max-Planck-Institut für Plasmaphysik — [2]MIT Plasma Science and Fusion Center — [3]Technical University of Denmark

The Wendelstein 7-X stellarator (W7-X) is in its second operation phase with full divertor geometry. W7-X is highly optimized to minimize neoclassical transport and designed to run steady state, and is thus the first stellarator in which the role of turbulent transport can be quantitatively assessed at reactor relevant parameters. These results feed back to ongoing modeling activities which predict ion temperature gradient and trapped electron modes that fundamentally differ in their scaling and spatial distribution from those observed in tokamaks.

Quantitative characterization of turbulence requires a broad range of profile and fluctuation diagnostics, including a new phase contrast imaging (PCI) system that measures spatially resolved electron density fluctuations along a sight line through the plasma center. The project is a collaboration between the MIT PSFC and IPP. An overview of diagnostic features and capabilities and exemplary results of characteristic discharge features are presented. These include remote alignment and optical reconfiguration of the CO_2 laser system to cover a broad spatial range in real (50-110 mm) and k space (5-17 cm^{-1}), absolute k-space and relative amplitude calibration by means of an acoustic speaker array, and radial localization of measurements by selective beam masking.

P 12.6 Tue 16:15 Redoutensaal

Commissioning of the soft X-ray tomography system (XMCTS) in the Wendelstein 7-X stellarator — •Christian Brandt, Natalie Lauf, Jonathan Schilling, Henning Thomsen, Alexander Card, Mirko Marquardt, Timo Schröder, Torsten Broszat, Ralph Laube, and The W7-X Team — Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

The X-ray multi-camera tomography system (XMCTS) has been commissioned in the stellarator experiment Wendelstein 7-X (W7-X) during operational phase 1.2a (Aug-Dec 2017). The current setup of the diagnostic consists of 18 pinhole cameras arranged on a poloidal array at a toroidal position with up-down symmetric triangular shaped flux surfaces. The emissivity of the plasma in the X-ray range ($1-10\,$keV) is measured along 324 lines-of-sight covering the poloidal cross section up to the last closed flux surface with a spatial resolution of $\approx 3-4\,$cm. The data acquisition system is commissioned to record 384 channels sampled with 2 MHz at a data rate of 1.6 GB/s capable of recording discharges of 300 s length. First experimental results of X-ray emission obtained during well-defined laser blow-off experiments and gas puffs using different materials and gases are presented. To calculate the 2D emissivity profiles for different magnetic field configurations the preparations for tomographic reconstruction and calibration are discussed.

P 12.7 Tue 16:15 Redoutensaal

Gyrokinetic Studies of Inter-ELM Pedestal Evolution using GENE Code — •Karl Stimmel — Max Planck Institute for Plasmaphysics, Boltzmannstraße 2, 85748 Garching bei München

For the Deutsch Physikalische Gesellschaft conference in Erlangen, preliminary results on Inter-ELM (Edge Localized Mode) pedestal structure for ASDEX Upgrade shot 31529 are outlined. The inter-ELM region is averaged into one coherent structure which can be simulated with GENE. Preliminary results outlining 3 regions of interest relative to ELM crash onset are outlined. The scope of future work and significance of the simulation results with regards to new diagnostics on ASDEX upgrade and new capabilities of GENEcode.

P 12.8 Tue 16:15 Redoutensaal

Analysis of the impurity content in Wendelstein 7-X using VUV spectroscopic data — •Birger Buttenschön, Rainer Burhenn, Daihong Zhang, Thomas Wegner, Golo Fuchert, Andreas Langenberg, and the W7-X Team — Max-Planck-Institut für Plasmaphysik, Wendelsteinstr. 1, 17491 Greifswald

Throughout the second operation phase of the stellarator Wendelstein 7-X, the impurity content and their (dynamic) behaviour in various discharge configurations were carefully monitored and investigated. The main diagnostics for the determination of impurity compositions is the VUV spectrometer system HEXOS. As this device is absolutely intensity calibrated, its data is also used, in conjunction with the 1D impurity transport code STRAHL, to derive the individual impurity concentrations.

First assessments of the impurity composition and concentrations in Helium and Hydrogen discharges are presented. This comparison might give insight into the general difference in performance in the two gases, and allows for a careful discussion of possible impurity sources during this operation phase.

P 12.9 Tue 16:15 Redoutensaal

Limitations on positron confinement in a magnetic dipole trap — •Juliane Horn-Stanja[1], Uwe Hergenhahn[1], Stefan Nissl[1], Thomas Sunn Pedersen[1,2], Haruhiko Saitoh[1,3], Eve V. Stenson[1], Matthew R. Stoneking[4], Marcel Dickmann[5], Christoph Hugenschmidt[5], Markus Singer[5], and James R. Danielson[6] — [1]Max-Planck-Institute for Plasma Physics — [2]Universität Greifswald — [3]University of Tokyo, Japan — [4]Lawrence University, USA — [5]Technische Universität München — [6]University of California, San Diego, USA

The magnetic dipole field permits both in planetary magnetospheres and in the laboratory exceptional charged particle confinement with an arbitrary degree of neutrality. This makes it a promising geometry for the creation and study of a maybe even more unconventional object of research - a magnetized low-energy electron-positron plasma. Basic prerequisite for its success is the development of techniques for charged-particle injection into a closed magnetic system and subsequent particle manipulation and confinement. These challenges have been addressed in positron experiments with a prototype dipole trap at NEPOMUC, the world's most intense source of low-energy positrons.

In recent injection-hold-dump experiments we observed positron confinement times ranging from 0.2 to 1.3 seconds depending on the experimental conditions. In this contribution we will discuss asymmetries and collisions with neutrals as potential loss mechanisms. Together with results from single-particle simulations this yields a reasonable explanation for the observed confinement times.

P 12.10 Tue 16:15 Redoutensaal

Transport properties of injected impurities in Wendelstein 7-X stellarator. — •Th. Wegner[1], B. Geiger[1], R. Burhenn[1], B. Buttenschön[1], D. Zhang[1], A. Langenberg[1], N. Pablant[2], and The W7-X Team[1] — [1]Max-Planck-Institute for Plasma Physics, Greifswald, Germany — [2]Princeton Plasma Physics Laboratory, Princeton, NJ, USA

Impurities in the plasma mainly influence the power balance. In particular, their existences increase the radiation losses and the dilution of the plasma. Especially in stellarators, impurities can be accumulated and cause an early pulse termination by radiation collapse. Hence, the investigation of the impurity transport properties is a demanding task for plasma devices with the potential of steady-state operation. Therefore, tracer impurities were injected by means of a new laser blow-off system on W7-X in a controlled manner. After the injection, the emission of several ionization states from the X-ray to XUV wavelength range were measured in different magnetic field configurations and plasma parameters. Simulation of their temporal behavior using measured radial profiles of the electron temperature and density allow access to transport properties. In particular, the impurity confinement time, the diffusion coefficient and the convection velocity will be presented for different impurity elements, plasma parameters and main plasma species.

P 12.11 Tue 16:15 Redoutensaal

Magnetic diagnostics integration in the Minerva framework for the Wendelstein 7-X stellarator — •Jonathan Schilling[1], Tamara Andreeva[1], Oliver Ford[1], Joachim Geiger[1], Ulrich Neuner[1], Kian Rahbarnia[1], Jakob Svensson[1], Henning Thomsen[1], Samuel Lazerson[2], John Schmitt[3], and The W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Princeton Plasma Physics Laboratory, New Jersey, USA — [3]Auburn University, Alabama, USA

For the latest experimental campaign of the Wendelstein 7-X stellarator, automated preanalysis of the magnetic diagnostics data was implemented in the Bayesian data analysis framework Minerva. We present first results of a simplified reconstruction of the toroidal current profile as well as a comparison of the experimental results with theoretical predictions based on equilibrium calculations using the VMEC code. A prediction of the measured signals is computed based on the equilibrium magnetic field within the framework and compared to results from established codes as DIAGNO and Extender. In this contribution the new implementation of the magnetic diagnostics response prediction in the context of the Minerva framework is presented. Benchmarks in terms of speed and accuracy against existing codes are presented and optimization towards sufficiently fast prediction for equilibrium reconstructions during the experiment program is assessed.

P 12.12 Tue 16:15 Redoutensaal

Gyrofluid Simulations of Tokamak Edge Plasmas — •Adam Dempsey, Huw Leggate, and Miles M. Turner — Dublin City University, Dublin 9, Ireland

Filaments are field aligned structures that are known to form in the scrape-off-layer (SOL) in tokamaks. These structures are composed of hot electrons and ions. They can constitute a non-negligible thermal and particle flux on the first wall. As such the propagation of these structures to the first wall is problematic. One approach to predicting such fluxes in plasmas is to rely on simulation.

The approach described herein is to use a gyrofluid model (GEM). Gyrofluid models incorporate higher order finite Larmor radius effects more naturally that other fluid models. Initial progress towards solving this gyrofluid model in a slab geometry is presented. BOUT++ which is a framework for writing fluid and plasma simulations is used to evolve the gyrofluid moment equations. The focus of these simulations is on the effect of finite Larmor radii on filament propagation near the SOL. Of particular interest are filament-background interactions and the verification of filament velocity scaling laws which have to date largely been identified using fluid models.

P 12.13 Tue 16:15 Redoutensaal

Progress on the development of superconducting coils as confinement devices for pair plasmas — •Markus Singer[1], James R. Danielson[2], Marcel Dickmann[1], Uwe Hergenhahn[3], Juliane Horn-Stanja[3], Stefan Nissl[3], Harukiho Saitoh[3], Eve V. Stenson[3], Matthew R. Stoneking[4], Thomas Sunn Pedersen[3,5], and Christoph Hugenschmidt[1] — [1]Technische Universität München — [2]University of California, San Diego, USA — [3]Max-Planck-Institute for Plasma Physics — [4]Lawrence University, USA — [5]University of Greifswald

A plasma composed of particles with identical masses but opposite charges is predicted to feature fundamentally different phenomena compared to electron ion plasmas. Even though extensive theoretical studies have been carried out for decades, the experimental demonstration of matter-antimatter pair plasmas has not succeeded yet. The APEX project is aiming for the creation of the first magnetically confined laboratory plasma consisting of electrons and positrons, using the worlds strongest high-flux low-energy positron source NEPOMUC. Recent experiments using a prototype permanent magnet dipole trap have already demonstrated high injection efficiencies and long confinement times. The simultaneous confinement of both electrons and positrons however, requires closed unperturbed magnetic field lines. For this purpose we are developing an upgraded dipole trap using a magnetically levitated high temperature superconducting coil. This contribution will depict the progress on the transition of the confinement volume from a mechanically supported to a levitated geometry.

P 12.14 Tue 16:15 Redoutensaal

Search for signatures of non-local electron heat transport in fusion plasmas — •Klara Höfler[1,2], Tim Happel[1], Pascale Hennequin[3], François Ryter[1], Ulrich Stroth[1,2], Udo Höfel[4], the ASDEX Upgrade Team[1], and the W7-X Team[4] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Physics Department E28, Technical University Munich, Garching, Germany — [3]Laboratoire de Physique des Plasma, Ecole Polytechnique, Palaiseau, France — [4]Max Planck Institute for Plasma Physics, Greifswald, Germany

Heat transport in fusion plasmas is in general described by Fick's law which predicts a direct dependence of energy fluxes on the local gradients in plasma temperature and plasma density. Fick's law has been experimentally confirmed, however, past and current fusion devices reported experiments where under certain conditions in transient state the local heat flux is no longer a function of the local parameters only. This talk presents the search for this kind of violations on the ASDEX Upgrade tokamak and the W7-X stellarator. Transient states in electron heat flux are generated by strong and fast changes of the electron microwave heating, both with sudden power steps after stationary state as well as fast power modulation. The spatially and temporally resolved heat flux is taken from subtracting the radiated and the absorbed power from the heating power. Conclusions about non-locality are drawn from relating the heat flux to the local temperature gradient and from simulations with the transport code ASTRA which connect power steps and modulation experiments.