P 12: Poster Session - Magnetic Confinement

Time: Tuesday 16:30–18:30 Location: SPA Foyer

P 12.1 Tue 16:30 SPA Foyer

Revision of the Spectroscopic Determination of Beam Parameters of the Neutral Beam Injection Systems on ASDEX Upgrade — •Felician Mink, Christian Hopf, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, EURATOM Association, Boltzmannstr. 2, 85748 Garching, Germany

Neutral beam injection is a frequently used powerful heating system on contemporary magnetic confinement fusion experiments such as ASDEX Upgrade. The injected beam is also used for plasma diagnostics based on charge exchange recombination spectroscopy. Increasing precision of these spectroscopic diagnostics as well as modern plasma transport codes require increasingly precise knowledge of the beam's geometry and composition as input.

These parameters are typically obtained through D_α beam emission Doppler spectroscopy.

Traditionally, a single number for the beam's divergence is obtained from these spectra using a simplified two-dimensional model and Gaussian fits. We replace this model with a fully 3-dimensional simulation of the Doppler-broadened spectra. The species distribution, i.e. the contribution of D^+, D_2^+ and D_3^+ to the primary ion beam, is derived from the ratios of the corresponding peak intensities. We critically review the validity of the usually applied Corona model and investigate experimentally in what parameter range collisional de-excitation has to be taken into account.

P 12.2 Tue 16:30 SPA Foyer

Expansion Morphology of Magnetic Flux Tubes in the FlareLab Experiment — •Jan Tenfelde[1], Felix Mackel[1], Sascha Ridder[1], Thomas Tacke[2], Jürgen Dreher[2], and Henning Soltwisch[1] — [1]Institut für Experimentalphysik V, Ruhr-Universität Bochum — [2]Institut für theoretische Physik I, Ruhr-Universität Bochum

In the frame of the FlareLab project the influence of the experimental boundary conditions on the expansion of arch-shaped plasma-filled magnetic flux tubes is investigated. Observations show that contrary to common assumptions the expansion is not driven exclusively by the magnetic stresses causing the hoop force. Instead, geometric constraints due to fixation of the current path on a comparatively small electrode surface lead to a deviation from this hoop force expansion scheme. Recently it was shown by means of numerical simulations that electrostatic boundary effects can play a significant role in the expansion of its apex when the flux tube geometry deviates from a toroidal shape due to tied foot points [1]. Here, we present experimental data confirming the deviation from torus expansion and substantiate the results obtained from simulations. The impact of the initial neutral gas distribution on the morphology of the flux tube expansion is investigated in a further modified plasma source. From careful comparison with the results of numerical MHD simulations adapted to this modification, conclusions concerning the impact of the proposed boundary-driven expansion are drawn.

[1] T. Tacke, J. Dreher and R.D. Sydora, PoP, 20, 072104 (2013)

P 12.3 Tue 16:30 SPA Foyer

Coherent mode generation during EBW heating in TJ-K — •Rennan Bianchetti Morales, Alf Köhn, and Mirko Ramisch — Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Universität Stuttgart

Electron Bernstein waves (EBWs) can be used to heat overdense plasmas when the plasma cut-off frequency is higher than the frequency of the injected microwaves. EBWs are electrostatic waves, which cannot propagate in vacuum and, therefore, need to be generated by mode conversion processes. The generation of EBWs is possible when the microwave heating power is high enough to increase the plasma density beyond the cut-off density. At this stage, the EBW mode conversion takes place and heating at the electron cyclotron resonance frequency (ECRF) and its harmonics is achieved. This heating scheme is successfully used in the stellarator TJ-K to heat overdense plasmas in low magnetic fields at ECRF harmonics.

Recent discharges using this heating scenario showed a quasi-coherent mode in density and potential fluctuations. This mode at approximately 4 kHz is dominant in the power spectrum and is evident from the center to the edge of the plasma, peaking at the separatrix region. In the presence of the coherent mode, the broadband turbulent fluctuations appear to be suppressed. This feature is more pronounced during discharges with the lower neutral gas pressures. In this contribution, the generation of this mode and its impact on the ambient turbulence is studied by means of Langmuir probe measurements.

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Blower Gun pellet injection system for W7-X — •Mathias Dibon[1], Jürgen Baldzuhn[1], Michael Beck[1], Antonio Cardella[2], Florian Köchl[3], Gabor Kocsis[4], Peter Lang[1], Rafael Macián-Juan[2], Bernhard Plöckl[1], Tamas Szepesi[4], and Wolfgang Weisbart[1] — [1]MPI für Plasmaphysik, EURATOM Association, Boltzmannstr. 2, 85748 Garching, Germany — [2]Lehrstuhl für Nukleartechnik, TU Munich, Boltzmannstr. 15, 85748 Garching, Germany — [3]Association EURATOM-ÖAW/ATI, Atominstitut, TU Wien, 1020 Vienna, Austria — [4]Wigner RCP, RMI, EURATOM Association, P.O.Box 49, H-1525 Budapest-114, Hungary

Foreseen to serve for the new stellarator W7-X for pellet investigations, the former ASDEX Upgrade Blower Gun was revised and revitalized in a test bed. The gun is able now to launch cylindrical pellets of 2 mm diameter and 2 mm length, produced from frozen Deuterium (D_2) or Hydrogen (H_2). Pellets are accelerated by a short pulse of pressurized helium propellant gas to velocities in the range of 100-250 m/s. Delivery reliabilities at the launcher exit close to unity are achieved. For pellet transfer to the plasma vessel a first mock up guiding tube version was investigated. Transfer through this S-shaped (inner diameter 8 mm; length 6 m) stainless steel guiding tube containing two 1 m curvature radii was investigated for both H_2 and D_2 pellets. Tests were performed applying repetition rates from 2 Hz to 50 Hz and propellant gas pressures ranging from 1 bar to 6 bar. For both H_2 and D_2, low overall delivery efficiencies were observed at slow repetition rates, but stable efficiencies of about 90% above 10 Hz.

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Curvature dependance of blob dynamics in TJ-K — •Stephen Garland[1], Golo Fuchert[2], and Mirko Ramisch[1] — [1]Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Universität Stuttgart — [2]Institut Jean Lamour, Université de Lorraine

Turbulent transport in the scrape-off layer (SOL) is an important area of investigation in magnetic confinement fusion research. Relatively dense and hot, field-aligned, filament-like structures (blobs) have been observed to propagate radially through the SOL in many fusion devices, and contribute significantly to SOL transport. The torsatron TJ-K operates with a low-temperature plasma, allowing Langmuir probe measurements in the entire plasma volume. Despite the low temperature, investigations are relevant to fusion research due to dimensionless plasma parameters similar to those in the edge region of fusion plasmas.

Analytical blob models link blob velocity in the SOL to blob polarisation, which can be driven by magnetic field line curvature. In TJ-K, average blob dynamics can be studied in detail using a 2D movable probe and a conditional averaging technique. In addition, a fast camera can be used to supplement probe data, and provide information on individual blob trajectories. With these tools, the connection between magnetic field line curvature and the poloidal component of blob velocity has been studied. Taking into account background $E \times B$ flows, initial investigations suggest a correlation between the poloidal component of blob velocity and averaged geodesic magnetic field line curvature.

P 12.6 Tue 16:30 SPA Foyer

Permutation entropy analysis of density fluctuations in the torsatron TJ-K — •Dong Wang and Mirko Ramisch — Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Universität Stuttgart

In order to explore the nature of density fluctuations in the edge of magnetically confined fusion plasmas, the technique of permutation entropy and statistical complexity is used. The location of fluctuations on the entropy versus complexity plane classifies the dynamical behaviour of the system. The behaviour can be differentiated between stochastic and chaotic. The latter is supposed to be connected to a specific temporal form of intermittent density events, i.e. blobs, in the

scrape-off layer (SOL).

In this contribution, density fluctuations measured with a Langmuir probe in the torsatron TJ-K are analyzed with respect to the dynamical nature. Radial scans are performed across the separatrix to distinguish the dynamics in the inner edge and the SOL. Comparisons with well known test systems indeed point to a qualitative change in the dynamics across the separatrix. In the region of maximum density gradient, the fluctuations are charaterized by minimum entropy. The results will be discussed on separated scales.

P 12.7 Tue 16:30 SPA Foyer

Investigation of zonal flows with toroidal correlation analysis in TJ-K — •Ivan Erofeev, Bernhard Schmid, and Mirko Ramisch — Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Universität Stuttgart

In toroidal fusion plasmas, zonal potential perturbations associated with zonal flows can appear. These potential structures have toroidal and poloidal symmetry. Zonal flows are intrinsically connected to flow shear and interact with drift-wave turbulence through the shearing of eddies. By this mechanism, the zonal flow gains energy and the transport through drift-wave turbulence is reduced. Zonal flows have been found to evolve naturally in the drift-wave dominated turbulence of low-temperature plasmas in the stellarator TJ-K. In order to capture their long-range feature through the symmetry properties, Langmuir-probe measurements are performed at two well separated toroidal positions. Long-range correlations are studied with respect to their spatio-temporal properties. In a first step, the radial structure is analyzed by means of a rake-like probe with radially separated pins. Thereby, the influence of zonal flows on radial correlation lengths of the ambient turbulence is shown. Furthermore, a stationary poloidal probe array is used in combination with a 2D-movable probe system in order to uncover the turbulent dynamics in the full poloidal cross-section, conditionally, when zonal flows evolve.

P 12.8 Tue 16:30 SPA Foyer

Untersuchung des Energietransfers in Zonalströmungen am Stellarator TJ-K — •Bernhard Schmid[1], Mirko Ramisch[1] und Ulrich Stroth[2] — [1]Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, Universität Stuttgart — [2]Max-Planck-Institut für Plasmaphysik, EURATOM Assoziation, Garching

Zonalströmungen erfahren in der Fusionsforschung verstärkt Beachtung, da angenommen wird, dass sie im Zusammenhang mit der H-Mode stehen. Dabei entstehen sie in eine Art Selbstorganisationsprozess aus der umgebenden Plasmaturbulenz. Durch Verscherung von Wirbelstrukturen wird Energie in die Zonalströmung transferiert. Die Verscherung wird hierzu mit dem Reynolds-Stress quantifiziert. Über die Kopplung in die geodätisch akustische Mode (GAM) erfolgt die Dämpfung. Zur Untersuchung des Energieübertrags wurde ein poloidaler Sondenkranz für den Einsatz in Niedertemperaturplasmen am Stellarator TJ-K entwickelt. Mit 128 Langmuir-Sonden wird dabei Potential oder Dichte gleichzeitig auf vier benachbarten Flussflächen gemessen. Die Sonden sind dabei so positioniert, dass radiale und poloidale Geschwindigkeiten gemessen werden können. Damit lässt sich der für den Antrieb wichtige Reynolds-Stress auf zwei Flussflächen und gleichzeitig das poloidale Modenspektrum bestimmen. Mit Bispektralanalysen wird die Wechselwirkung einzelner Moden gezeigt. Dabei wird der Energietransfer von der Driftwellenturbulenz in die Zonalströmung und von der Zonalströmung in die GAM untersucht.

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On the influence of boundary conditions on the excitation of instabilities in magnetohydrodynamic systems — •Claudia-Veronika Meister, Bo Ram Lee, and Dieter H.H. Hoffmann — Technische Universität Darmstadt, Institut für Kernphysik, Schlossgartenstr. 9, 64289 - Darmstadt

The recent stage of the magnetohydrodynamic energy principle which may be applied to laboratory and space plasmas, is briefly reviewed. Some steps are made to develop the principle further to apply it also to inhomogenous, incompressible systems. Especially it is tried to introduce inhomogeneous magnetic fields in the inner parts of pinch plasmas. In doing so, a system of mathematical equations is derived, the solution of which gives the dispersion relation in plasmas with disturbances in non-cylindrical symmetry. But the numerical applications presented here are only performed for plasma disturbances with cylindrical symmetry and homogeneous axial magnetic fields. Using the model of a pinch plasma separated from the outer conducting wall by a vacuum, sausage instabilities are described in ITER-type and lightning plasmas. The ratios of the values of the inner and external magnetic fields are found at which sausage instabilities will occur at very small wave numbers. In case of the lightning plasma, it was even possible to estimate the radial displacements in the plasma.

P 12.10 Tue 16:30 SPA Foyer

Estimation of statistical moments for single point measurements in the Scrape Off Layer — •Ralph Kube and Odd Erik Garcia — University of Tromsø, Department of Physics and Technology, Tromsø, Norway

Recent theoretical work argues that time series of the plasma particle density in the scrape-off layer (SOL) may be modelled as a shot noise process. It was shown that the superposition of individual bursts with an exponentially decaying wave form, exponentially distributed waiting times between bursts and burst amplitudes cause the particle density to be gamma distributed, in good agreement to single point measurements in the SOL.

In this contribution we derive expressions for the mean error on estimators for the mean, variance, skewness, and kurtosis for this class of shot noise processes. The number of samples of the time series, N, and the intermittency parameter γ that gives the ratio of the e-folding time of individual burst events to the waiting time between bursts, are free parameters.

We find that the rate of convergence of the estimator for the mean and normalized variance increase with γ and that the e-folding time of the individual burst events further cause a deviation from the N^{-1} rate of convergence that holds for normally distributed random variables.

Comparing the expressions for the mean-squared error to synthetic time series shows good agreement. We also present a comparison to long ($t \simeq 0.3$s) single point measurements obtained by a Langmuir Probe and Gas-Puff imaging in the scrape-off layer of Alcator C-Mod.

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Einschluss von MeV-Elektronen im Stellarator WEGA — •Marion Dostal[2], Heinrich Peter Laqua[1] und Torsten Stange[1] — [1]Max-Planck-Institut für Plasmaphysik, 17491 Greifswald, EURATOM Association — [2]Institut für Physik, Universität Rostock, 18055 Rostock

Ein zentrales Problem von Stellaratoren als auch Tokamaks ist der Einschluss schneller Teilchen. Am klassischen Stellarator WEGA wurde gezeigt, dass Elektronen über einen stochastischen Heizprozess mittels 2,45 GHz-Mikrowellen auf Energien bis zu MeV beschleunigt werden können. Die Detektion dieser überthermischen Elektronenkomponente erfolgt über Synchrotron- und Bremsstrahlung sowie den generierten Plasmastrom. Durch Berechnung der Teilchenbahnen wurde der Einfluss der Magnetfeldkonfiguration auf den Einschluss der schnellen Elektronen untersucht. Bei überwiegend parallelem Impuls ist unter bestimmten Randbedingungen ein guter Einschluss gewährleistet. In diesem Fall schrumpfen die resultierenden Driftflächen gegenüber den Vakuumflußflächen mit zunehmender Teilchenenergie. Dieser Effekt ist weiterhin abhängig von der verwendeten Magnetfeldkonfiguration, die über separate Veränderung des Toroidal- und Helikalfeldes und optional eines Vertikalfeldes beliebig variiert werden kann. Von besonderem Interesse waren dabei der Einfluss von Rotationstransformation und magnetischen Inseln.

P 12.12 Tue 16:30 SPA Foyer

Systems code studies for assessment and selection of operational points for a tokamak DEMO reactor — •Mitja Beckers, Wolfgang Biel, and Ulrich Samm — Institut für Plasmaphysik, Forschungszentrum Jülich GmbH, EURATOM Association, D-52425 Jülich, Germany

A big step towards commercial fusion will be the commissioning of the first DEMO power plant. For tokamaks a steady state can only be achieved in advanced scenarios with a high bootstrap fraction and non-inductive current drive. For designing a reactor the parameter space is limited by physics constraints, which can hardly be computed alltogether on a sophisticated level. Thus empirical findings are extrapolated to larger machines by scaling laws in order to cast complex physics into computable macroscopic dependencies. Systems codes are used to predict stable operational points for given reactor scenarios and to perform parameter scans for optimized selection. Scenario specifications like divertor detachment and their effects on material lifetime and plasma stability need to be more properly represented in systems codes in order to define new criteria for the fine-selection of stable operational points, which can then be further investigated by highly sophisticated, but time-consuming codes. Therefore the scalings

and equations in the code were cross-checked with latest experimental findings and a new module for lifetime estimations for the first Wall is being developed.