SOL density variations during ICRF heating and gas injection

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We explore through modeling effect of gas injection on the SOL (Scrape-off-layer) density profiles (n_{eSOL}) during ICRF (Ion Cyclotron Resonance Frequency) heating. Gas injection during ICRF wave operation has been tested in several tokamaks with the goal of improvement of the coupling by modifying the edge density profile n_{eSOL}, thus facilitating the fast wave (FW) ICRF propagation through the evanescent layer [1]. The EDGE2D two fluid code was adapted to model the presence of a wide SOL and a magnetic geometry relevant to the JET experiments with a 2nd X-point near to the top of the wall (like JET pulse #77293 [2]). Effects of ExB convection and ponderomotive forces are not included. In the modeled 2D geometry, the gas puff location is by definition magnetically connected to the ICRF antenna location. We assume that the ICRF wave does not participate in the gas ionization and does not ionize the SOL directly by local SOL RF energy absorption/ heating. Both the SOL ionization and the related n_{eSOL} increase are due to increased SOL temperature in the SOL during the ICRF heating in the core, similarly as during any core heating. The simulations show that without top or Outer Mid Plane (OMP) gas puff, n_{eSOL} modestly varies (by up to 15%) as a function of ICRF power (up to 3 MW) absorbed in the core. The absorbed ICRF power then enhances the outward thermal flow through the separatrix and consequently also the SOL temperature. Even without any ICRF power absorbed in the core, n_{eSOL} increases as a function of the gas puff magnitude: In the far SOL, n_{eSOL} magnitude grows by up to about 50% both for the OMP and for the top puff of rate $6x10^{21}$ el/s. When accounting for the ICRF power absorbed in the core, n_{eSOL} grows as a function of the ICRF power and the gas puff rate from the OMP, and only slightly for the top puff (up to $9x10^{21}$ el/s in the simulations): n_{eSOL} rises more than twice for ICRF power level of 2 MW and OMP gas puff of $9x10^{21}$ el/s. The outward spatial shift of the FW cut-off layer density ($n_{ecut-off}$ approx. $2\text{-}6x10^{18}m^{-3}$) is larger than 1 cm in this case. The trends of n_{eSOL} variations found in simulations are consistent with JET measurements [3] of n_{eSOL} by Li-beam and reciprocating probe, in which an outward shift of the cut-off layer of slightly more than 1 cm was observed for gas puff rate of $12x10^{21}$ el/s and ICRF power of 0.5 MW. Observations from ASDEX-U [4] by Li-beam and interferometry exhibit similar n_{eSOL} increase and outward shifts of the cut-off density as that found in simulations at the same gas puff rates. Further comparison of simulations with experiments will be provided in the Conference paper.

[1] M.-L. Mayoral et al., 23rd IAEA Conference 2010, Daejeon, Korea, paper ITR/P1-11. [2] V. Petrzilka et al., 38th EPS Conference on Plasma Physics (2011) P4.099; A. Ekedahl et al., Plasma Phys. Contr. Fusion, accepted for publication. [3] I. Monakhov et al., Topical Group on Heating and Current Drive, CCIC 2008, Culham. [4] P. Jacquet et al., submitted to Nuclear Fusion.

This work was supported by EURATOM and carried out within the framework of the European Fusion Development Agreement. The views and opinions expressed herein do not necessarily reflect those of the European Commission. V. P. acknowledges support of the Czech Science Foundation Grant 205/10/2055, and of MSMT CR Grant LG11018.

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* See the Appendix of F. Romanelli et al., Proceedings of the 23rd IAEA Fusion Energy Conference 2010, Daejeon, Korea