Plasma edge profile characteristics in the X-point radiator scenario at ASDEX Upgrade

R. M. McDermott[1], L. Hofstadler[2], E. Wolfrum[1], M. Bernert[1], F. Klossek[1], L. Radovanovic[2], M.G. Dunne[1], M. Griener[1], U. Stroth[1], the ASDEX Upgrade and the EUROfusion Tokamak Exploitation Teams

[1] Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85478 Garching, Germany
[2] Institute of Applied Physics, Wiedner Hauptstr. 8-10, TU Wien, 1040 Vienna, Austria

The introduction of nitrogen as a radiating impurity into conventional H-mode scenarios can lead to a regime in which the radiation is concentrated in a small region around the X-point and is therefore called the X-point radiator (XPR) scenario [1,2]. The balance between N fuelling rate and heating power determines the position of the radiating zone, which can also be controlled by these two actuators [3]. The physical mechanism is successfully described by the power balance between the mid-plane region and the magnetically expanded region around the X-point. It considers radiation due to N and ionisation and charge-exchange processes with D neutrals [4,5].

In this contribution, the plasma edge profile behaviour is shown in dependence on the XPR height, selecting data from discharges with similar heating power, so that the XPR position is moved upwards with increased N seeding. As the XPR moves upwards, the upstream electron and ion temperatures continually decrease in the steep gradient region ($0.975 < \rho_{pol} < 1.0$). The same relative decrease can be reproduced quantitatively by the power balance model. The pedestal top density first increases, then decreases again when the XPR is higher than 5 cm. At the beginning of the upward movement of the XPR, the divertor is partially detached, ELMs are still visible, the complete pedestal is locally ballooning unstable (no second stability access), and close to the global ballooning stability boundary. At an XPR height of 5 cm, the density decreases and only as the pedestal pressure gradient is below the peeling ballooning boundary, the ELMs disappear at an XPR height of 7 cm. Then, the scenario is ELM-free, the full pedestal area is ballooning stable and resembles an L-mode edge, i.e. the pressure gradient is too shallow to drive ideal MHD modes. The loss of confinement is partially compensated by an increased pressure gradient in the outer core region ($0.7 < \rho_{pol} < 0.95$). This contribution will also present the evolution of the nitrogen content in the pedestal and main chamber, as well as the behavior of the edge impurity density profiles, which lends insight into pedestal impurity transport in this regime.

[1] F. Reimold et al 2015 Nucl. Fusion 55 033004
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[3] M. Bernert et al 2021 Nucl. Fusion 61 024001
[4] U. Stroth et al 2022 Nucl. Fusion 62 076008
[5] O. Pan et al 2023 Nucl. Fusion 63 016001