P 20: Magnetic Confinement VI

Time: Thursday 11:00–12:45 Location: ELP 6: HS 3

Invited Talk P 20.1 Thu 11:00 ELP 6: HS 3

Modelling of tungsten erosion and deposition in fusion devices — •Andreas Kirschner, Sebastijan Brezinsek, and Juri Romazanov — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany

In magnetically confined fusion devices plasma-wall interaction and resulting erosion and deposition at the wall components is a major concern due to lifetime limitations of the wall components, long-term tritium retention via co-deposition and plasma contamination by eroded impurities. Tungsten is currently the favoured wall material for future fusion devices due to comparably low sputtering and high melting point. However, as high-Z material, tungsten can lead to unacceptably high radiation in the core plasma resulting in plasma collapse. Therefore, detailed understanding of tungsten erosion, migration and redeposition is needed to minimise the net erosion of tungsten. The present contribution provides an overview of the main processes involved in tungsten erosion and migration. The role of the eroding species will be discussed in view of fuel ions (including isotope effects) and CX neutrals compared to plasma impurities and tungsten self-sputtering. Also, the contribution of intra- and inter-ELM phases to the tungsten erosion will be analysed. The importance and extent of tungsten prompt redeposition, which reduces the net erosion, will be examined. Besides more generic studies, ERO modelling in combination with experimental findings in particular from the divertor of JET will be shown.

Invited Talk P 20.2 Thu 11:30 ELP 6: HS 3

Drift flows in the island divertor of W7-X — •Carsten Killer[1], Sean Ballinger[2], Seung-Gyou Baek[2], Dario Cipciar[1], Olaf Grulke[1,3], Adrian von Stechow[1], and Jim Terry[2] — [1]Max-Planck-Institut für Plasmaphysik, Greifswald, Germany — [2]MIT Plasma Science and Fusion Center, Cambridge, MA, USA — [3]Technical University of Denmark, Lyngby, Denmark

The plasma boundary in the W7-X stellarator is formed by a chain of intrinsic resonant magnetic islands that are partially intersected by the modular divertor targets. Transport of heat and particles in the island plasma is subject to the interplay of field-parallel gradients, drift flows and turbulent cross-field transport. Two new diagnostic tools, a gas-puff imaging system and a 2D array of Langmuir probes, provide insight into the role of poloidal and radial drift flows and the 3D equilibrium structure of plasma parameters. Stationary radial electric fields within the magnetic islands measured with probes are consistent with the direct imaging of poloidal drift flows with velocities of a few km/s. As parallel transport has to span several 100m of connection length to the divertor targets in W7-X, these drift flows on the island flux surfaces are a significant (and sometimes dominant) transport channel. We observe - sensitively depending on size and position of the magnetic island - multiple shear layers of opposing flows / electric fields with typical widths of just 1-2 cm. In addition, small poloidal electric fields and corresponding radial flows can be present in some scenarios. Turbulent radial transport levels are rather small, particularly when compared to the plasma edge in tokamaks.

P 20.3 Thu 12:00 ELP 6: HS 3

Edge impurity behavior and plasma distribution after boronization on W7-X — •Pei Ren[1,3], Yunfeng Liang[1,3], Yu Luo[1,3], Erhui Wang[1], Stepan Sereda[1,3], Ralph W.T. König[2], Maciej Krychowiak[2], Sebastijan Brezinsek[1], Dorothea Gradic[2], Marcin W. Jakubowski[2], Petra Kornejew[2], Olaf Neubauer[1], Arun Panaey[2], Shuai Xu[1], and The w7-x Team[1,2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany — [2]Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany — [3]Faculty of Mathematics and Natural Science, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany

Controlling the impurity source and wall particle re-cycling is necessary to achieve long-pulse high-performance steady-state plasma operation on the W7-X stellarator. In the experimental campaign OP1.2b, the passively cooled test divertor unit made of graphite has been used. The low-Z impurities, oxygen and the carbon, were identified as mostly contributing to the radiated power in the initial phase of OP1.2b. With the help of boronized wall conditions, a significant reduction in impurity concentration was observed by a newly installed divertor spectroscopy endoscope on W7-X. These results demonstrate the potential of boronization for edge plasma parameter optimization and control in upcoming high-power steady-state plasma operations. In this paper, the changes in impurity content and distribution in the divertor area, as well as the related changes in the edge plasma profiles (Te, ne) before and after boronization will be discussed.

P 20.4 Thu 12:15 ELP 6: HS 3

Experimental investigation of the turbulent drive of the shear flow at the stellarator TJ-K — •Nicolas Dumérat and Mirko Ramisch — IGVP, University of Stuttgart, Germany

Drift wave turbulence has been found to be the dominant instability in the edge of the stellarator TJ-K. Naturally driven by the density gradient, drift waves play a key role in the turbulent transport of particles and energy at the edge of magnetically confined experiments. Inherently related to the coupling between density and potential fluctuations, the drift waves become unstable in case of a non-adiabatic response of the electrons to a density perturbation. Another key agent in such two- dimensional turbulence systems, the zonal flows (ZF) is tied to this cross-coupling. Its interplay with background turbulence is investigated in this work. To this end, convergent cross mapping, a method measuring the causal coupling between variables measured in the same dynamical system is used. By means of multi-dimensional Langmuir probe measurements, and conditional sampling, the plasma fluctuations can be resolved and studied from a new perspective: causality. The causal coupling between density and potential fluctuations during ZF occurrence indicates a clear causality of the density over potential while penetrating the ZF shear layer. Both fluctuations are shown to cause the growth of the ZF, following the drift wave character of the turbulence in the edge of TJ-K. Extending this analysis to wave-number space, the coupling between k_θ modes of plasma fluctuations, unveils the non-locality of the turbulence drive of the ZF as well as evidence of an inverse energy cascade.

P 20.5 Thu 12:30 ELP 6: HS 3

Estimation of turbulent diffusion by conditional variance — •Tobias Tork[1,2], Nicolas Bian[3], Felix Reimold[1], Carsten Killer[1], Wladimir Zholobenko[4], Peter Manz[2], Gustavo Grenfell[4], ASDEX Upgrade Team[4], and Wendelstein 7-X Team[1] — [1]Max-Planck-Institute for Plasma Physics, 17491 Greifswald, Germany — [2]Institue of Physics, University of Greifswald, 17489 Greifswald, Germany — [3]Department of Space Sciences and CSPAR, University of Alabama in Huntsville, USA — [4]Max-Planck-Institute for Plasma Physics, 85748 Garching, Germany

Particle and heat transport is of key importance for the optimization of magnetic confinement devices. Transport in magnetized plasmas is the result of interactions between different fields and therefore cannot be measured directly with just one observable. We conjecture estimating the turbulent diffusion coefficient by analyzing the growth of the variance conditioned on small perturbations. This transport estimate relies solely on a time series and the local spatial gradient of one measured variable in the relevant transport direction. We heuristically verify the conjecture with gyrofluid simulations and probe measurements from ASDEX Upgrade and Wendelstein 7-X. The vast majority of estimations demonstrate a considerable accuracy, typically within a factor of two of the actual transport.