Experimental helium exhaust studies in the full-W ASDEX Upgrade

A. Zito[1,2], A. Kappatou[1], M. Wischmeier[1], V. Rohde[1], E. Hinson[3], O. Schmitz[3], M. Cavedon[4,1], R.M. McDermott[1], R. Dux[1], M. Griener[1], A. Kallenbach[1], U. Stroth[1,2] and the ASDEX Upgrade Team

[1] *Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany*
[2] *Physik-Department E28, Technische Universität München, Garching, Germany*
[3] *University of Wisconsin-Madison, USA*
[4] *Dipartimento di Fisica G. Occhialini, Università di Milano-Bicocca, Milano, Italy*

In future fusion devices helium will be generated in the core of a burning plasma as a product of the D-T reaction. In order to avoid fuel dilution and not degrade the confinement properties, the core helium concentration must be kept within tolerable values [1]. It will be therefore mandatory to efficiently remove helium ash from the plasma, which imposes constraints on edge and divertor conditions and requires an adequate design of the pumping systems.

An experimental investigation of helium recycling and pumping has been performed at the ASDEX Upgrade (AUG) tokamak. This is an ideal test environment thanks to the ITER-like plasma geometry and the presence of PFCs made of tungsten, which is a fusion-relevant wall material. The time evolution of helium following a small injection during otherwise steady-state deuterium discharges was measured spectroscopically in the plasma with CXRS [2][3] and in the exhaust gas using in-vessel Penning gauges [4]. Applying simple analytical multi-reservoir particle balances, the decay of the helium content in the plasma was interpreted by means of a pumping efficiency, limited by the technical capability of the pumping system, and a divertor compression efficiency, which quantifies helium transport in the edge and retention in the divertor plasma. Distinct decay times were fitted to separately characterize the two processes.

In all scenarios the limited performance of the AUG pumping system was identified as the main bottleneck for an efficient exhaust. This is mainly due to the fact that helium is not pumped by the installed in-vessel cryopump. The influence of helium retention in the W-wall was also identified to play a non negligible role in the decay dynamics. It was found that helium compression in the divertor strongly depends on the plasma scenario. In attached H-modes plasmas, helium compression was found to greatly increase with increasing divertor neutral pressures, with a resulting decay time in the plasma decreasing roughly linearly with increasing neutral pressure. On the other hand, the exhaust efficiency was seen to degrade with the divertor entering a detached state in L-mode, in line with past observations at AUG with C-wall [5].

References

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