4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Inter-machine study of impurity ion and neutral flow dynamics in the SOL of the tokamak ASDEX Upgrade and optimized stellarator Wendelstein 7-X

D. Gradic[1], V. Perseo[1], R. König[1], A. Burckhart[2], F. Reimold[1], R. Dux[2], F. Effenberg, M. Krychowiak[1], T. Sunn Pedersen[1], V. Winters[1], the W7X Team[1,*], the ASDEX Upgrade Team[2,**] and the EUROfusion MST1-Team[2,***]

[1] Max Planck Institute for Plasma Physics, Greifswald, Germany
[2] Max Planck Institute for Plasma Physics, Garching, Germany
[3] Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA
e-mail (speaker): Dorothea.Gradic@ipp.mpg.de

An inter-machine study of the impurity ion and neutral flow velocity behavior has been carried out in the Scrape-off-Layer (SOL) of the medium-sized tokamak ASDEX Upgrade (AUG) and the optimized stellarator Wendelstein 7-X (W7-X). As main diagnostic, the same Doppler Coherence Imaging Spectroscopy (CIS) system was used at both devices [1,2], providing 2D flow velocity images derived from single atomic or ion emission lines. By exploiting the 2D imaging capabilities of CIS, large parts of the divertor and SOL regions can be diagnosed (see Fig. 1 and 2). Since the friction force dominates in the low temperature parts of the SOL, where the CIS measures light emission from e.g. CIII and NII, the impurity flows are closely coupled to the hydrogen ions, thus providing information on the main ion flows. Even though very different divertor concepts are realized in AUG and W7-X, impurity flow velocities on the order of a few tens of km/s parallel to the magnetic field lines are observed in both their SOLs, with their magnitude and direction depending on X-point location(s) and primarily being driven by pressure gradients along the open magnetic field lines. In both machines, the flow velocity magnitudes and dynamics are found to be remarkably sensitive to magnetic topologies (upper-, lower- and double-null in AUG as well as the different island topologies in W7-X) and consistent with pressure drive. Furthermore, processes such as impurity seeding or detachment reveal strong effects in impurity dynamics. Major differences between the island divertor of W7-X and the poloidal field divertor of AUG are the presence of magnetic islands with closed magnetic field lines and much longer connection lengths for open magnetic lines in the SOL of W7-X. These are believed to be the cause for the observed widening of the target heat-load profiles due to enhanced perpendicular transport. Additionally, these and other differences might influence secondary flow drivers or restraints, such as the ones reported in e.g. Mach probe studies from other experiments [3]. To investigate possible different secondary effects on the comprehensive flow behaviors, a deeper investigation with e.g. SOLPS or EMC3-Eirene simulations is required, for which CIS results can give a solid experimental reference.

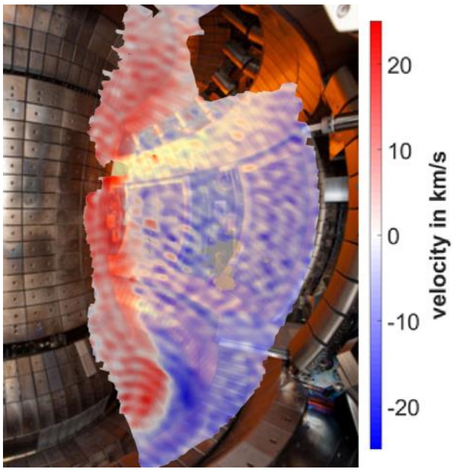

Fig 1: Measured C2+ flow in the SOL of AUG (lower single null, attached state). A photo of the AUG inner vessel was added for orientation.

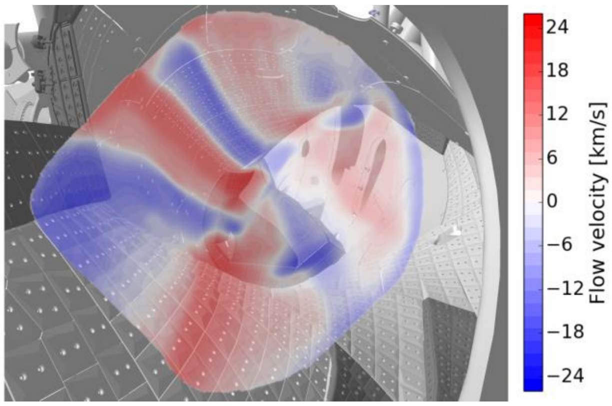

Fig. 2: Measured C 2+ flow in the SOL of W7-X [4] (standard config., attached state). CAD-Model of W7-X inner vessel added for orientation.

References:
[1] D. Gradic et. al. Plas. Phys. Control. Fus. **60** (2018) 084007 (12 pp)
[2] V. Perseo et al. Nucl. Fusion **59** (2019) 124003
[3] B. LaBombard et al. Nucl. Fusion **44** (2004) 1047–66
[4] V. Perseo (2020) PhD thesis (https://epub.ub.uni-greifswald.de/files/3829/PhDthesis_Perseo.pdf)

* See author list: T. Klinger et al 2019 Nucl. Fusion 59 112004 ** author list: H. Meyer et al 2019 Nucl. Fusion 59 112014 *** author list: B. Labit et al 2019 Nucl. Fusion 59 0