Inner-outer midplane density asymmetries and the link to the HFSHD close to double null at ASDEX Upgrade

D. Hachmeister[1], C. Silva[1], J. Santos[1], G. D. Conway[2], L. Gil[1], A. Silva[1], U. Stroth[2,3], J. Vicente[1], E. Wolfrum[2], R. M. McDermott[2], R. Dux[2], B. Kurzan[2], D. Brida[2], and the ASDEX Upgrade Team

[1]*Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Portugal*
[2]*Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany*
[3]*Physik-Department E28, Technische Universität München, 85747 Garching, Germany*

Research at ASDEX Upgrade (AUG) has reported the formation of a high-field side high density (HFSHD) front in the divertor region associated with the inner divertor detachment [1]. The dynamics of the midplane edge electron density profiles and its link to divertor detachment have been previously studied on AUG, taking advantage of the high-resolution HFS/LFS O-mode reflectometry diagnostic [2]. It has been shown that the formation of a high-density region in the midplane in front of the inner wall leads to strong poloidal asymmetries in the scrape-off layer density [2]. Building on these results, this work details the divertor detachment and HFSHD formation in highly shaped plasmas - close to double null (DN) configuration - characteristic of many reactor concepts.

For this purpose, we performed plasma configuration scans from lower single null (LSN) to upper single null (USN) passing through DN configuration. These scans were performed in both L- and H-mode at different fuelling and seeding levels to vary the detachment state and overall plasma density. During the transition from LSN to USN, we measured: (i) the inner and outer divertor density and temperature using Thomson scattering and stark broadening spectroscopy; (ii) the target density and temperature using Langmuir probes; (iii) the scrape-off layer density at the inner and outer midplane using O-mode reflectometry. These measurements allowed us to monitor the detachment state and the magnitude and location of the HFSHD during the LSN to USN transition.

While moving from LSN to DN, the HFSHD moves from the far-SOL to the X-point region as the HFSHD becomes increasingly disconnected from the LFS. Interestingly, the HFS density even increases when approaching DN despite the reduced magnetic connection to the LFS. In the midplane scrape-off layer, the LFS density experiences little change going from LSN to USN, but the HFS density - dominated by the midplane HFSHD front - is significantly lower in the USN case. This highlights the importance of the ExB drift in the divertor in establishing the HFS density since the drift points inwards in LSN and outwards in USN [3].

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[2] L. Guimarãis et al., Nuclear Fusion 59 (2019) 126041.

[3] A. W. Leonard, Plasma Physics and Controlled Fusion, 60(4) (2018), 044001.