P 13: Magnetic Confinement

Zeit: Dienstag 16:30–18:30 Raum: HS Foyer

P 13.1 Di 16:30 HS Foyer

High-efficiency injection of positrons into a magnetic dipole trap — •Markus Singer[1], James R. Danielson[2], Marcel Dickmann[1], Uwe Hergenhahn[3], Juliane Horn-Stanja[3], Haruhiko Saitoh[3,4], Eve V. Stenson[3], Matthew R. Stoneking[5], Thomas Sunn Pedersen[3,6], and Christoph Hugenschmidt[1] — [1]Technische Universität München — [2]University of California, San Diego — [3]Max-Planck Institut für Plasmaphysik — [4]University of Tokyo — [5]Lawrence University, Wi, USA — [6]Ernst-Moritz-Arndt University Greifswald

Electron-positron plasmas represent a unique state of matter as pair-plasmas. The mass symmetry of the particles lead to fundamentally different physical phenomena compared to conventional electron-ion plasmas. Despite great theoretical interest these plasmas have not been magnetically confined yet. The goal of APEX (A-Positron-Electron-eXperiment) projects is the creation of magnetically confined electron-positron plasmas, by injecting positrons from the world*s most intense positron source NEPOMUC (NEutron-induced POsitron Source MUniCh) into a magnetic dipole trap, which will also allow the simultaneous confinement of electrons. The current prototype trap mainly consists of a cylindrical permanent magnet which is placed in the center of a segmented ring electrode. Positrons are guided into the dipole by E x B plates which induce a drift motion across closed magnetic field lines.In recent experiments, by tailoring electrostatic fields in the trap, the injection efficiency could be increased up to 100%. The results from these experiments will be presented and compared to simulations.

P 13.2 Di 16:30 HS Foyer

Global model for radio frequency magnetron sputtering — •Dennis Engel, Dennis Krüger, and Ralf Peter Brinkmann — Institute of Theoretical Electrical Engineering, Ruhr University Bochum, Germany

During the last decades magnetron sputtering gained a high technological significance. It is used wherever high quality thin films are needed. Due to the high complexity, the active control of this process is current subject of research. Active control allows to keep the plasma in a stable working condition. An efficient model in terms of computation time is required. This work shows one possible model, based on a lumped circuit model for a capacitively coupled radio frequency discharge [1]. The necessary changes to this model regarding the magnetic field are shown. The newly proposed model is used to investigate the influence of various input parameters on the sheath voltage and the discharge current. These parameters can be the magnetic field strength, the neutral gas pressure or the applied voltage.

[1] T. Mussenbrock et al., PSST **16**, 377-385 (2007)

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Compression of the radial positron profile in a magnetic dipole trap by rotating electric fields — •J. Horn-Stanja[1], U. Hergenhahn[1], T. S. Pedersen[1,2], H. Saitoh[1,3], E. V. Stenson[1], M. R. Stoneking[4], M. Dickmann[5], C. Hugenschmidt[5], M. Singer[5], and J. R. Danielson[6] — [1]Max-Planck-Institute for Plasma Physics — [2]Ernst-Moritz-Arndt University Greifswald — [3]University of Tokyo — [4]Lawrence University — [5]Technische Universität München — [6]University of California, San Diego

An electron-positron plasma is, in contrast to a conventional electron-ion plasma, characterized by the mass balance of the oppositely charged components. Although offering a fundamentally different playground for plasma physics, the experimental investigation of these plasmas is still in its infancy. The APEX project aims to create the first magnetically confined electron-positron plasma by first accumulating positrons from the world's most intense positron source NEPOMUC in novel linear trapping devices (the Positron Accumulation eXperiment PAX) and second injecting them into a magnetic dipole trap which allows to confine them simultaneously with electrons.

Recent experiments with a prototype dipole trap operated at the NEPOMUC source proved the interaction of rotating electric fields with positrons in a magnetic dipole field. In a broad frequency range around 150kHz a compression of the radial positron profile was observed. In this contribution, results from these experiments as well as from simulations on the interaction of rotating electric fields with positrons in this dipole trap will be presented.

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Numerical Investigation of Microwave Propagation at the Stellarator TJ-K — •Lennart Bock, Gabriel Sichardt, Eberhard Holzhauer, Carsten Lechte, and Mirko Ramisch — Institute of Interfacial Process Engineering and Plasma Technology, University Stuttgart

The plasma of the stellarator TJ-K allows electron cyclotron radiation to propagate through the whole torus via multiple reflections and to be detected with a dedicated diagnostics. In a first step, 2D full wave simulations were used to analyze microwave propagation in both, toroidal and poloidal cross section. The solving algorithm implements the Finite Difference Time Domain method and assumes a fixed ion background. Plasma density profiles and magnetic background fields were chosen representative for TJ-K. The simulation incorporates the geometry of the receiver system including an antenna at the outer port and a reflecting mirror on the inside wall of the torus. Different geometrical configurations were simulated to optimize the weighting function of the receiving system. Furthermore, the importance of the resonator geometry of TJ-K with its highly reflective walls was investigated. In a next step, the simulation was extended to 3D and implemented in the IPF-FD3D code in order to cover the full toroidal geometry of TJ-K for a full extent analysis of the weighting function. The stellarator's realistic magnetic background field was implemented and the density profile was modeled to be constant on the flux surfaces. This contribution compares 2D with 3D results and is considered essential for the interpretation of experimental results from the measuring system.

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Development status of a levitated dipole experiment for pair-plasma production — •Haruhiko Saitoh[1], Juliane Horn-Stanja[1], Eve V. Stenson[1], Uwe Hergenhahn[1], Thomas Sunn Pedersen[1], Markus Singer[2], Matthew R. Stoneking[3], and Nagato Yanagi[4] — [1]Max-Planck-Institut für Plasmaphysik — [2]Technische Universität München — [3]Lawrence University, USA — [4]National Institute for Fusion Science, Japan

Magnetic dipole is a simple and most common field configuration in the Universe, which generates a variety of plasma phenomena in a strongly inhomogeneous magnetic field. One of scientific applications of the dipole field is its usage as a trapping geometry for electron-positron pair-plasmas. For this purpose, we, the APEX (A Positron Electron Experiment) collaboration [1], is developing a compact levitated dipole device, APEX-D, to be operated at the NEPOMUC slow positron facility [2]. In order to minimize perturbations to plasmas, the superconducting dipole field coil (F coil, "F" for floating) of APEX-D will be magnetically levitated in a vacuum chamber. We plan to fabricate a Bi-2223 high-temperature superconducting (HTS) F coil that is magnetically levitated by using a feedback-controlled levitation coil (L coil), after inductive excitation of a persistent current in the F coil. We report design studies and status of development on the APEX-D project.

[1] T. Sunn Pedersen et al., New J. Physics **14**, 035010 (2012).
[2] C. Hugenschmidt et al., New J. Physics **14**, 055027 (2012).

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Shearing rate dependence of turbulent transport — •Til Ullmann and Mirko Ramisch — Institute of Interfacial Process Engineering and Plasma Technology, University of Stuttgart

In toroidally confined fusion plasmas, poloidal $E \times B$ shear flows play a crucial role in the reduction of radial turbulent transport Γ. Theoretical predictions exist for the functional dependence of Γ on the shearing rate on a rational surface and close by. In order to test the transport's shearing rate scaling, plasma biasing via a ring electrode is used at the stellarator TJ-K for controlling the shearing rate Ω of imposed stationary flows. The applicability of this method could already be demonstrated: Ω generally increases with bias voltage. In a next step, the cross-field transport is calculated from data of a poloidal 64-pin probe array alternately measuring potential and density fluctuations. The background flow shear is deduced from radial profiles of the plasma potential as measured with a moveable emissive probe. Spectral contributions to turbulent transport are correlated with the shearing rate and compared to theoretical predictions.

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Surface Temperature Measurement of In-Vessel Components Using Infra Red Spectroscopy — •Raheesty Devi Nem, Bernhard Sieglin, Albrecht Herrmann, and ASDEX Upgrade Team — IPP, Boltzmannstraße 2, 85748 Garching bei München

Neutral beam injection (NBI) is one of the auxiliary heating method used on ASDEX Upgrade. If the neutral beam is not absorbed by the plasma, it can deposit a high heat load with a heat flux density of up to $\approx 40\,\frac{\mathrm{MW}}{\mathrm{m}^2}$ on the first wall. For the machine protection, the **H**eat **S**hield **T**hermography (HST) is used to observe the strike points of the beam. The current HST system uses two colors pyrometers at wavelengths of about $0.9\,\mu$m and $1.6\,\mu$m to evaluate the surface temperature. Volume radiation influences the measurement, resulting in an overestimation of the surface temperature. As a consequence, the NBI is switched off unnecessarily. The aim of this work is to improve the HST by using infra red spectroscopy to disentangle thermal radiation from volume radiation. The basic principles for the surface temperature evaluation using IR thermography is shown. The calibration process of the IR spectrometer in laboratory is discussed. The spectrometer has been commissioned in the lab and tested at the high heat flux test facility GLADIS. The experimental setup and the results from GLADIS are shown. In addition the uncertainties of the spectroscopic measurement are discussed using synthetic data. An outlook to the commissioning of the new HST system on ASDEX Upgrade during the start of the 2017 campaign is given.

P 13.8 Di 16:30 HS Foyer

On the comparison of energy confinement in stellarators and tokamaks — •Ulrich Stroth[1,3], Birkenmeier Gregor[3,1], Fuchert Golo[2], Schneider Philip[1], ASDEX Upgrade team[1], and Wendelstein 7-X team[2] — [1]Max-Planck-Institut für Plasmaphysik, 85748 Garching — [2]Max-Planck-Institut für Plasmaphysik, 17491 Greifswald — [3]Physik-Department E28, Technische Universität München, 85747 Garching

With the ASDEX Upgrade (AUG) tokamak and the successful start of the stellarator Wendelstein 7-X (W7-X), the MPI for plasma physics operates two major fusion facilities. This motivates a direct comparison of the confinement quality of two fundamentally different magnetic configurations. While experimentally [1] and theoretically [2] it has been shown that turbulent transport can be expected to be rather different in character, the global energy confinement time of both stellarators and tokamaks can be described with the same scaling expression if appropriate parameters are chosen [3]. A physically relevant comparison of confinement has to concentrate on the transport coefficients. This can be achieved by eliminating from the scalings trivial parameter dependencies such as on plasma volume and surface or by directly comparing transport analyses of dimensionally similar discharges from both devices. The presentation discusses the different techniques for a direct confinement comparison and presents first applications to experimental data from AUG and W7-X.

[1] G. Birkenmeier et al., PRL **107**(2011),025001; [2] P. Helander et al., PPCF **54**(2012),124009; [3] U. Stroth, PPCF **40**(1998),9

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Preparation of an experimental plasma stability survey in Wendelstein 7-X plasmas — •Henning Thomsen[1], Tamara Andreeva[1], Christian Brandt[1], Joachim Geiger[1], Axel Könies[1], Ulrich Neuner[1], Carolin Nührenberg[1], Kian Rahbarnia[1], Jonathan Schilling[2], and W7-X Team[1] — [1]Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany — [2]Christian-Albrechts-Universität zu Kiel, IEAP, Leibnizstr. 11, 24114 Kiel, Germany

The Wendelstein 7-X stellarator (W7-X) ended its first operational phase in March 2016. The preparations for the next experimental phase (which is planned to begin in summer 2017) have been started. Currently ongoing upgrades of the first wall and the microwave heating system enable the realization of higher plasma performance in W7-X. Additionally, the plasma diagnostic capabilities are extended. In view of the detection of the magneto-hydrodynamic (MHD) properties, the most important supplements are the installation of the X-ray multi camera tomography system (allowing the reconstruction of a poloidal flux surface) and the integration of a set of Mirnov coils (magnetic probes for the detection of MHD modes). These improvements provide the possibility to investigate the MHD stability of the Wendelstein 7-X stellarator plasmas and the validation of this design optimization goal for different magnetic configurations. In this contribution we present the planning for the proposed measurements during the next experimental campaign, based on the results obtained during the first experimental phase as well as the new diagnostic and device capabilities.

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Completion of magnetic diagnostics at Wendelstein 7-X stellarator — •K Rahbarnia[1], T Andreeva[1], B B Carvalho[2], M Endler[1], D Hathiramani[1], J Geiger[1], S Lazerson[3], U Neuner[1], J Svensson[1], H Thomsen[1], A Werner[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 — [3]Princeton Plasma Physics Laboratory, Princeton, NJ 08540, USA

During the first operation phase (OP 1.1) of Wendelstein 7-X about 50% of the magnetic sensors, i.e. diamagnetic loops, Rogowski and saddle coils were commissioned. The measured diamagnetic energies and plasma currents are in reasonable agreement with theoretical predictions and results of other diagnostics (Thomson scattering, Bolometry) with respect to absolute values, confinement times and global energy balance. The completion of the equilibrium diagnostics in OP 1.2 (start summer 2017) allows a precise reconstruction of magnetic equilibria complemented by calculations using STELLOPT. Based on the diamagnetic flux measurement an interlock signal is generated to avoid damage of machine and diagnostics due to continued heating after a sudden plasma breakdown. Previous fluctuation measurements during OP 1.1 using 4 Mirnov coils clearly showed mode activity in the low kHz-range ($\sim$ 7 kHz) as well as potential alfvénic behaviour in the 100 kHz-range. The completion of the Mirnov diagnostic (125 sensors) allows more detailed investigations and cross-comparisons to other fluctuation diagnostics, like reflectometry and soft X-ray tomography.

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Influence of the Neutral Velocity Distribution on the Results of Pedestal Transport Modeling — •Johannes Gnilsen[1], Florian Laggner[1], Sebastian Keerl[1], Elisabeth Wolfrum[2], Emiliano Fable[2], Gregor Birkenmeier[2], and Eleonora Viezzer[3] — [1]Institut für Angewandte Physik, TU Wien, 1040 Vienna, Austria — [2]Max-Planck- Institut für Plasmaphysik 85748 Garching, Germany — [3]Department of Atomic, Molecular and Nuclear Physics, Universidad de Sevilla, 41012 Spain

High confinement mode operation in tokamak plasmas is accompanied by periodically appearing collapses of the edge transport barrier (pedestal) and a burst-like ejection of particles and energy, called edge localized modes (ELMs). After each ELM, both, the electron density and temperature recover and the pedestal builds up again. The temporal evolution of the density recovery is modeled using the transport code ASTRA, which solves the continuity equation for the tokamak geometry. Experimentally measured profiles are modeled interpretatively by adapting the profile of the diffusion coefficient. At the plasma edge the ionization of neutrals causes a significant source of plasma particles, which strongly contributes to the density build-up. This work will investigate the influence of assumptions made on the neutral velocity distribution on the diffusion coefficients derived from ASTRA modeling. Diffusion coefficients obtained from simulations with purely thermal neutrals will be compared to results using distributions with higher velocities, which stem from e.g. Franck-Condon decay or direct reflection from high-Z walls.

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Origin of radiative fluctuations close to the X-point during detachment in ASDEX Upgrade — •Peter Manz[1], Steffen Potzel[1], Marco Wischmeier[1], Sergei Krasheninnikov[2], and the ASDEX Upgrade Team[1] — [1]Max-Planck-Institut für Plasmaphysik, Garching, Germany — [2]University California San Diego, La Jolla, USA

The dynamics of radiative fluctuations in the divertor region close to the X-point during the fluctuating state of detachment are studied in ASDEX Upgrade. In this state the inner divertor is detached and the outer divertor is still attached. The X-point fluctuations appear at a frequency of a few kHz, which is at rather low frequency for plasma instabilities, but also at a rather high frequency for equilibrium related phenomena. Two possibilities will be discussed. The first one equates the X-point fluctuations with the dynamics of the ionization front. Fluctuations arise due to geometric restrictions on the propagation of the ionization front. The divertor nose constitutes an obstacle for the perpendicular neutral flux from the target to the region above the X-point. Passing into this shadow the ionization front fades away. A cyclic reformation of the ionization front propagating from below to above the X-point occurs. Another possibility for the X-point fluctuations is the current convective instability caused by the large temperature difference between the inner and outer divertor and a radial gradient in the resistivity.

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Non-local turbulent plasma transport in fusion plasmas — •Klara Höfler[1,2], Pascale Hennequin[3], Tim Happel[1], and Ulrich Stroth[1,2] — [1]Max Planck Institute for Plasma Physics, Garching, Germany — [2]Physik Department E28, TUM, Garching, Germany — [3]Laboratoire de Physique des Plasmas, Ecole Polytechnique, Palaiseau, France

The understanding of particle and energy transport in magnetically confined plasmas is one of the key topics in fusion research. In general both collisional and turbulent transport are described in terms of Fick's law through a diffusion coefficient and a local temperature or density gradient. There exist observations, however, where transport at one location depends on the gradients at a different position. Such a non-local description would dramatically change our physical understanding of transport in fusion plasmas. In this master thesis, turbulence measurements from different microwave diagnostics on the ASDEX Upgrade tokamak will be used and changes in the fluctuation characteristics will be correlated with profile changes. Previous observations of non-local transport will be summarized and the plans for experiments on ASDEX Upgrade as well as the relevant diagnostics will be presented.

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Scaling of Zonal Flow Power with Shearing Rate — •Rafael Carmona Cabezas, Til Ullmann, and Mirko Ramisch — Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Pfaffenwaldring 31, Stuttgart, Deutschland

In toroidal magnetic plasma confinement, zonal flows (ZF) play an important role in regulating drift-wave turbulence and, thus, edge cross-field transport. These flows are driven by gradients in turbulent Reynold stress, which is related with an average vortex tilt in the turbulent fluctuations. Thus, an already present background shear flow is expected to favour the ZF drive by tilting eddies.

In this work, the dependence of ZF amplitude on background ExB flow shear is investigated. To this end, the shearing rate of radially localized and stationary poloidal ExB flows are controlled via external plasma biasing. Different types of biasing electrodes are employed. Radial profiles of the ExB flow are measured by means of a movable emissive probe. At the same time, fluctuations in plasma density and potential are acquired using a poloidal 64-Langmuir probe array situated on one magnetic flux surface. The amplitude of the poloidally averaged potential fluctuations has proven useful as a good approximation for the time-varying ZF. This way, ZF power is detected, experimentally, and correlated with background flow shear.